quantitative analysis of retail productivity

kwantitatieve analyse van produktiviteit in de detailhandel

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR
IN DE ECONOMISCHE WETENSCHAPPEN
AAN DE ERASMUS UNIVERSITEIT ROTTERDAM
OP GEZAG VAN DE RECTOR MAGNIFICUS
PROF.DR. M.W. VAN HOF
EN VOLGENS BESLUIT VAN HET COLLEGE VAN DEKANEN.
DE OPENBARE VERDEDIGING ZAL PLAATSVINDEN OP
DONDERDAG 5 APRIL 1984 TE 16.00 UUR

DOOR

ADRIAAN ROY THURIK

GEBOREN TE ROTTERDAM

1984
W. D. MEINEMA B.V. - DELFT

Promotor: Prof. Dr. J. Koerts

ISBN 90 211 4020 9

aan Margreeth

PREFACE.

This book is the final report of a series of studies which I conducted at the Department of Basic Research of the Research Institute for Small and Medium-Sized Business in the Netherlands (E.I.M.: "Economisch Instituut voor het Midden- en Kleinbedrijf"). These studies are part of a joint project with the Econometric Institute of the Erasmus University Rotterdam (E.U.R.) and they were conducted from 1980 to 1983. Preliminary versions of several of these studies appeared as reports of the Econometric Institute and/or as research papers issued by the Research Institute for Small and Medium-Sized Business. Adapted versions of chapters two, three and six will appear in The economics of distribution (Franco Angeli Editore, Milano), International small business journal (Vol. 2, No. 2) and Service industries journal (Vol. 4, No. 1), respectively.

I am greatly indebted to Prof.Dr. J. Koerts of E.U.R. who supervised my studies and this final report. Without his motivating scientific guidance, moral support and enthusiasm my studies would by no means have been started nor completed.
I am also indebted to my colleagues in the Department of Basic Research of E.I.M. who contributed to my knowledge of retail behaviour and especially to Dr. B. Nooteboom, my predecessor, and to Mr. H.A.C. van Schaik, who assisted me with the collection and processing of the considerable amount of data material.
I am grateful for the stimulating working climate at the Econometric Institute, where I have been a guest for several years.
My thanks also go to E.I.M. for the opportunity to integrate my studies into a dissertation.
Preliminary reports were typed by Mrs. J.C.J. Ledegang and this final report by Mrs. P.L. Hoek van Dijke. Critical comments on my use of the English language were made by Mrs. S.E. Cooper.
Printing this book was financed by a grant from "Stichting Nederlandsche Middenstandsbank Fonds".

This book is concerned with the analysis of productivity differences among retail establishments. I hope that the application of some of the results of my study will lead to a better understanding of the problems which the entrepreneurs in retailing, and particularly in small or medium-sized retailing, are facing. I also hope that my results will contribute to the development of a model which can explain the total operational and financial structure, i.e. the total cost and profit structure of retail establishments. Such a model, which may be used for the diagnostics of retail business, has not yet been completed.

The studies reported in this book show that quantitative methods can be usefully applied in the fields of small and medium-sized business and retailing. I therefore hope that the interest of model builders and econometricians for these fields will be raised by this book, which makes ample use of their methods. In my opinion, such a development could not fail to produce a contribution towards the solution of the problems of retail entrepreneurs in the long run.

Roy Thurik,

December 1983.

CONTENTS

CHAPTER ONE.

INTRODUCTION.

1.1. Preamble.

In this introductory chapter we would like to explain the history of the research programme of which this study is a part (section 1.2). The purpose and the starting points of this study are dealt with briefly in sections 1.3 and 1.4. Section 1.5 is concerned with the organization of this book and the data material used. Ten interesting general conclusions are given in section 1.6. Section 1.7 contains an explanation of the position of this book in the research programme and, finally, possible related future research is discussed in Section 1.8.

1.2. History.

In 1973 a research programme was initiated as a cooperative project of the Research Institute of Medium and Small-Sized Business (E.I.M.) in The Hague and the Econometric Institute of the Erasmus University Rotterdam (E.U.R.). The reason for this research programme was the dissatisfaction felt by the Committee for Short and Medium-Term Development [1] with the short-term predictions made by E.I.M. These predictions are concerned with a description of the position of medium and small-sized business in the Dutch national economy. This description should represent the interests of medium and small-sized business, national authorities, national employers' organizations and branch organizations and it should analyse the consequences of continuous changes in the national economy and policy measures. Moreover, the results should help individual employers to conduct their business with respect to information about general economic developments.

The dissatisfaction was caused by the fact that the short-term predictions

- were insufficiently based on theoretical or empirical analysis;
- were subjective, i.e. their procedure was known only to insiders and could not be verified;
- were insufficiently differentiated and the influence of policy measures was difficult to establish.

The aim of this research programme was to solve these three problems. A Sub-committee Model Building was established to guide this research programme [2]. The actual research was supervised by Prof.Dr. J. Koerts of the Econometric Institute of E.U.R. In 1979 the Department of Basic Research was founded at E.I.M. and the Sub-committee became the Guiding Committee Basic Research [3]. In the initial phase of the research programme three basic decisions were made concerning the first line of attack:

i) researchers should follow the econometric approach: the use of models, data and statistical techniques;
ii) research should focus on retailing. This sector is important from the point of view of medium and small-sized business and interesting from the point of view of economic policy. A considerable amount of data material is available in this sector as opposed to sectors of the hospitality business, wholesale trade, industry etc.;
iii) research should start at a low aggregation level (at the level of a shop type or rather at the level of the individual shop). Notion of the behaviour of individuals is essential to acquire knowledge at an aggregate level.

The operational line of attack can be summarized as follows:

i) explanation of the total value of the consumption expenditure in the Netherlands in 45 product groups;
ii) explanation of the partitioning of these spendings among shop types, so that total sales per shop type can be computed;
iii) explanation of the number of shops per shop type, so that average sales per shop can be computed;
iv) explanation of average costs and average gross margin per shop in the shop types, so that average net profit can be computed;
v) aggregation of the results per average shop in a certain shop type to results valid for the total retail sector.

The above research programme is extensive and complex and, obviously, cannot be completed in a short period. The first major report of results of the research programme is Nooteboom's dissertation [4]. See Koerts [1981] for an evaluation of further results made in the period 1973 to 1980. The present study attempts to be a second major report.

1.3. Purpose of the study.

This study deals with the explanation of floorspace productivity differences per shop in a certain shop type and with the explanation of labour productivity differences per shop in a certain shop type. A shop (= establishment) is an (enclosed) space where goods are sold to the public. A shop type is defined as a group of establishments which has a certain homogeneity regarding assortment composition, service level, extent of own production and type of organization. Floorspace productivity is associated with the relationship between value of annual sales (in Dutch guilders or French francs) on the one hand and the amount of total available floorspace (in square metres) per establishment on the other. Labour productivity is associated with the relationship between value of annual sales on the one hand and volume of labour (in full-time equivalents or labour hours) per establishment on the other. Differences in floorspace productivity and labour productivity are caused by differences in properties of the establishment and its environment. "Explanation" is used here in the quantitative empirical sense.

The study is carried out because

i) it is interesting to study whether relationships exist between the value of annual sales and floorspace and between the value of annual sales and volume of labour, and what these relationships look like. Results could support municipal or regional retail planning, employment studies etc.;

ii) it is interesting to study to what extent differences of floorspace productivity and labour productivity per establishment are caused by differences in size, type of product, type of location, type of labour etc. Results of these analyses enable a diagnosis of the performance of individual establishments to be made;

iii) the analyses mentioned under ii) contribute to a model which explains net profit of an establishment. Net profit equals gross profit (= value of annual sales minus invoice costs) minus total annual costs. Total annual costs consist of occupancy costs (related to floorspace), labour costs and remaining costs. Our analyses contribute to the explanation of the role of occupancy costs and labour costs. Remaining costs are only a minor part of total costs. We have not yet been able to study gross profit per establishment consistently;

iv) it contributes to the development of theories on a higher aggregation level: explanation of average costs per shop for different shop types. See point iv) of the initial operational line of attack in section 1.2.

1.4. Starting points of the study.

This study has the following starting points:

i) the econometric approach will be followed, i.e. firstly, a model (relationship(s) among variables) is formulated based on economic theory (consistent set of ideas). Secondly, relevant data are collected. Thirdly, model and data are confronted using statistical techniques to estimate and test systematically the relationship(s) among the variables;

ii) it will be attempted to formulate and to estimate relationships at a low aggregation level, i.e. relationships are considered among variables for a certain shop type; the level of observation is the individual shop;

iii) it will be attempted to estimate the relationships using sets of samples of observations of individual shops, where the samples of a certain set have distinct properties whenever possible. To obtain general results samples consisting of small establishments are studied, but also samples of large establishments, of food and non-food establishments, of Dutch and French establishments, of chain and independent establishments, of establishments measured in the early and in the late seventies;

iv) the essential variables of this study are value of annual sales per establishment, total available floorspace per establishment and volume of labour per establishment. Total available floorspace per establishment is exogenous. Shopkeepers try to maximize the value of annual sales by choosing a market or operational strategy. These assumptions provide a basis for the relationship between total available floorspace per establishment and the value of annual sales studied in chapters two, three and four. The volume of labour per establishment is determined by the value of annual sales and the market or operational strategy. The relationship between volume of labour per establishment and value of annual sales is studied in chapters five through eight. The relationship used is based on Nooteboom's analyses [5]. Our study can be viewed as a further development of these analyses. The value of annual sales per establishment, market or operational strategy and volume of labour are endogenous variables in this framework. All other variables are exogenous: total available floorspace and the establishment properties (occupancy costs per square metre, wage rate per man hour etc.). The causal structure is depicted in Figure 1.1. This framework permits a separate study of the relationship between value of annual sales per establishment and total available floorspace on the one hand and the relationship between volume of labour per establishment and value of annual sales on the other. [6].

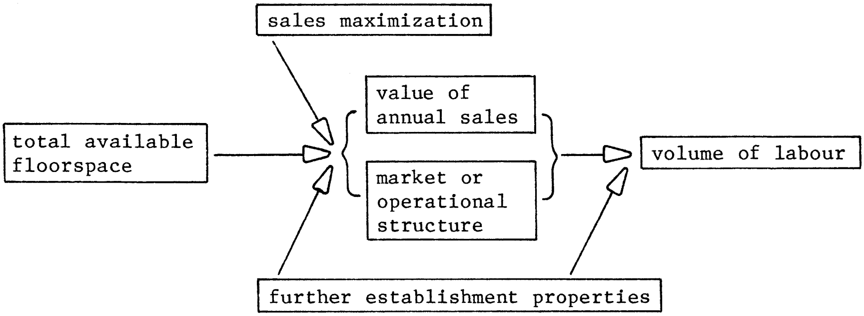

Figure 1.1. Basic causal structure.

1.5. Organization of this book.

This book comprises three parts: a study of the relationship between value of annual sales per establishment and volume of total available floorspace in chapters two, three and four, and a study of the relationship between the volume of labour per establishment and value of annual sales in chapters five through eight. Finally, chapter nine studies whether retail entrepreneurs try to maximize the value of annual sales per establishment or that of annual net profit.

Chapter two investigates the relation between total available floorspace, the value of total annual sales and the partitioning of total available floorspace into selling area and remaining space. This partitioning is associated with the marketing or operational strategy. The model presented consists of three equations with selling area, remaining space, and the value of total annual sales as endogenous variables. Ten cross-section samples of Dutch and French supermarket(-like) establishments are investigated. The three equations model

ments: occupancy costs, depth of assortment composition, share of fresh food sales, share of meat and meat product sales, presence of a butcher's shop, share of non-food sales, weekly opening time, presence of a petrol station, cafeteria and other activities, gross margin and year of observation.
The aim of chapter three is to apply the model of chapter two to other shop types than supermarket(-like) shop types, to examine the influence of some environmental variables (size of the shopping centre, size of the township) and to extend the model by considering the partitioning of total available floorspace into selling area, own production space and remaining space. The shop types considered consist of small Dutch establishments.
Chapter four attempts to improve the explanation of the relationship between value of annual sales per establishment and total available floorspace using environmental variables. In chapters two and three environmental variables are generally omitted as opposed to those variables describing specific properties of the shop itself. This is done claiming that characteristics of the shop itself play a dominant role, that the environment does influence the characteristics of the shop and that environmental variables are hardly available consistently. The first claim is investigated in this chapter.
Chapter five can be viewed as an introduction to chapters six, seven and eight. The basic elements of the relationship between volume of labour and value of annual sales developed by Nooteboom are presented. Our basic empirical relationship, which will be used in our studies on labour productivity in the succeeding chapters, is also presented. This relationship accounts for the fact that the assortment composition may vary among establishments of a certain shop type. The appendix to chapter five reports on tests as to whether the linear non-homogeneous relationship between volume of labour and value of annual sales found for small shops also applies to large French establishments. This appendix devotes considerable attention to method.
The aim of chapter six is to investigate whether the relationship between volume of labour and value of annual sales also applies to French supermarket(-like) shop types. In addition, differences in labour productivity are explained as a consequence of specific properties of the establishments: mode of service, wage rate, mode of supply to the shop, weekly opening time, gross margin, presence of a petrol station and year of observation.
Chapter seven studies the influence of the share of part-time labour in total labour on labour productivity in retailing. Various aspects of the role of part-time labour are discussed: shopkeepers' motives for using part-time la-

bour are discussed as are the motives of employees to work on a part-time basis. Moreover, the effects of the use of part-time labour on labour productivity are estimated empirically using eight samples of small Dutch establishments and one of large French establishments.
Chapter eight deals with the question whether average transaction per customer affects labour productivity in supermarkets. The role of transaction per customer is discussed. Additionally, the influence of average transaction is estimated using seven samples of Dutch establishments and one of French.
Chapter nine is concerned with entrepreneurial behaviour. It studies whether retail entrepreneurs try to maximize the value of annual sales per establishment or that of annual net profit. The former hypothesis is maintained in chapters two and three. A model is presented, which consists of relationships already discussed in preceding chapters. Data from large French supermarket(-like) establishments are used for testing.

The chapters of this book are in essence independent units. Most chapters contain an appendix in which a description of the data and their sources is given. The appendices sometimes contain reports on further analyses, which are not essential for comprehension of the text of the chapter.

Finally, we would like to make some comments on the data material used in this study and its consequences for the organization of this book. Per subject we collected many samples which themselves are as large as possible. This means that throughout the book we have to deal with a varying number of samples, whereas the number of observations per sample also varies depending on the availability of the relevant variables. This involves sample properties being described in nearly all the appendices. Obviously, it would have been ideal to have one series of samples with all variables always available. In that case, the distribution of our analyses among chapters would not have been necessary, whereas now, for instance, the influence of weekly opening time, mode of supply to the shop and presence of a petrol station on labour productivity on the one hand and that of the share of part-time labour on the other are investigated in separate chapters using different samples.
The data material used originates from the Research Institute for Small and Medium-Sized Business (E.I.M.) in The Hague, the "Institut Français du Libre Service" in Paris, the Netherlands Central Bureau of Statistics and a large Dutch grocery chain. Only some sample properties are given in this book. This

is done not only to limit the size of the book, but also to maintain the secrecy of the data. All data are available on a confidential basis - except that of the Dutch grocery chain - at E.I.M., P.O. Box 96818, The Hague.

1.6. Some general conclusions.

The chapters of this book may essentially be read independently. All chapters contain a section with conclusions [7]. Nevertheless, we shall give a brief review of ten general conclusions, which in our opinion should prove interesting:

i) the model used in chapters two and three appears to have a very wide applicability: an extremely wide range of shop types is considered and the explanation of the relationships is always high in view of the fact that cross-section samples are dealt with. The model attempts to explain the value of total annual sales and the partitioning of total available floorspace into selling area (own production area) and remaining space per establishment;

ii) differences in the values of the coefficients of this model within a shop type can very well be explained by taking into account the characteristics of the shops. For instance, strong support is found for the hypothesis that efficiency of total available floorspace (which can be associated with the value of annual sales per square metre floorspace) increases if occupancy costs per unit of floorspace increase: the elasticity of efficiency of total available floorspace with respect to relative occupancy costs per square metre is significantly positive in all cases investigated (24 cases). Its value however, ranges from .28 for Dutch chain supermarkets to .81 for Dutch confectioner's shops [8];

iii) evidence is provided that a threshold space in the selling area exists, space which must be present in every establishment of a shop type; its size is equal for all establishments and it provides space for activities indispensable for retailing products. As a consequence, the elasticity of the value of total annual sales with respect to total floorspace decreases with increasing total available floorspace. The extent of this decrease drops as total available floorspace increases and the asymptotic value of the elasticity is consistently less than one;

iv) efficiency of total available floorspace does not appear to be influenced by characteristics of the environment of the establishment. This conclusion is the result of numerous exercises using many variables and various research methods. Our initial intuitive claim that characteristics of the establishment itself play a dominant role in establishing the value of total annual sales, is certainly not disproven. We surmise that the environment influences these characteristics, while they, in turn, affect the value of total annual sales. Other causes will be discussed in the relevant chapter;

v) the hypothesis of a linear relationship between volume of labour and value of annual sales cannot be rejected for 35 samples of five shop types of very large French retail establishments. Additionally, the estimated values of the intercept of this relationship can be explained in terms of threshold labour. Linearity in combination with threshold interpretation of the intercept are basic elements of the relationship used;

vi) the relationship between volume of labour and value of annual sales discussed in chapter five serves its purpose very well for large French supermarket(-like) establishments. It appears to be useful when explaining differences in labour productivity by taking into account several characteristics of the establishments: practically all estimated coefficients show signs which support the hypotheses to be tested, standard errors are small in the light of the complicated specificaton and the explanation of the relationship is extremely high for a cross-section sample. Threshold labour (which plays a dominant role in the theoretical justification of the relationship) varies according to what is expected;

vii) the hypothesis is supported that labour productivity increases if the share of part-time labour in total labour increases for Dutch counter service shop types and French "magasins populaires". There is no support for this hypothesis in the case of small Dutch self-service shop types;

viii) economies regarding the use of labour can be obtained by increasing the value of annual sales per establishment, but no support is found for the hypothesis that additional economies are obtained, if this increase is caused by increasing average transaction per customer;

ix) strong support is found for the hypothesis that labour productivity increases if the wage rate per man hour (or man year) increases: the elasticity of scale adjusted labour intensity with respect to the relative wage rate is significantly negative in all cases investigated (23 cases). Its value however, ranges from -.2 for independent Dutch clothes shops to approximately -.95 for French "magasins populaires" [9];

x) the hypothesis that retail entrepreneurs try to maximize the value of annual sales per establishment cannot be rejected against the alternative hypothesis that they try to maximize that of annual net profit.

1.7. Position of this study.

In this section some further introductory remarks will be made, not covered by the preceding sections of this chapter but relevant if this book is to be understood well.

Neither consumption nor production can proceed smoothly without a proper distributive system. The academic world does not seem to honour the importance of the role played by the distributive system. Theoretical or empirical studies hardly exist in the field of cost and profit structures of retail and wholesale enterprises or establishments. This book is concerned with a supply-orientated analysis of retail behaviour, and particularly with the relationships which exist between labour, floorspace and sales per shop. We would like to use this section to comment on what we feel is new in this book and on the connection between the studies reported here and the first major report of the research programme given in Nooteboom's dissertation. The main contributions which this study attempts to make are

i) the use of models consisting of more than one relationship and the use of statistical techniques (estimation by non-linear least squares and full information maximum likelihood), which are familiar to advanced economic model builders and econometricians, but practically unknown in our field of study [10];

ii) methodological rigour in the sense that a continuous attempt is made to formulate hypotheses which can indeed be tested within the context of the proposed model and the available data. A distinction is made between maintained hypotheses and hypotheses to be tested. A list containing the 39 hypotheses which are tested is given at the end of this book;

iii) the use of large numbers of observations. Per subject (chapter) we collected as many samples of observations as we could and tried to keep these samples as large as possible;

iv) specific confined topics. Most important are in our view:
   - the explanation of the partitioning of total available floorspace into selling area and remaining space. This partitioning is an indicator for

the level of own production and the share of self-service sales;
- extensive empirical tests on the influence of environment on efficiency of total available floorspace;
- the study of differences in labour productivity for large French supermarket(-like) establishments with particular attention paid to the influence of assortment composition, weekly opening time and presence of a petrol station;
- the discussion of the role of part-time labour in retailing;
- the comprehensive empirical tests on the influence of part-time labour and average transaction per customer on labour productivity;
- the attempt to test empirically whether retail entrepreneurs try to maximize sales or profits.

In the sphere of productivity analysis Nooteboom's dissertation is concerned with the theoretical and empirical explanation of
- labour and floorspace productivity differences per shop;
- differences in regional average labour productivity;
- growth of average labour and floorspace productivity per shop type.

However, other topics are also dealt with [11]. The emphasis of this study lies on small retail establishments.

A comparison between Nooteboom's studies and the studies reported in this book reveals the following elements:
- we do not use his theoretical concept of the analysis of floorspace productivity [12]. However, the idea of threshold space will be used in our analysis. Additionally, some factors influencing floorspace productivity within the framework of Nooteboom's analysis are also investigated in our analysis, in particular the role of occupancy costs [13] and that of the share of selling space in total available floorspace [14];
- we do use his theoretical concept of the analysis of labour productivity [15]. Moreover, we analysed some factors influencing labour productivity such as wage rate [16], share of part-time labour and transaction per customer, which play an important role in Nooteboom's concept, extensively in our study. In our study, however, more attention is paid to a correct estimation method in view of the theoretical specification and to a systematic comparison between largely varying shop types. In addition, various aspects of the role of part-time labour are discussed [17];

- our studies are concerned exclusively with the explanation of differences on the level of the individual shop, whereas Nooteboom's studies are also concerned with the explanation of differences between averages (per region and per shop type);
- on the individual shop level we do not confine ourselves to the study of (primarily small) Dutch establishments, but also study large French establishments.

The econometric approach is practically absent in all other literature on cost structures in retailing [18]. Results of these studies are used primarily when formulating hypotheses on the influences of establishments properties on the basic relationships describing floorspace and labour productivity.

1.8. Relating future research.

We would like to conclude this introductory chapter with some propositions about relating future research, emphasizing that the study reported in this book covers only a limited area of the fundamental research, which can and should be done for the benefit of small and medium-sized business [19].
Firstly, it would be very interesting to have at our disposal one large sample of 500 to 1000 observations of individual establishments with measurements of all relevant operational and environmental variables. Should this sample be available, then all influences could be estimated and tested simultaneously. Secondly, a model should be designed to explain differences in gross margin per shop. This is the missing link in the explanation of net profit per shop. Thirdly, the explanation of differences of average costs per shop among shop types could be studied using the results of studies within shop types [21]. Results could help national authorities, national employers' organizations and branch organizations in their policy making. Fourthly, the relation between financial and operational variables could be investigated to improve the diagnosis of the performance of individual establishments and to help make better investment decisions. Fifthly, research could be carried out along similar lines of attack in other sectors of the national economy, where small and medium-sized business plays an important role: hospitality business, wholesale trade, industry etc. Sixthly, specific questions raised by the present study could be researched in more detail: e.g. is there over- or undercapacity of retail floorspace? See section 4.4. Seventhly, a model should be de-

veloped which explains market shares of the consumption expenditure of product groups among the respective shop types in the Netherlands. The above list is far from complete. Several of the above research projects are in preparation or being carried out by the Department of Basic Research of E.I.M. or at the Econometric Institute of E.U.R. [21].

Footnotes to chapter one.

[1] Chairman is Prof.Dr. G.W. Groeneveld.

[2] Chairman was Dr. J.B.D. Derksen of the Netherlands Central Bureau of Statistics.

[3] Chairman is Prof. H. den Hartog of the Netherlands Central Planning Bureau.

[4] Nooteboom [1980].

[5] See Nooteboom [1982] for a concise theoretical explanation.

[6] A separate study of (differences in) labour productivity and (differences in) floorspace productivity has also been carried out by Nooteboom [1980] claiming that
- substitution of capital (floorspace) for labour alters the service level, so that the (shop) type of a certain shop changes;
- substitution opportunity is frustrated by the short-term rigidity of floorspace.

Substitution could be a useful concept studying differences between shop types, rather than within a shop type. It is questionable, however, whether the ratio of capital to labour is regulated by their relative prices only. See Thurik [1984a] for an attempt to test formally the justification of studying the use of labour and floorspace separately.

[7] Chapter five does not contain a section with conclusions: conclusions of the analyses of the appendix to this chapter are given in section A.5.4.

[8] See Tables 2.2, 2.3, 3.1, 3.2 and 3.3.

[9] See Tables 6.2, 7.2, 8.1 and 8.2.

[10] All statistical techniques are programmed in the computer language A.P.L. and run on the AMDAHL V7B and I.B.M. 370/58 computers of the "Centraal Reken Instituut" of the University of Leiden.

[11] For instance, the explanation of sales size on the level of the individual shop and on that of regional averages is dealt with as is an explanation of average gross margin differences per shop type.

[12] This decision will be elucidated in footnote 10 of chapter two.

[13] See footnote 43 of chapter two.

[14] See footnote 9 of chapter two.

[15] See section 5.2 for a brief discussion.

[16] See footnote 17 of chapter six.

[17] See section 7.2.

[18] See Tucker [1975] and Ingene [1983] for instance, for surveys of scale and cost studies in retailing and Nyström [1970] for a review of retail pricing literature.

[19] See also the Committee Development Plan Basic Research Report under the chairmanship of Prof.Dr. J. Koerts (Koerts et al. [1982]).

[20] See Nooteboom [1980], chapter seven with a special application to the growth of productivity and Thurik and Vollebregt [1984], Thurik [1984a] and [1984b] and Thurik and Van Schaik [1984].

[21] The explanation of gross margin per shop is studied by Bode (E.U.R.) jointly with Koerts (E.U.R.) and Thurik (E.I.M.). Financial models are studied by Van der Wijst (E.I.M.) jointly with Spronk (E.U.R.). Van der Hoeven (E.I.M.) is doing fundamental research in the hospitality business and Van Iperenburg (E.I.M.) in the industrial sector. Kooiman (E.U.R.) and Thurik (E.I.M.) plan to extend the analysis of retail floorspace.

CHAPTER TWO.

THE USE OF SUPERMARKET FLOORSPACE AND ITS EFFICIENCY.

2.1. Introduction.

The aim of this chapter is to investigate the relation between total available floorspace, the value of total annual sales and the partitioning of total available floorspace for supermarkets into selling area and remaining space. The model presented in this chapter consists of three equations with selling area, remaining space, and value of total annual sales as endogenous and total available floorspace as exogenous variable [1].

This study is conducted because it is of interest for

i) retail planning (shopping centres, retailers' location decision);

ii) shop design (as a consequence of size of the establishment and products to be sold);

iii) forecasting retailers' income (if the model presented in this study is embedded in a larger model which also explains volume of labour, assortment composition, price setting behaviour, price of labour, occupancy costs per unit of space and costs other than those for labour or occupancy).

The basic three equations-model is refined by studying the influence of specific properties of the establishments on the values of the coefficients of the basic model. Specific properties investigated are occupancy costs, depth of assortment composition, share of fresh food sales, share of meat and meat products sales, presence of a butcher's shop, share of non-food sales, weekly opening time, presence of a petrol station, cafeteria and other activities, gross margin and year of observation.

Ten cross-section samples of supermarket(-like) establishments (811 in all) are investigated: some of their properties are described in the appendix to this chapter.

In section 2.2 the five maintained hypotheses, which lead to the basic three equations-model, are discussed. Some implications of this model are dealt with in section 2.3. The influence of the specific properties of the establishments is discussed extensively in section 2.4. The method of estimation is dealt with in section 2.5. The results of the tests are reported in section 2.6 (Dutch samples) and section 2.7 (French samples). The final section gives conclusions and a summary.

The model developed in this chapter will be extended in chapter three, so that it can be applied to other shop types; it will be used to analyse the influence of environment on floorspace efficiency in chapter four and it will be embedded in a larger retail model in chapter nine.

2.2. Assumptions.

The following five assumptions are maintained throughout this chapter.
Firstly, the value of annual sales of a retail establishment depends on two groups of variables [2]:

- characteristics of the establishment itself [3] (size, design, assortment composition, service level, price level, advertising etc.);
- characteristics of the environment of the establishment (competitors, customers' habits, description of the site etc.).

In this chapter only the influence of the characteristics of the establishment itself will be studied. This is done because:

- it is felt that, notwithstanding the importance of the environment of the establishment, the characteristics of the establishment itself play a predominant role;
- the environment of the establishment may influence or be influenced by the characteristics of the establishment itself, so that the simplification of omitting environmental variables seems permitted. For instance, a favourable location results in high rent costs or the presence of a petrol station results in a high average transaction per customer [4];
- environmental variables are problematic in the sense that they appear to be seldom collected and if collected, unsystematically. For example, environmental variables are available for only five out of the ten samples which are studied in this chapter and moreover, these variables are usually not available for all observations per sample. Furthermore, they are often strongly intercorrelated [5].

Therefore, the study in this chapter can be interpreted as an attempt to build a model explaining sales and floorspace partitioning, while environmental variables are neglected unless their influence is represented by establishment characteristics. The influence of environmental variables will be studied in a subsequent chapter using the results of this study. This is done to avoid estimating and reporting problems caused by the unsystematical occurrence of environmental data. The influence of the shopping centre in particular will be dealt with.

Secondly, total available floorspace of a retail establishment can be partitioned into selling area and remaining space. Selling area is the space to which customers have access: space used for receiving and serving customers, displaying goods and restocking displays. This space includes room for cash desks, service counters etc. Remaining space consists of space used for storage, handling goods (packing, pricing etc.), own production [6], administration, staff rooms etc. Customers have no access to these parts of a retail establishment [7].
Shopkeepers have a certain flexibility in choosing the partitioning of total available floorspace. This partitioning is assumed to be flexible before as well as after the instalment of the shop.

(2.2.1) $$W_i \triangleq C_i + R_i,$$

where W_i: total available floorspace of establishment i;
C_i: selling area;
R_i: remaining space.

Thirdly, total available floorspace is exogenous. The shopkeeper's present "plant size" is the result of a long term decision made in the past. In this study we will not try to describe the economic behaviour and technical restrictions involved in this decision. This assumption is made because

- expansion of an existing shop is often impracticable and always expensive in terms of money;
- it is felt that, as soon as a shopkeeper is inclined to alter his total floorspace considerably, he is also willing to reorientate his market strategy, i.e. to change the shop type of his establishment or to change the shop location.

Fourthly, the value of annual sales per establishment belonging to a certain shop type depends on the size of its selling area and of its remaining space [8]:

$$(2.2.2) \qquad Q_i = \beta(C_i - \gamma_1)^{\pi\varepsilon} (R_i - \gamma_2)^{(1-\pi)\varepsilon} \text{ with } \beta > 0,\ 0 \leq \gamma_1 < C_i,\ 0 \leq \gamma_2 < R_i,\ 0 < \pi < 1 \text{ and } \varepsilon > 0,$$

where Q_i: value of annual sales in establishment i.

A shop type in the food trade is defined as a group of establishments which has a certain homogeneity regarding assortment composition, extent of own production and type of organization (chain, cooperative, independent). Equation (2.2.2) must be considered as a basic relationship between the value of annual sales and floorspace. The influence of the remaining heterogeneities (with respect to the characteristics of the establishments themselves) within a shop type will be dealt with in section 2.4. However, these heterogeneities are disregarded for the time being to illustrate the role of the coefficients of (2.2.2). Specification (2.2.2) reminds us of a Cobb-Douglas production function with two inputs: $C - \gamma_1$ and $R - \gamma_2$; a unique output Q corresponds to each combination of these inputs.
Specification (2.2.2) is chosen because it is assumed that in retailing both selling area and remaining space contribute to establish the value of annual sales and that these inputs can be substituted for one another. This substitution represents different marketing or operational strategies within a shop type. The definition of a shop type given above is flexible enough to permit such strategies. A low ratio R/W is associated with

- a high share of self-service sales and a low share of counter service sales;
- a low share of own production: if this production is performed in the remaining space as is usual in retailing [9];
- a strategy in which only few goods are kept in stock and many are displayed;
- a strategy in which most handling of goods and most activities of employees are performed in the selling area.

Of course a high ratio R/W is associated with the opposite strategies.
A multiplicative specification is chosen because it is felt that the effect of a change of one input factor on the value of annual sales depends on the level of the other. The Cobb-Douglas-type specification is chosen, because

- the above mentioned mechanisms justify such a specification;

- it has an easy interpretation;
- the use of γ_1 and γ_2 renders the Cobb-Douglas specification more flexible and they may be given a physical interpretation as will be explained below.

The coefficients have the following interpretation:
- $\beta > 0$ is a coefficient which can be used to denote efficiency;
- obviously, specification (2.2.2) is not homogeneous, if C and R are regarded as input factors. However, if $C - \gamma_1$ and $R - \gamma_2$ are regarded as input factors, $\varepsilon > 0$ gives the degree of homogeneity. A value of $\varepsilon = 1$ indicates constant returns to scale, and increasing or decreasing returns are indicated by values greater or less than unity;
- $0 < \pi < 1$ indicates the degree to which an establishment of a certain shop type is selling area intensive. It will be illustrated that π can be interpreted as the distribution coefficient of the partitioning of total floorspace;
- coefficients γ_1 and γ_2 are associated with certain threshold spaces: space which must be present in every establishment of a shop type, space whose size is equal for all establishments and where activities are performed indispensable to retail products. Nooteboom [1980] uses threshold labour in his analysis of labour productivity. He provides a theoretical justification of the value of threshold labour using queuing theory. He analyses floorspace productivity along the same line of thought [10]. We do not provide a theoretical justification for a selling area threshold and a remaining space threshold in our model of the use of floorspace. However, the idea of a threshold is attractive.

  We shall leave hypotheses on a precise physical interpretation of thresholds until we are able to examine the estimated values of γ_1 and γ_2. Meanwhile, γ_1 and γ_2 will be called threshold coefficients.

The roles of coefficients γ_1 and γ_2 can also be described as follows:

(2.2.3) $$\frac{\partial \log Q}{\partial \log C} = \pi\varepsilon C/(C - \gamma_1)$$

and

(2.2.4) $$\frac{\partial \log Q}{\partial \log R} = (1 - \pi)\ \varepsilon\ R/(R - \gamma_2).$$

The elasticity of the value of annual sales with respect to selling area decreases if $\gamma_1 > 0$. If $\gamma_1 > 0$, $\pi\varepsilon$ can be viewed as the asymptotic elasticity of the value of annual sales with respect to selling area. Scale effects can be studied using γ_1 and γ_2.

The ease of substitution is usually measured using the elasticity of substitution σ. It is defined as the proportionate change in the ratio of the amounts of the factors as a result of a proportionate change in the marginal rate of substitution (= ratio of the marginal physical productivity of the factors $= \frac{\partial Q}{\partial C} / \frac{\partial Q}{\partial R}$). In our case, its expression can easily be derived from the expression for the elasticity of substitution based directly upon the production function [11]:

$$(2.2.5) \qquad \sigma = \pi \frac{R - \gamma_2}{R} + (1-\pi) \frac{C - \gamma_1}{C}.$$

It is easy to see from (2.2.5) that

- $\sigma = 1$ if $\gamma_1 = \gamma_2 = 0$. In this case specification (2.2.2) is the Cobb-Douglas production function;
- σ increases with increasing C if $\gamma_1 > 0$ and σ increases with increasing R if $\gamma_2 > 0$. Scale effects can be studied using γ_1 and γ_2;
- $\sigma < 1$ if $\gamma_1 > 0$ and $\gamma_2 > 0$.

Assumption (2.2.2) is a mere summary of constraints of a technical (operational) nature. Economic behaviour (the shopkeeper's decision) will decide what use will be made of total floorspace.

Fifthly, a shopkeeper tries to maximize the value of annual sales by manipulating the partitioning of total available floorspace, i.e. his marketing or operational strategy. The first order condition $dQ/dC = 0$ gives after substitution of (2.2.1) into (2.2.2)

$$(2.2.6) \qquad C_i = \gamma_1 + \pi(W_i - \gamma_1 - \gamma_2).$$

Also, equations (2.2.1) and (2.2.6) give

$$(2.2.7) \qquad R_i = \gamma_2 + (1-\pi)(W_i - \gamma_1 - \gamma_2).$$

It is easy to show that the stationary point defined by (2.2.6) and (2.2.7) refers to maximum [12].
Equations (2.2.6) and (2.2.7) can be viewed as the linear shop design expansion path.

An obvious competitive type of behaviour is that a shopkeeper tries to maximize annual net profit, i.e. total revenue from annual sales minus total annual acquisition costs (= wholesale or invoice costs) minus total annual costs.
In variables

(2.2.8) $$P_n \triangleq M.Q - K,$$

where P_n and M are called annual net profit and average percentage gross margin divided by 100, respectively and K total annual costs and

(2.2.9) $$M \triangleq (p^V q - p^I q)/p^V q,$$

where q: volume of total sales;
p^V: average selling price per item ($Q \triangleq p^V q$);
p^I: average purchasing price per item.

We choose to assume the maximization of the value of annual sales, because
- it is realistic. A shopkeeper will concentrate on sales or market share rather than on profit, if he considers his market power towards customers and suppliers or if he considers his prestige. Furthermore, there are circumstances in which the continuity of a shop depends on the increase of sales rather than on that of profit;
- it is simple. Sales is an entity easy to observe continually, whereas profit is a result given, so to speak, by the auditor once a year. Furthermore, the problem of maximization of the value of annual net profit is probably too complicated for shopkeepers who usually fail to have staff facilities. It involves not only the analysis of the explanation of sales (see above), but also that of percentage margin and costs (see below);
- maximization of the value of annual net profit will not necessarily alter our model considerably. This will be illustrated below.

Shopkeepers' behaviour of maximizing P_n boils down to (2.2.6), if one assumes that for establishments belonging to a certain shop type M and K are exogenous and independent of the ratio R/W (marketing or operational strategy) and Q. It is interesting however, to consider alternative hypotheses. For instance

- M depends on R/W in that if R/W is relatively high, large quantities can be bought from manufacturers or wholesalers, so that p^I drops;
- if R/W is relatively low occupancy costs may be high (owing to energy, insurance, maintenance costs etc.);
- a high degree of counter service and own production may require a high value of R/W and high labour costs.

These hypotheses will be considered in chapter nine, as will the hypothesis of profit maximization. For the time being, we suppose that average percentage gross margin, occupancy costs and labour costs can be explained using the ratio R/W only to a moderate degree. Other factors play a more important role. We therefore conclude that an assumption other than maximization of value of annual sales will not necessarily alter our model considerably.

2.3. Basic model.

The reduced form of our model is obtained after substitution of equations (2.2.6) and (2.2.7) into (2.2.2):

(2.3.1) $$Q_i = \beta\left(\frac{\pi}{1-\pi}\right)^{\pi\varepsilon} (W_i - \gamma_1 - \gamma_2)^{\varepsilon} (1-\pi)^{\varepsilon},$$

(2.2.6) $$C_i = \gamma_1 + \pi (W_i - \gamma_1 - \gamma_2)$$

and

(2.2.7) $$R_i = \gamma_2 + (1-\pi) (W_i - \gamma_1 - \gamma_2).$$

The endogenous variables are value of annual sales of establishment i, Q_i, the size of its selling area C_i and of its remaining space R_i; the exogenous variable is total available floorspace W_i. The vector of coefficients is called θ with $\theta' = (\beta\ \gamma_1\ \gamma_2\ \pi\ \varepsilon)$.

The coefficients have the following restrictions: $\beta > 0$, $0 \leq \gamma_1 < C_i$, $0 \leq \gamma_2 < R_i$, $0 < \pi < 1$ and $\varepsilon > 0$. The second order condition of a maximum is fulfilled (see section 2.2), if these restrictions are met.

We shall now further discuss the role of the coefficients in the model consisting of equations (2.3.1), (2.2.6) and (2.2.7) and the hypotheses we want to test. From equation (2.3.1) it is seen that

$$\frac{d\log Q}{d\log W} = \varepsilon\, W/(W - \gamma_1 - \gamma_2) \stackrel{\Delta}{=} E \tag{2.3.2}$$

or expressed in words: the elasticity of the value of annual sales with respect to total floorspace, E, is scale dependent if $\gamma_1 + \gamma_2 \neq 0$. Scale is associated here with total available floorspace. The meaning of γ_1 and γ_2 is explained in section 2.2 by their interpretation as threshold coefficients. The elasticity of the value of annual sales with respect to total available floorspace decreases with scale, if indeed $\gamma_1 + \gamma_2 > 0$. The coefficient ε can be regarded as the asymptotic elasticity of the value of annual sales with respect to total floorspace (or rather as the threshold adjusted elasticity). Coefficient ε has a more practical use, in that it determines, together with $\gamma_1 + \gamma_2$, the scale of an establishment above which diseconomies arise. Rearranging (2.3.2) we get

$$W = (\gamma_1 + \gamma_2)E/(E-\varepsilon). \tag{2.3.3}$$

We see that $d\log Q/d\log W \gtrless 1$ for all $W \lessgtr W^*$, where W^* denotes the scale of an establishment where $E = 1$.

We do not provide a theoretical value of ε against which we want to test our model. However, we shall assume that $\varepsilon \leq 1$ [13]. Diseconomies may arise, because with increasing scale of the establishment shopkeepers are likely to increase

i) depth of the assortment composition (= number of different items per product group) [14]. This will result in diseconomies with respect to storage and display space and customers are likely to need more space;
ii) height of the assortment composition (= quality level of products). This will result in diseconomies with respect to storage and display and customers are likely to need more space;

iii) width of the assortment composition (= number of different product groups) [15]. The width of the assortment composition within a shop type is not likely to differ largely. The assortment composition can be widened with non-foods (tobacco products, magazines, household products etc.). A certain minimum amount of space must be made available, to make shoppers aware that items of the product group are present in the shop. Furthermore, a shopkeeper does not usually choose his "best" space to display these articles;

iv) space per item. The more space is allocated to an item, the more likely it is to be seen by a shopper and, hence, the more likely to be purchased. We suppose, however, that there are diseconomies in this mechanism [16].

Two counterforces with respect to these diseconomies can be mentioned:

- with increasing depth and height of the assortment composition the average price level of goods increases. In our analysis Q is defined in terms of money (value of annual sales);
- the attractiveness of an establishment increases with increasing depth, height and width of the assortment composition, which may result in higher sales per unit of floorspace for the basic part of the assortment (goods which are present in every establishment of a shop type irrespective of its scale) than would have been the case without a deep, high or wide assortment composition.

It is not assumed that these counterforces are stronger than the arguments in favour of diseconomies [17].

Coefficient π indicates the degree to which an establishment of a certain shop type is selling area intensive. This is best seen in equations (2.2.6) and (2.2.7): π sets the partitioning of total floorspace. The line defined by equation (2.2.6) shifts anti-clockwise, if π increases. The distribution coefficient also plays a role in reduced form equation (2.3.1). It can be derived that $\frac{\partial Q}{\partial \pi} = \varepsilon Q \log\frac{\pi}{1-\pi}$, so that $\frac{\partial Q}{\partial \pi} \gtrless 0$ if $\pi \gtrless .5$.

Threshold coefficients γ_1 and γ_2 are discussed in section 2.2. Coefficient β is merely an efficiency coefficient.

The model consisting of equations (2.3.1), (2.2.6) and (2.2.7) is our maintained hypothesis.

The following hypotheses will be tested:

H1: the elasticity of the value of annual sales with respect to total available floorspace, E, decreases with size, i.e. $\gamma_1 + \gamma_2 > 0$;

H2: the asymptotic elasticity of the value of annual sales with respect to total floorspace, ε, is less than or equal to one.

If both $\gamma_1 + \gamma_2 > 0$ and $0 < \varepsilon < 1$ cannot be rejected, it implies that E is a decreasing function of W and that there is a total floorspace $W^* > 0$, below which $E > 1$ and above which $E < 1$.

Furthermore, it will be interesting to see whether both selling area and remaining space show a threshold (i.e. both $\gamma_1 > 0$ and $\gamma_2 > 0$) and to interpret differences in the values of all coefficients for the different samples. Moreover, we want to see whether our model is able to describe the data satisfactorily.

Finally, scatter diagrams are presented in Figure 2.1 (Dutch chain supermarkets of 1974: SUP74), Figure 2.2 (Dutch independent supermarkets of 1979: SUP79) and Figure 2.3 (French supermarkets of 1975 to 1979: SUP7579) to give some justification for the maintained hypotheses: there is a clear linearity of the relation between selling area and total available floorspace.

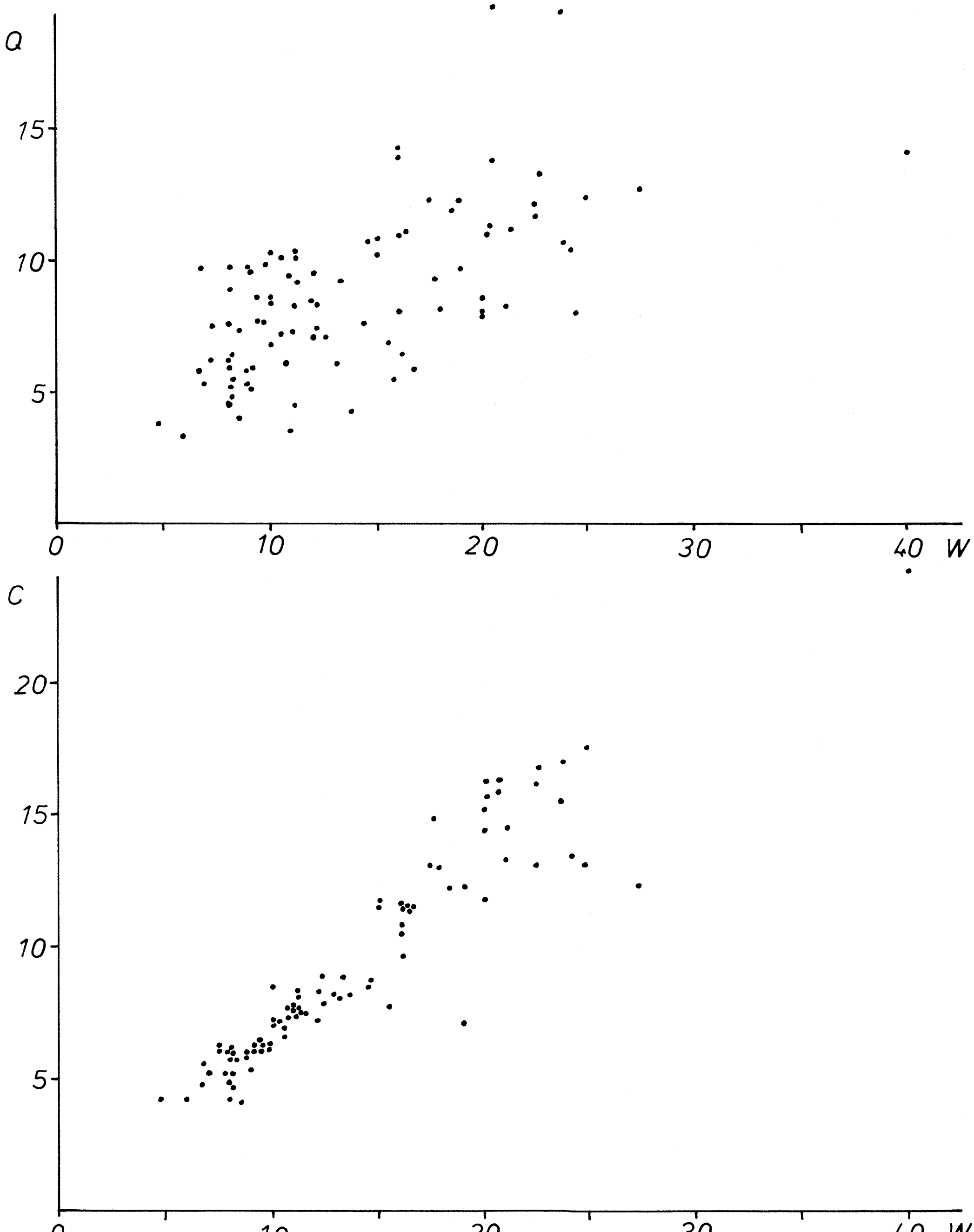

Figure 2.1. Scatter diagrams for SUP74 (Dutch chain supermarkets of 1974). W: total available floorspace (in 10^2 m^2); C: selling area (in 10^2 m^2); Q: value of annual sales (in 10^6 Dutch guilders).

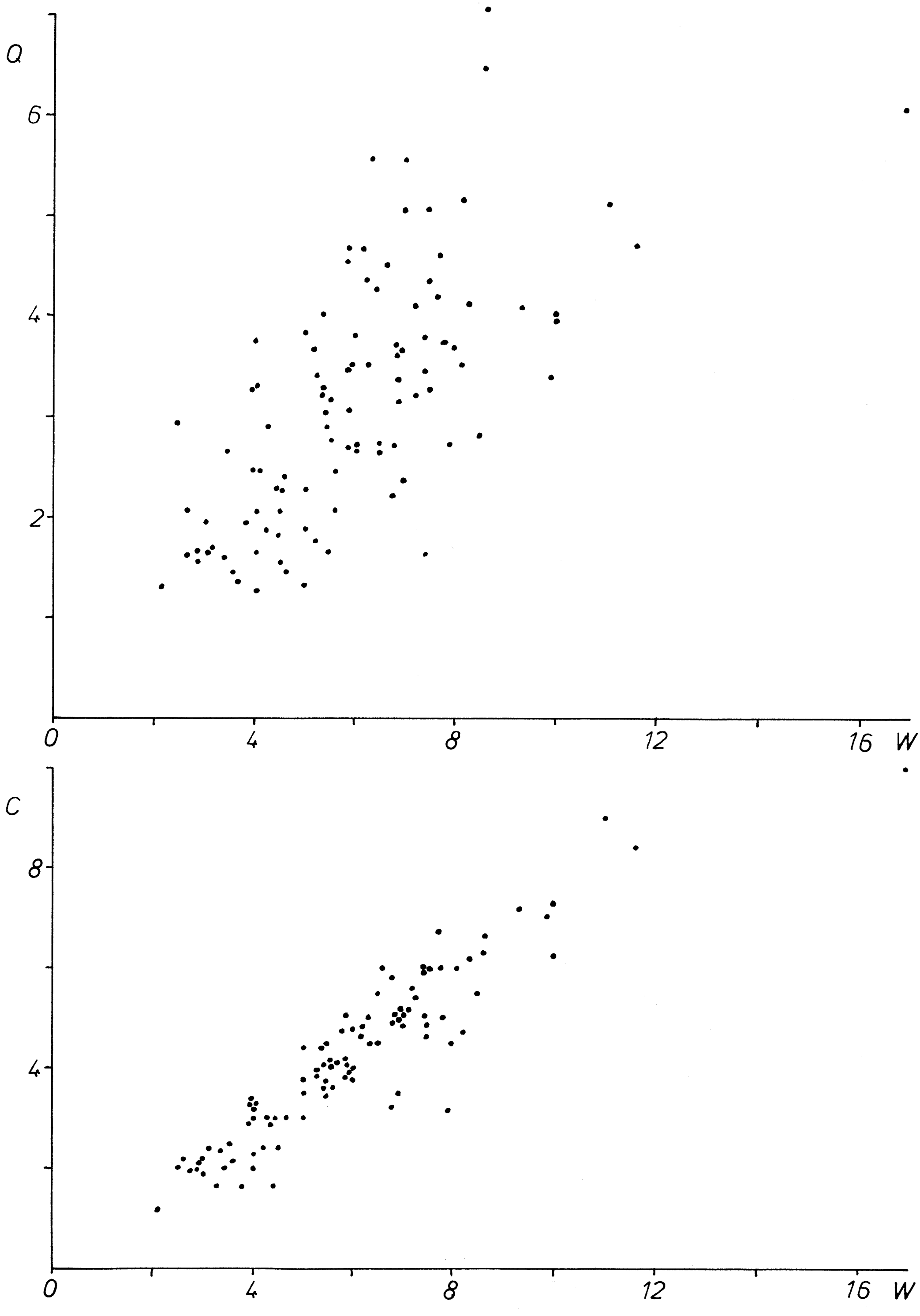

Figure 2.2. Scatter diagrams for SUP79 (Dutch independent supermarkets of 1979). W: total available floorspace (in 10^2 m^2); C: selling area (in 10^2 m^2); Q: value of annual sales (in 10^6 Dutch guilders).

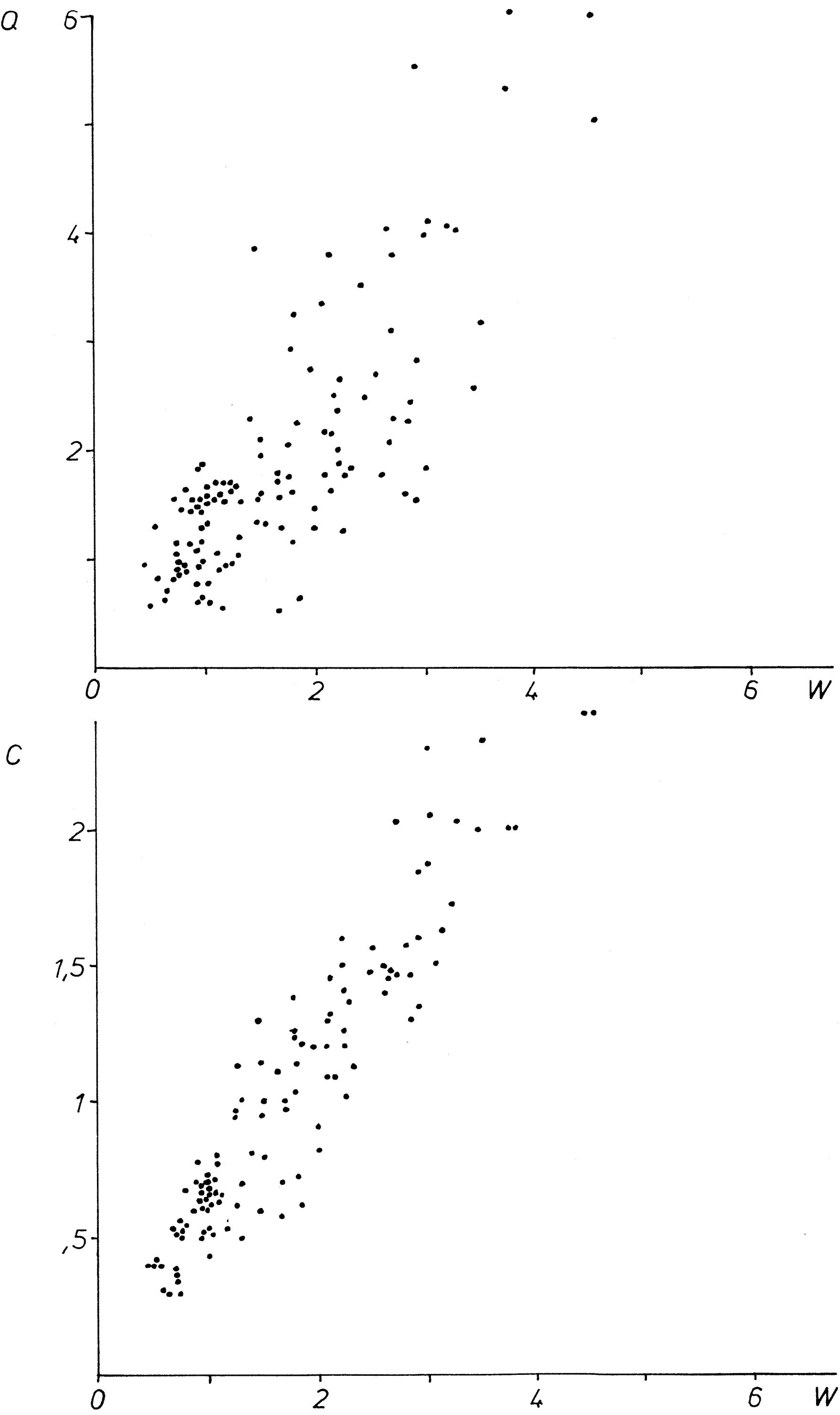

Figure 2.3. Scatter diagrams for SUP7579 (French supermarkets of 1975 through 1979). W: total available floorspace (in 10^3 m^2); C: selling area

2.4. Further hypotheses.

In this section differences of the characteristics of establishments within a shop type will be discussed as well as consequences of these differences regarding the value of the coefficients of equations (2.3.1), (2.2.6) and (2.2.7). The coefficients discussed up to now relate to "averages" per shop type. From now on we shall assume that the values of some of the coefficients depend on the specific properties of the establishments. Sometimes it is difficult to decide which coefficient is influenced by a specific property. Most specific properties are assumed to influence the efficiency coefficient, others are assumed to influence the distribution coefficient or the threshold coefficients [18]. The choice of which specific properties are used depends largely on availability of data. The influence of environmental variables will be studied separately.
In his study of the explanation of differences in productivity of retail floorspace Nooteboom [1980] uses some of the specific properties which are also mentioned below. As regards French samples some of the specific properties mentioned below are also used in our study of labour productivity in chapter six.
Special attention is given to the influence of the share of meat sales, other fresh food sales and non-food sales, because these three product groups were introduced most recently in grocery shops. These product groups are faced with problems concerning perishability, regulations, preparation, prepacking etc. [19].
Regarding the Dutch samples, a study is made of the influence of occupancy costs, depth of assortment composition, fresh food sales share, meat and meat products sales share, the presence of a butcher's shop, non-food sales share and year of observation. Regarding the French samples, the influence of occupancy costs, non-food sales share, weekly opening time, presence of a petrol station, cafetaria or other departments, gross margin and year of observation is studied. A priori hypotheses will be formulated on the sign of the influence as much as possible. This, however, will not always be possible.

Occupancy costs.

Occupancy costs are defined as consisting of two components: rent or estimated rent (in case the entrepreneur owns his premises) and remaining occupancy costs (energy, insurance, maintainance of inventory etc.) The second component is relatively small. Firstly, it is assumed that rent price per unit of total floorspace is an indicator of the environmental attraction of the establishment [20]. Secondly, it is assumed that the motivation to use available floorspace efficiently is induced by the height of occupancy costs per unit of floorspace. The use of rent price as an indicator for attraction makes the omission of environmental variables less serious. However, one can think of situations in which attraction and rent price are not necessarily correlated (e.g. cheap old city-centre building; almost entirely depreciated property). If estimated rent is calculated for the Dutch samples, attraction is taken into account.

H3: efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase.

Depth of assortment composition.

Depth of assortment composition is defined as the number of different goods per product group. Supermarket product groups include dairy products, vegetables, dry grocery products, meat and meat products, non-foods etc. Width of assortment depends on the number of product groups. Generally, the width of assortment is about equal for all establishments (of the shop types studied in this paper). It is difficult to make an assumption about the effect of a deeper assortment on efficiency of floorspace given a certain amount of floorspace.

There are various effects:

i) number of items sold per unit of time decreases;

ii) number of items displayed per unit of selling area decreases (more space must be made available for specialty goods than for mass goods) as does the number of items stored per unit of remaining space;

iii) customers will need more room to choose goods (from the shelves);

iv) average selling price per good increases (Q is defined in value terms!);

v) the attraction of the establishment increases. A shopper does not know in advance whether a particular shop carries all the items she requires. The advance whether a particular shop carries all the items she requires. The larger the range of goods carried by a shop, the greater the shopper's reason for expecting that the shop supplies all she needs.

We do not have an a priori hypothesis about the influence on efficiency of floorspace if depth of assortment increases given a certain amount of floorspace. It is interesting however, to study this influence [21].

A deeper assortment is assumed to affect the partitioning of total floorspace. It is assumed above that number of items displayed per unit of selling area decreases if assortment composition deepens. Undoubtedly, the efficiency of the use of storage space will decrease if the assortment deepens. Here, however, concessions can be made, whereas these are more difficult to achieve in the display to the customers.

We propose the following hypothesis:

H4: selling area intensity increases if depth of assortment composition increases.

Share of fresh food sales.

The share of fresh food sales is defined as the value of annual sales of fresh foods divided by the value of total annual sales. Fresh foods consist of fresh vegetables, fresh dairy products, fresh bread and other confectioner's products etc. Meat and meat products are excluded because they will be treated separately. There are two effects of a high share of fresh foods on efficiency of floorspace given a certain amount of floorspace:

- fresh foods are often sold using counter service, which is assumed to have a higher floorspace efficiency than self-service;
- the attraction of the establishment increases.

H5A: efficiency of total available floorspace increases if share of fresh food sales increases.

The share of fresh foods is assumed to affect the partitioning of total floorspace. In general, storage of fresh foods is difficult and most goods in stock are usually displayed to the customer.

H5B: selling area intensity increases if the share of fresh food sales increases.

Meat and meat products.

There are two important factors with respect to meat and meat products: share of meat and meat products sales and the presence of a butcher's shop. It is difficult to make an assumption about the effect of a high share of meat (product) sales on efficiency of floorspace given a certain amount of floorspace. There are various effects:

i) if a butcher's shop is present and meat is sold using counter service, floorspace efficiency is assumed to be high;
ii) average selling price per good increases considerably;
iii) the attraction of the establishment increases, but also
iv) spacious equipment (coolers) is needed if meat (products) is displayed to the customers.

We propose the following hypothesis:

H6A: efficiency of total available floorspace increases if the share of meat (products) sales increases.

In our opinion more interesting than the share of meat (products) sales is the presence of a butcher's shop, because it is an attraction factor of considerable significance. The influence of the presence of a butcher's shop will therefore be tested by assuming that it influences the elasticity of the value of total annual sales with respect to total floorspace, E. It is assumed that, if a butcher's shop is present, the value of the threshold coefficient increases: if the threshold coefficient can indeed be interpreted as a physical threshold, it is obvious that the presence of a butcher's shop will lead to additional threshold space.

H6B: the presence of a butcher's shop leads to additional threshold space and therefore to a higher elasticity of the value of total annual sales with respect to total available floorspace.

Share of non-food sales.

We do not have an a priori hypothesis about the influence on efficiency of floorspace if the share of non-food sales increases given a certain amount of floorspace. An inherent difficulty in the case of non-food sales is that they cover a large range of products (tobacco products, magazines, household products, textiles, clothes etc.) with probably largely differing effects on floorspace efficiency. The entrepreneurial argument to introduce non-food products will be their high percentage gross margin [22]. For the Dutch samples (with a low share), only the influence on floorspace efficiency will be studied. For the French samples (with a high share), the influence on sales area intensity will also be studied.

Weekly opening time.

The purpose of the extension of opening hours is to increase customer convenience. The pressures to extend opening hours arise from the fact that many households have a working wife or consist of one working person. In addition, the family car is often used for commuting and therefore not available during the day [23].
Weekly opening time in the Netherlands is regulated by law and practically equal for all establishments. Weekly opening time in France varies considerably. Therefore, in the French samples the variable "value of total annual sales per hour weekly opening time" is taken as the endogenous variable instead of "value of total annual sales". It is assumed that the efficiency of floorspace decreases if weekly opening time increases, because an increasing number of opening hours comprises more "odd hours".

H7: efficiency of total available floorspace (with respect to value of total annual sales per hour weekly opening time) decreases, if the number of weekly opening hours increases.

Presence of a petrol station, cafeteria etc.

Large French supermarkets often supply an extra range of services such as a petrol station, a cafeteria or other departments (hobby centre, garden centre etc.). It is assumed that, if such services are supplied, the efficiency of total floorspace (with respect to the departments of the conventional assortment composition consisting of foods and non-foods) will increase through a higher attraction.

H8: efficiency of total available floorspace (excluding the petrol station) is higher if there is a petrol station adjacent to the establishment.

H9: efficiency of total available floorspace (excluding the cafeteria) is higher if there is a cafeteria adjacent to the establishment.

H10: efficiency of total available floorspace (excluding these departments) is higher if departments such as a hobby centre or a garden centre are present on the premises of the establishment.

Gross margin.

For the Dutch samples a good indication of the products supplied is provided by means of depth of assortment composition, share of fresh food sales, share of meat (products) sales and presence of a butcher's shop. Such indicators of the "service level" are lacking in the French samples. Therefore, average percentage gross margin will be used as a makeshift. See section 2.2 for a definition. It is unorthodox to use this variable, which can also be viewed as a resultant of retail activities. It is assumed, however, that a high average percentage gross margin stems from

- a high average selling price, which might indicate that the assortment composition is particularly deep, contains an important share of non-foods, meat (products) or other fresh products. We have no hypothesis about the influence of an assortment composition which is deep or contains an important share of non-foods. A high share of meat (products) or other fresh products is assumed to give a high efficiency of floorspace;
- a low average purchasing price, which might indicate that considerable labour (own production) has to be performed before the goods can be displayed to customers. The performance of this labour takes space. A low purchasing price might also indicate large transactions per purchase, which implies a low ordering frequency, leading to higher stock levels.

The influence of competition on the buying and selling market is neglected in the above assumptions. The influence of productivity on price-setting is also ignored. It is difficult to state a hypothesis about the influence on efficiency of floorspace if average percentage gross margin increases [24].
We assume that the positive influence (of gross margin on efficiency of floorspace) related to counter service (meat (products) and other fresh products) is limited in French supermarkets, because self-service is also predominant for meat (products) and other fresh products.

Consequently, we propose the following hypothesis:
H11: efficiency of total available floorspace decreases if average percentage gross margin increases.

Influence of year.

It is assumed that efficiency of floorspace increased in recent years due to rising costs stimulating management to use floorspace efficiently. This effect may be intensified by an increasing level of competition [25]. Our samples cover the period between 1973 and 1979. An increasing level of competition can also mean that

- entrepreneurs concentrate on non-price competition (increase of depth, height or width of assortment competition). This may also influence efficiency of floorspace;
- number of competitors decreases, whereas total consumption grows moderately (which was the case between 1973 and 1979). Efficiency of floorspace will then show an exogenous increase.

We propose the following hypothesis:

H12: efficiency of total available floorspace increased in recent years.

2.5. Estimation.

In our discussion of the estimation procedure we ignore the implications of the further hypotheses. We return to the vector of basic coefficients θ with $\theta' = (\beta\ \gamma_1\ \gamma_2\ \pi\ \varepsilon)$. The estimation procedure - and hence the result - depends upon the assumptions we make with respect to the stochastic specification of our model [26]. We simply choose to add disturbance terms to the reduced form of our model after taking logarithms in (2.3.1). We obtain the following stochastic reduced form [27]:

$$\log Q_i = \log\beta + \pi\varepsilon\log\frac{\pi}{1-\pi} + \varepsilon\log(W_i - \gamma_1 - \gamma_2)(1-\pi) + v_{1i}; \tag{2.5.1}$$

$$C_i = \gamma_1 + \pi(W_i - \gamma_1 - \gamma_2) + v_{2i}; \tag{2.5.2}$$

$$R_i = \gamma_2 + (1-\pi)(W_i - \gamma_1 - \gamma_2) + v_{3i}. \tag{2.5.3}$$

It should be noted that $v_{2i} + v_{3i} = 0$ in equations (2.5.2) and (2.5.3). Therefore, one of these equations can be deleted in our estimation procedure. We choose to leave out equation (2.5.3) [28]. We now define V_i with

$$V_i = \binom{v_{1i}}{v_{2i}} \sim N(0, \Omega)$$

for i = 1, ..., I: bivariate normal distribution with zero means and constant, positive and symmetric covariance matrix

$$\Omega = \begin{pmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{pmatrix}.$$

Moreover, we assume the disturbance vectors V_i to be independent over the individuals, i.e. $E(V_i \; V'_{i'}) = 0$ for $i \neq i'$.

The normality assumption is made for the sake of convenience only.
The joint density of the V's is then given by

$$(2.5.4) \qquad P(V_1, \ldots, V_I) = P(V_1) \ldots P(V_I) = \\ = \frac{1}{(2\pi)^I (\det \Omega)^{I/2}} \exp\left[-\tfrac{1}{2} \sum_{i=1}^{I} V'_i \, \Omega^{-1} V_i\right].$$

(N.B.: in (2.5.4) π is not a coefficient to be estimated; it is the well-known constant 3.14159....)

The joint density function of the vector of endogenous variables $Y_i = \begin{pmatrix} \log Q_i \\ C_i \end{pmatrix}$ for i = 1, ..., I, is given as

$$(2.5.5) \qquad P(Y_i, \ldots, Y_1) = P(Y_1) \ldots\ldots P(Y_1) = \\ = P(V_1) \ldots\ldots P(V_I) . \left|\det \frac{\partial V_1}{\partial Y_1}\right| \ldots\ldots \left|\det \frac{\partial V_I}{\partial Y_I}\right|,$$

where $\left|\det \frac{\partial V_i}{\partial Y_i}\right|$ for i = 1, ..., I, is the absolute value of the Jacobian determinant of the transformation involved. Since V_i for i = 1, ..., I, are vectors of reduced form disturbance terms, these determinants are all unity, and we immediately obtain the following expression for the loglikelihood function of the coefficient vector θ and the covariance matrix Ω [29]:

$$(2.5.6) \qquad L(\theta, \Omega | Y) \propto -\frac{I}{2} \log(\det \Omega) - \frac{1}{2} \sum_{i=1}^{I} \hat{V}'_i \, \Omega^{-1} \hat{V}_i,$$

where the residuals $\hat{V}_i$ now have to be interpreted as functions of θ, implicitly defined by (2.5.1) and (2.5.2).

Concentrating with respect to Ω, the concentrated loglikelihood function obtains as [29a]

$$(2.5.7) \qquad L(\theta|Y) \propto -\frac{I}{2}\log(\det \sum_{i=1}^{I} \hat{V}_i\hat{V}_i').$$

The covariance matrix Ω is then estimated as

$$(2.5.8) \qquad \hat{\Omega} = \frac{1}{I}\sum_{i=1}^{I} \hat{V}_i\hat{V}_i'.$$

Full information maximum likelihood estimates may now be found by locating a minimum of L with respect to the coefficient vector θ.
Numerical minimization of L is performed by the variable metric algorithm of Broyden, Fletcher, Goldfarb and Shanno [30].
The asymptotic distribution of the maximum likelihood estimator $\hat{\theta}$ is multivariate normal with mean θ and covariance matrix Σ. A consistent estimate of Σ is given by $\hat{\Sigma}$, where [31]

$$(2.5.9) \qquad \hat{\Sigma} = \left(-\frac{\partial^2 L}{\partial\theta\partial\theta'}\right)^{-1} \text{ in } \theta = \hat{\theta}.$$

Before taking into account the further hypotheses of section 2.4 and consequently enlarging the vector of coefficients considerably, we experimented with the basic model consisting of equations (2.5.1) and (2.5.2). It appeared that the threshold coefficient of remaining space γ_2 does not differ significantly from zero. Table 2.1 gives the estimates of the coefficients of the model consisting of equations (2.5.1) and (2.5.2) for Dutch chain supermarkets of 1974 (SUP74), Dutch independent supermarkets of 1979 (SUP79) and French supermarkets (SUP7579). For the Dutch samples, Q_i is value of annual sales. It is expressed in 10^3 Dutch guilders of 1979 and C_i and W_i in 10^2 m^2.
For the French samples, Q_i is value of annual sales per hour weekly opening time. It is expressed in 10^3 French francs of 1979 and C_i and W_i in 10^3 m^2.
In Table 2.1 we see that

- $\hat{\gamma}_2$ does not differ significantly from zero in all cases;
- if the likelihood ratio test statistic $2[L(\gamma_2 = 0) - L(\gamma_2 \neq 0)]$ is computed, which has asymptotically a χ^2-distribution with one degree of freedom, then the hypothesis $\gamma_2 = 0$ is not rejected at a 10 per cent level of significance;
- standard errors of all coefficients except π drop if $\gamma_2 = 0$.

In the remaining part of this study it is assumed that $\gamma_2 = 0$. In addition, we are more interested in scale effects in the elasticity of the value of annual sales with respect to selling area than with respect to remaining space. In other words: we are more interested in the selling area threshold than in the remaining space threshold, because

- selling area is more important and usually larger than remaining space;
- the value of the remaining space threshold may never be high, since $\gamma_2 < \min R_i$ and $\min R_i \ll \min C_i$.

We conclude this section with two remarks:

i) experiments are also conducted with a model where equation (2.5.1) is replaced by equation (2.2.2) after taking logarithms and adding a disturbance term. Estimates of the coefficients and the above conclusions do not differ from those obtained with the model consisting of equations (2.5.1) and (2.5.2). From this we conclude that there is a certain robustness with respect to the specification of the disturbance structure;

ii) in analyses with cross-section data, disturbance terms are often assumed to have a heteroskedastic structure: their variance is assumed to increase according to a function of an explanatory variable or to the expectation of the variable to be explained. We do not make this assumption, because
   - such a structure is not decisively indicated by the scatter diagrams (cf. Figures 2.1 through 2.3);
   - in the determination of the estimates such a structure assigns a high weight to the observations at the lower end of the scale. This may be a drawback, because sometimes our samples are not randomly collected at the lower end of the scale: lower limits are set to value of annual sales or size of floorspace or selling area.

Table 2.1. Estimates of coefficients of the model consisting of equations (2.5.1) and (2.5.2): SUP74, SUP79 and SUP7579.

shop type		SUP74	SUP74	SUP79	SUP79	SUP7579	SUP7579
restriction		none	$\gamma_2 = 0$	none	$\gamma_2 = 0$	none	$\gamma_2 = 0$
efficiency	$\log\hat{\beta}$	8.42 (.28)	8.24 (.17)	6.62 (1.00)	7.18 (.22)	6.08 (.08)	6.12 (.04)
threshold	$\hat{\gamma}_1$	2.86 (1.26)	2.07 (.82)	-.94 (2.08)*	.21 (.53)*	.175 (.106)	.231 (.062)
threshold	$\hat{\gamma}_2$	.51 (.78)*		-.58 (.93)*		-.062 (.094)*	
distribution	$\hat{\pi}$	.617 (.024)	.616 (.024)	.691 (.028)	.697 (.027)	.531 (.018)	.535 (.017)
sales elasticity	$\hat{\varepsilon}$	.390 (.121)	.456 (.075)	1.00 (.44)	.747 (.124)	.665 (.133)	.596 (.074)
number of observations	I	91	91	104	104	121	121
neg. concentr. loglikelihood	L	316.5	316.6	300.1	301.2	227.1	228.1

Note Table 2.1: estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficients. An asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\,\hat{\sigma}(\hat{\eta})$ i.e. if η is not significantly different from zero at a 10% level of significance.

2.6. Tests: Dutch samples.

Hypotheses H1 (threshold space), H2 (ε) and some of the hypotheses mentioned in section 2.4 are tested using a model consisting of equations (2.5.1) and (2.5.2) where β, γ_1 and π are substituted by β_i, γ_{1i} and π_i:

(2.6.1) $$\beta_i = \beta_0\left(\frac{HV_i}{\overline{HV}}\right)^{\beta_1}\exp[\beta_2 f(NF_i) + \beta_3(VL_i - \overline{VL}) + \beta_4 DPR_i];$$

(2.6.2) $$\gamma_{1i} = \gamma_{10} + \gamma_{11}\, DSL_i;$$

(2.6.3) $\pi_i = \pi_0 + \pi_1 \; DPR_i$,

where W_i: total available floorspace (in 10^2 m^2) of establishment i;

C_i: selling area (in 10^2 m^2);

Q_i: value of annual sales (in 10^3 Dutch guilders of 1979);

HV_i: occupancy costs per m^2 (in Dutch guilders of 1979);

$\overline{HV} = (\sum_{i=1}^{I} HV_i)/I$: sample average occupancy costs per m^2;

I: number of observations

and where differences in the assortment composition are described using the following variables:

$f(NF_i) = DNF_i$ for SUP73, SUP74 and ZB7374. See appendix to this chapter for an explanation of these codes;

DNF_i = 1 if the establishment has an orientation towards non-food products and 0 otherwise;

$f(NF_i) = NF_i - \overline{NF}$ for SUP75, ZB75, SUP79 and ZB79;

$NF_i = QNF_i/Q_i$: share of non-food sales;

QNF_i: value of annual non-food sales (in 10^3 Dutch guilders of 1979);

$\overline{NF}$: sample average share of non-food sales;

$VL_i = QVL_i/Q_i$: share of meat (products) sales;

QVL_i: value of annual meat (products) sales (in 10^3 Dutch guilders of 1979);

$\overline{VL}$: sample average share of meat (products) sales;

DPR_i = 1 for SUP73, SUP74 and ZB7374 the establishment has a particularly deep assortment composition and 0 otherwise;

DPR_i = 1 for SUP75, ZB75, SUP79 and ZB79 the share of fresh food sales exceeds a certain number PR* and 0 otherwise [32];

DSL_i = 1 if a butcher's shop is present and 0 otherwise.

We restrict ourselves to a multiplicative specification for β_i, because
- such a specification accounts for interaction between variables;
- a convenient specification is obtained after logarithmization.

The definition of the variables describing differences in the assortment composition depends primarily on restrictions of our data sources.

Interpretation of coefficients of (2.6.1), (2.6.2) and (2.6.3):

β_0: measure of the "average" efficiency of floorspace;

β_1: elasticity of β_i with respect to $HV_i/\overline{\overline{HV}}$;

β_2: influence of share of non-food sales;

β_3: influence of share of meat (products) sales;

β_4: influence of deep assortment composition, respectively share of fresh food sales;

γ_{10}: threshold coeffficient if $DSL_i = 0$ or if DSL_i is not available;

$\gamma_{10} + \gamma_{11}$: threshold coefficient if $DSL_i = 1$;

π_0: distribution coefficient if $DPR_i = 0$ or if DPR_i is not available;

$\pi_0 + \pi_{11}$: distribution coefficient if $DPR_i = 1$.

Table 2.2. Estimates of coefficients of the model consisting of equations (2.5.1) and (2.5.2) with (2.6.1), (2.6.2) and (2.6.3): Dutch samples.

shop type		SUP73	SUP74	ZB7374	SUP75	ZB75	SUP79	ZB79
average efficiency	$\log\hat{\beta}_0$	8.35	8.31	7.68	7.26	6.72	7.20	6.68
		(.15)	(.13)	(.06)	(.23)	(.09)	(.18)	(.11)
occupancy costs	$\hat{\beta}_1$	.276	.393	.647	.397	.657	.673	.586
		(.134)	(.128)	(.186)	(.104)	(.113)	(.084)	(.086)
non-foods	$\hat{\beta}_2$	-.13	-.03		-.10	1.20	-1.29	.06
		(.10)*	(.10)*		(.87)*	(1.21)*	(.98)*	(.69)*
meat (products)	$\hat{\beta}_3$	1.34	2.99		.17		.35	-.27
		(.98)*	(1.10)		(.53)*		(.45)*	(.60)*
deep/fresh assortment	$\hat{\beta}_4$	.11	.11		.12	.07	.02	.07
		(.06)	(.06)		(.05)	(.06)*	(.05)*	(.04)
threshold	$\hat{\gamma}_{10}$	2.46	3.24	.78	.31	-.06	-.10	-.19
		(.91)	(.69)	(.14)	(.63)*	(.21)*	(.50)*	(.19)*
butcher's shop	$\hat{\gamma}_{11}$	.64	.20		.60		.71	
		(.43)*	(.48)*		(.30)		(.29)	
distribution	$\hat{\pi}_0$	.537	.501	.500	.615	.578	.663	.651
		(.050)	(.043)	(.027)	(.049)	(.040)	(.028)	(.025)
deep/fresh assortment	$\hat{\pi}_1$	.068	.103		.018	.060	.042	.036
		(.037)	(.033)		(.028)*	(.024)	(.021)	(.017)
sales elasticity	$\hat{\varepsilon}$	.435	.429	.431	.772	.634	.779	.817
		(.077)	(.068)	(.083)	(.133)	(.122)	(.095)	(.099)
number of observations	I	73	91	39	60	73	104	111
neg.concentr. loglikelihood	L	221.8	304.3	27.9	113.2	103.1	267.7	230.7
goodness of fit 1	r^2	.54	.56	.62	.67	.60	.69	.77
goodness of fit 2	r^2	.89	.89	.90	.81	.78	.87	.88
goodness of fit 3	r^2	.77	.77	.90	.50	.64	.58	.66
correlation of residuals	r	.25	.15	.26	.11	.12	-.06	.25

Note Table 2.2: see next page.

Note Table 2.2: estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficients. An asterisk (*) is printed next to the standard error of coefficient η if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$, i.e. if $\hat{\eta}$ is not significantly different from zero at a 10% level of significance.
The square of the correlation coefficient between the vectors of the dependent variable and its estimation is taken as measure of goodness of fit: 1 refers to the antilog form of equation (2.5.1), 2 to equation (2.5.2) and 3 to equation (2.5.3). The correlation coefficient between the vectors of residuals of equations (2.5.1) and (2.5.2) is computed. Its value is relevant to conclude whether our assumption of a non-diagonal covariance matrix Ω is meaningful.

The following conclusions regarding the hypotheses formulated above can be drawn from Table 2.2:

H1: $\hat{\gamma}_{10} > 0$ and significantly [33] for the samples of chain establishments (SUP73, SUP74 and ZB7374). $\hat{\gamma}_{10}$ is not significantly different from zero for the samples of independent establishments (SUP75, ZB75, SUP79 and ZB79). Support is found for the hypothesis that the elasticity of the value of annual sales with respect to total available floorspace, E, decreases with scale for the chain establishments. However, E seems to be scale independent for the independent establishments.

H2: $0 < \hat{\varepsilon} < 1$ and significantly for all samples. Support is found for the hypothesis that the asymptotic elasticity of the value of annual sales with respect to total available floorspace is not greater than one. $\hat{\varepsilon}$ does not differ significantly within the group of chain establishment samples (their values are approximately .43) nor within the group of independent establishment samples (their values do not differ significantly from .75). $\hat{\varepsilon}$ differs significantly between chain establishment samples on the one hand and independent establishment samples on the other.

It can be computed that E > 1 for chain supermarkets if $W < \pm\ 525\ m^2$ (assuming $\gamma_{10} = 3.00$) and for chain superettes if $W < \pm\ 130\ m^2$ (assuming $\gamma_{10} = .75$). The respective minimum sizes of these samples are approximately equal to these values: we conclude that E < 1 for the total size range of chain supermarkets and superettes. E is higher for chain supermarkets than for independent supermarkets if $W < \pm\ 700\ m^2$. E is higher for chain superettes than for independent superettes if $W < \pm\ 175\ m^2$ (assuming that for the latter $\varepsilon = .75$). Our data sources show that there are hardly any chain supermarkets smaller than 700 m^2, so that in practice E is always higher for independent supermarkets than for chain supermarkets. In Figure 2.4, E is drawn as a function of W.

We conclude that

- E decreases with size for chains and E is independent of size for independents;
- $E < 1$ for all samples;
- E is equal for independent superettes and independent supermarkets;
- E is higher for independent supermarkets than for chain supermarkets;
- E is higher for independent superettes than for chain superettes if $W > \pm 175\ m^2$.

H6B: $\hat{\gamma}_{11} > 0$ for all four samples of supermarkets, and significantly in the case of independents (SUP75 and SUP79). The hypothesis is supported that the presence of a butcher's shop leads to additional threshold space.

H3: $\hat{\beta}_1 > 0$ and significantly for all samples. Strong support is found for the hypothesis that effeciency of total available floorspace increases if occupancy costs per unit of floorspace increase. The elasticity of β_i with respect to relative occupancy costs per m^2 $HV_i/\overline{HV}$, $\hat{\beta}_1$, varies between .276 for chain supermarkets of 1973 and .673 for independent supermarkets of 1979. $\hat{\beta}_1$ is approximately equal to .6 for all superette samples. See footnote 43 for a comparison with other results.

H4: before discussing H4, we first examine the values found for the distribution coefficient if there is no particularly deep or fresh assortment, π_0. $0 < \pi_0 < 1$ and significantly for all samples, which is in accordance with the theoretical requirements. π_0 is approximately .5 for chain establishments and significantly higher for independents. No significant differences between supermarkets and superettes can be established. Neither can a development in time be established. It would be interesting to study the hypothesis whether and why chain establishments are less selling area intensive than independents.

$\hat{\pi}_1 > 0$ and significantly for SUP73 and SUP74. Support is found for the hypothesis that selling area intensity increases if depth of assortment composition increases.

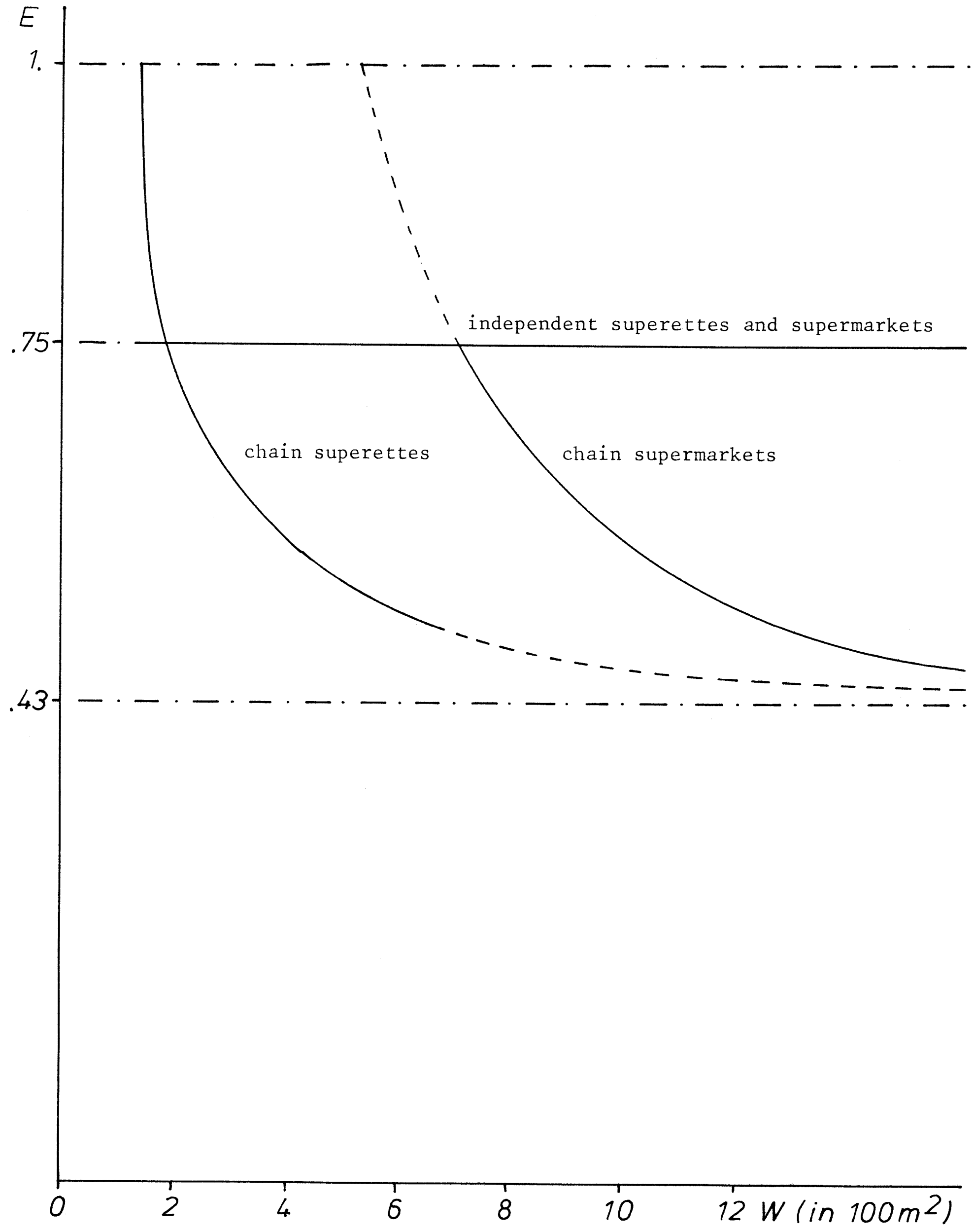

Figure 2.4. Elasticity of the value of annual sales with respect to total available floorspace, E, as a function of available floorspace W: cf. equation (2.3.2) with $\varepsilon = .43$ for chains, $\varepsilon = .75$ for independents, $\gamma_{10} = 3.00$ for chain supermarkets, $\gamma_{10} = .75$ for chain superettes and $\gamma_{10} = 0$ for independents.

H5A: $\hat{\beta}_4 > 0$ in all four cases of independent establishments but significantly in only two cases: not significantly for ZB75 and SUP79 and significantly for SUP75 and ZB79. The hypothesis is supported that efficiency of total available floorspace increases if share of fresh food sales increases.

H5B: $\hat{\pi}_1 > 0$ in all four cases of independent establishments and significantly in three cases: not significantly for SUP75. Support is provided for the hypothesis that selling area intensity increases if the share of fresh food sales increases.

H6A: $\hat{\beta}_3 > 0$ in four out of five cases and significantly in only one: significantly for SUP75. The hypothesis is not rejected that efficiency of total available floorspace increases if share of meat (products) sales increases.

H12: no significant difference is found between the values of $\log\hat{\beta}_0$ for 1975 and for 1979. No support is found for the hypothesis that efficiency of total available floorspace increased in recent years. We do see that $\log\hat{\beta}_0$ is significantly higher for chain establishments than for independents and that $\log\hat{\beta}_0$ is significantly higher for supermarkets than for superettes. The facts that chains are generally larger than independents and that supermarkets are generally larger than superettes stimulate the investigation of the hypothesis that β_0 increases with increasing average size of shop type establishments.

From Table 2.2 it can also be seen that

i) the level of non-food sales appears to have no significant influence on the efficiency of total available floorspace. However, $\hat{\beta}_2$ is always negative for supermarkets and positive for superettes;

ii) a deep assortment appears to have a positive influence on the efficiency of total available floorspace for chain establishments.
$\hat{\beta}_4 > 0$ and significantly for SUP73 and SUP74. Support is also found for the hypothesis (H4) that selling area intensity increases if depth of assortment composition increases ($\hat{\pi}_1 > 0$).
It was also noted that $\hat{\pi}_0$ is not smaller than .5. This implies a second positive effect on the value of total annual sales (See section 2.3);

iii) it is remarkable that the values of the estimated coefficients for the independents are practically equal for all four shop types: there is no decisive difference between supermarkets and superettes or between 1975 and 1979. An exception is the "average" efficiency, which is significantly higher for supermarkets than for superettes.

The likelihood ratio test statistic $2[L(\gamma_2 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \gamma_{11} = \pi_1 = 0) - L(\gamma_2 = 0)]$ can be computed from Tables 2.1 and 2.2 for SUP74 and SUP79. This test statistic has asymptotically a χ^2- distribution with six degrees of freedom. For SUP74 its value is 24.6 and for SUP79 its value if 67.0: the hypothesis that $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \gamma_{11} = \pi_1 = 0$ is rejected at a 10 percent level of significance: it appears useful to take into account further characteristics of establishments per shop type.

The final remarks of this section involve the interpretation of the threshold coefficient of selling area, γ_1. The values found are $\pm$ 280 m^2 for chain supermarkets, $\pm$ 75 m^2 for chain superettes, $\pm$ 0 m^2 for independents, and if a butcher's shop is present an incremental value of $\pm$ 40 m^2 (not significant) for chain supermarkets and $\pm$ 65 m^2 for independent supermarkets [34]. If threshold floorspace is assumed to consist of entrance space, space for some cash stands as well as space for possible queues of customers, space for the display of basic goods and adjacent aisles, we can very well understand the values found for chain establishments. If threshold floorspace for a butcher's shop consists of space for a counter, possible queues, some hardware and room for butchering, we can very well understand the values found for the additional value if a butcher's shop is present. We do not understand the low values found for the independent establishments. In the appendix to this chapter a report is given of some further exercises with Dutch independents.
Support for the threshold interpretation of γ_{10} and γ_{11} is provided by the fact that:

- $\hat{\gamma}_{10}$ or $\hat{\gamma}_{10} + \hat{\gamma}_{11} < \min C_i$ for all samples;
- $\hat{\gamma}_{10}$ or γ_{11} are nowhere significantly < 0;
- $\hat{\gamma}_{10} > 0$ and significantly for chain establishments;
- additional values for a butcher's shop ($\hat{\gamma}_{11}$) do not differ significantly among the samples (we do not suppose that there is room for largely differing butcher's shops between chain and independent establishments);
- $\hat{\gamma}_{10}$ or $\hat{\gamma}_{10} + \hat{\gamma}_{11}$ are a reflection of the average sizes per sample.

2.7. Tests: French samples.

Hypotheses H1 (threshold space), H2 (ε) and some of the hypotheses mentioned in section 2.4 are tested using a model consisting of equations (2.5.1) and (2.5.2) with Q_i replaced by the value of total annual sales per hour weekly opening time, Q_i/DO_i, and where β and π are substituted by β_i and π_i:

$$(2.7.1) \qquad \beta_i = \beta_0\left(\frac{HV_i}{\overline{\overline{HV}}_i}\right)^{\beta_1} \left(\frac{DO_i}{\overline{\overline{DO}}_i}\right)^{\beta_2} \exp[\beta_3(M_i - \bar{M}_i) + \beta_4 DNF_i + $$

$$+ \beta_5 DCA_i + \beta_6 DES_i + \beta_7 DAA_i + \beta_8 DT_i];$$

$$(2.7.2) \qquad \pi_i = \pi_0 + \pi_1 DNF_i,$$

where W_i: total available floorspace for foods and non-foods [35] (in 10^3 m^2) of establishment i;

C_i: selling area of foods and non-foods [35] (in 10^3 m^2);

Q_i: value of annual sales of foods and non-foods [36] (in 10^3 French francs of 1979);

DO_i: weekly opening time (in hours);

$\overline{\overline{DO}}_i$: sample average weekly opening time of the observations of 1978 and 1979 if i is observed in 1978 or 1979 or sample average weekly opening time of 1975, 1976 and 1977 if i is observed in 1975, 1976 and 1977;

HV_i: total non-labour costs per m^2 (in French francs of 1979): occupancy costs are not available;

M_i: average percentage gross margin divided by 100. See equation (2.2.9);

$\overline{\overline{HV}}_i$ and $\bar{M}_i$: sample averages defined in the same manner as $\overline{\overline{DO}}_i$;

DNF_i = 1 if the share of non-food sales exceeds a certain number NF* and 0 otherwise [37];

DCA_i = 1 if a cafeteria is present and 0 otherwise;

DES_i = 1 if a petrol station is present and 0 otherwise;

DAA_i = 1 if other activities are performed (hobby centre, garden centre etc.) 0 otherwise;

DT_i = 0 if the observation refers to 1975, 1976 or 1977 and 1 if the observation refers to 1978 or 1979;

Interpretation of coefficients of (2.7.1) and (2.7.2) is analogous to that of (2.6.1) and (2.6.3).

We examine columns MP7579, HYP7577 and SUP7579 of Table 2.3. The following conclusions can be drawn regarding the hypotheses formulated above:

H1: $\hat{\gamma}_1 > 0$ and significantly for all samples: support is found for the hypothesis that the elasticity of the value of annual sales per weekly opening hour with respect to total available floorspace, E, decreases with scale for all samples.

H2: $0 < \hat{\varepsilon} < 1$ and significantly for all samples, whereas $\hat{\varepsilon}$ is significantly smaller for hypermarkets than for supermarkets and "magasins populaires". Support is found for the hypothesis that the asymptotic elasticity of the value of annual sales with respect to total available floorspace is not greater than one. It can be computed that E > 1 for "magasins populaires" if $W < \pm$ 1350 m^2, for hypermarkets if $W < \pm$ 4400 m^2 and for supermarkets if $W < \pm$ 600 m^2. Cf. equation (2.3.3). The respective minimum sizes of these samples are smaller than these values: we conclude that E > 1 for small establishments of the respective shop types. E is higher for "magasins populaires" than for supermarkets. E is higher for hypermarkets than for "magasins populaires" and supermarkets if $W < \pm$ 12000 m^2 and $W < \pm$ 14000 m^2, respectively. From Table A.2.3 in the appendix to this chapter we see that "magasins populaires" and supermarkets are not that large, so that in practice E is always higher for hypermarkets than for "magasins populaires" and supermarkets. In Figure 2.5, E is drawn as a function of W.

Table 2.3. Estimates of coefficients of the model consisting of equations (2.5.1) and (2.5.2) with (2.7.1) and (2.7.2) and with Q_i replaced by Q_i/DO_i: French samples.

shop type		MP7579	HYP7577	SUP7579	MP7579 ∪ SUP7579	
average efficiency	$\log\hat{\beta}_0$	6.01 (.08)	6.38 (.16)	6.06 (.06)	6.09 (.04)	
occupancy costs	$\hat{\beta}_1$	.545 (.074)	.590 (.080)	.449 (.071)	.480 (.052)	
weekly opening time	$\hat{\beta}_2$	-1.03 (.30)	-.57 (.34)	-.72 (.21)	-.71 (.17)	
% gross margin	$\hat{\beta}_3$	-1.56 (1.06)*	2.66 (2.82)*	-2.25 (1.26)	-2.85 (.82)	
non-foods	$\hat{\beta}_4$	.04 (.06)*	.05 (.08)*	.09 (.05)	.09 (.04)	
cafeteria	$\hat{\beta}_5$		.11 (.06)	-.10 (.05)		
petrol station	$\hat{\beta}_6$			.18 (.05)		
other activities	$\hat{\beta}_7$		.22 (.05)			
year	$\hat{\beta}_8$	.09 (.05)		-.01 (.06)*	-.01 (.04)*	
threshold	$\hat{\gamma}_1$ or $\hat{\gamma}_{10}$	.472 (.135)	1.877 (.461)	.207 (.059)	.563 (.073)	$\hat{\gamma}_{11}$ = -.364 (.173)
distribution	$\hat{\pi}_0$	.363 (.044)	.369 (.026)	.520 (.020)	.332 (.025)	$\hat{\pi}_2$ = .195 (.023)
non-foods	$\hat{\pi}_1$	-.016 (.032)*	.015 (.038)*	.035 (.018)	.014 (.062)*	
sales elasticity	$\hat{\varepsilon}$	.653 (.091)	.571 (.079)	.656 (.063)	.638 (.053)	
number of observations	I	71	68	121	192	
neg. concentr. loglikelihood	L	98.4	189.5	195.6	459.9	
goodness of fit 1	r^2	.64	.83	.78	.68	
goodness of fit 2	r^2	.55	.68	.89	.78	
goodness of fit 3	r^2	.84	.87	.86	.84	
correlation of residuals	r	.42	.24	.31	.35	

Note Table 2.3: see Note Table 2.2.

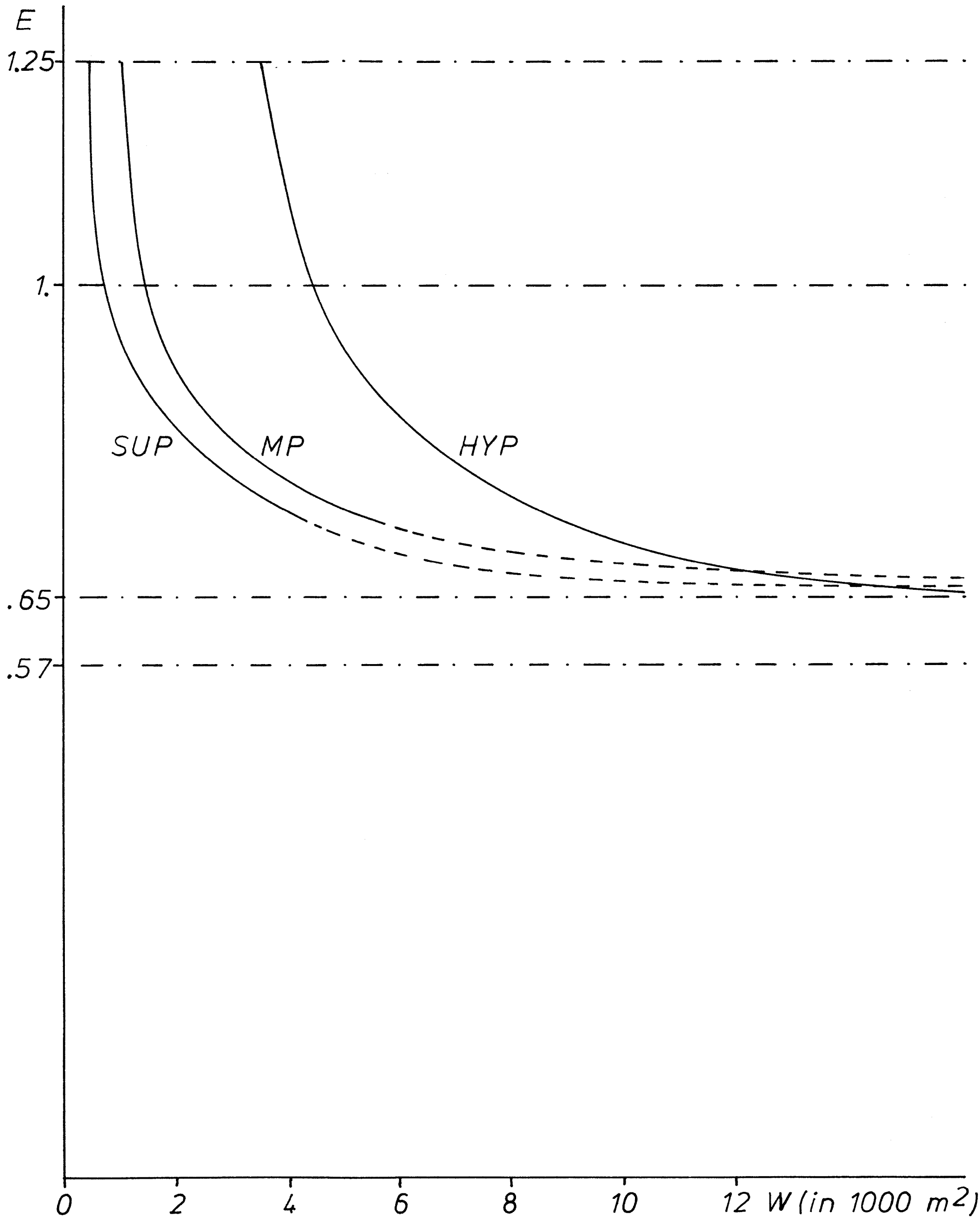

Figure 2.5. Elasticity of the value of annual sales with respect to total available floorspace, E, as a function of total available floorspace W: cf. equation (2.3.2) with $\varepsilon = .65$ for "magasins populaires" and supermarkets, $\varepsilon = .57$ for hypermarkets and $\gamma_1 = .47$ for "magasins populaires", $\gamma_1 = 1.88$ for hypermarkets and $\gamma_1 = .20$ for supermarkets.

We conclude that

- E decreases with size for all samples;
- E > 1 for small establishments of all samples;
- E is higher for hypemarkets than for "magasins populaires";
- E is higher for "magasins populaires" than for supermarkets.

H3: $\hat{\beta}_1 > 0$ and significantly for all samples. Strong support is found for the hypothesis that efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase [38]. The elasticity of β_i with respect to relative occupancy costs per m^2 $HV_i/\overline{HV}$, β_1, varies around .5 for the French samples. See footnote 43 for a comparison with other results.

H7: $\hat{\beta}_2 < 0$ and significantly for all samples. Strong support is found for the hypothesis that efficiency of total available floorspace (with respect to the value of total annual sales per weekly opening hour) decreases if opening time increases. The elasticity of β_i with respect to relative opening time $DO_i/\overline{DO}_i$, β_2, does not differ significantly from -.8 for all samples. The efficiency of total available floorspace (with respect to the value of total annual sales) does not depend on weekly opening time if $\beta_2 = -1$. $\hat{\beta}_2$ does not differ significantly from -1 for all samples, though $\hat{\beta}_2 > -1$ for hypermarkets and supermarkets.

H8: $\hat{\beta}_6 > 0$ and significantly for supermarkets. Support is found for the hypothesis that efficiency of total available floorspace is higher if there is a petrol station adjacent to the establishment.

H9: $\hat{\beta}_5 > 0$ and significantly for hypermarkets, but < 0 and significantly for supermarkets. Rejection of hypothesis H9 in the case of supermarkets might be caused by the fact that it is not possible to deduct the cafeteria floorspace from total available floorspace. See footnote 35.

H10: $\hat{\beta}_7 > 0$ and significantly for hypermarkets. Support is found for the hypothesis that efficiency of total available floorspace is higher if departments such as a hobby centre or a garden centre are present on the premises of an establishment.

H11: $\hat{\beta}_3 < 0$ for "magasins populaires" and supermarkets but significantly only for supermarkets. The hypothesis that efficiency of total available floorspace decreases if average percentage gross margin increases cannot be rejected for these shop types.

H12: $\hat{\beta}_8 > 0$ and significantly for "magasins populaires". Thus support is found for the hypothesis that efficiency of total available floorspace increased in recent years. No such support is found for supermarkets [39].

From Table 2.3 it can also be seen that:

i) $\log\hat{\beta}_0$ is significantly higher for hypermarkets than for supermarkets and "magasins populaires". Again we see that apparently $\log\beta_0$ increases with increasing average size of the shop type establishments. Cf. section 2.6, where this is also observed for Dutch samples;

ii) $0 < \hat{\pi}_0 < 1$ and significantly for all samples. $\hat{\pi}_0$ is significantly higher for supermarkets than for "magasins populaires" and hypermarkets. Regarding the Dutch samples, $\hat{\pi}_0$ is significantly higher for independents than for chains. From Tables A.2.2 and A.2.3 of the appendix to this chapter it is seen that generally the average size of chain establishments is larger than that of independents and that the average size of "magasins populaires" and hypermarkets is larger than that of supermarkets. These findings stimulate the investigation of the hypothesis that selling area intensity decreases with increasing average size of the shop type establishments;

iii) the non-food sales share appears to have a positive influence on the efficiency of total available floorspace as well as a positive influence on selling area intensiy for supermarkets. No significant effects are noted for "magasins populaires" and hypermarkets. This is concluded from the examination of $\hat{\beta}_4$ and $\hat{\pi}_1$. The positive influence on the efficiency of total available floorspace found for French supermarkets is contrary to that found for Dutch supermarkets.

Support for the threshold interpretation of γ_1 is given by the fact that for all samples:

- $\hat{\gamma}_1 < \min C_i$;
- $\hat{\gamma}_1 > 0$ and significantly;
- $\hat{\gamma}_1$ is a reflection of the average sizes per sample.

We do not have sufficient knowledge to give a precise physical interpretation of threshold floorspace for the large French establishments.

Comparing the estimates of columns MP7579, HYP7577 and SUP7579 in Table 2.3, it is seen that there are no large differences between the estimates of "magasins populaires" and supermarkets. All 192 observations of both shops types are pooled to obtain more general results (and sometimes smaller errors). This is done for two reasons:

- we are not satisfied with the results as regards the influence of the year of observation, gross margin and opening time;
- we would like to have a sounder basis for hypotheses as regards the influence of non-food sales share.

A dummy variable is introduced to permit supermarkets to have a lower threshold floorspace and to be more selling area intensive. Variables DAA_i, DCA_i and DES_i are left out of consideration, because they appear only in one shop type. Equations (2.7.1) and (2.7.2) are replaced by

$$(2.7.3) \qquad \beta_i = \beta_0 \left(\frac{HV_i}{\overline{HV}_i}\right)^{\beta_1} \left(\frac{DO_i}{\overline{DO}_i}\right)^{\beta_2} \exp[\beta_3(M_i - \bar{M}_i) + \beta_4\ DNF_i + \beta_8\ DT_i];$$

$$(2.7.4) \qquad \pi_i = \pi_0 + \pi_1\ DNF_i + \pi_2\ DSU_i$$

and γ_1 is substituted by γ_{1i}:

$$(2.7.5) \qquad \gamma_{1i} = \gamma_{10} + \gamma_{11}\ DSU_i,$$

where $DSU_i = 1$ if the establishment is a supermarket and 0 otherwise.

Column MP7579 ∪ SUP7579 in Table 2.3 shows that, when the observations of "magasins populaires" and supermarkets are grouped together,

- non-food sales share appears to have a positive effect on efficiency of total available floorspace and no effect on selling area intensity;
- support is found for the hypothesis that average percentage gross margin has a negative effect on efficiency of total available floorspace;
- no support is found for the hypothesis that efficiency of total available floorspace increased in recent years;
- $\hat{\beta}_2 > -1$ and significantly: the efficiency of total available floorspace (with respect to the value of annual sales) increases with weekly opening time.

2.8. Conclusions and summary.

The model consisting of equations (2.3.1), (2.2.6) and (2.2.7) is derived from the assumptions of section 2.2. It tries to explain the relation between the value of total annual sales and total available floorspace as well as the partitioning into selling area and remaining space. The coefficients of the model are estimated for ten samples of supermarket-like shop types (seven Dutch shop types and three French). Influences of heterogeneities per shop type are also taken into account. The main conclusions of this study are:

i) the model serves its purpose very well, because

a) samples are studied consisting of small as well as of large establishments, of Dutch as well as of French establishments [40], of chain as well as of independent establishments and of establishments of the early as well as of the late seventies. The values found for the vector of basic coefficients θ (consisting of coefficients denoting efficiency of total available floorspace, selling area threshold, remaining space threshold, selling area intensity and asymptotic elasticity of annual sales with respect to total floorspace) do not contradict the logical restrictions in any one case. See section 2.3;

b) no specification test is performed. However, examination of the values of the residuals of the equations does not reveal any structure. In Figures 2.6 to 2.8 the residuals are drawn for Dutch chain supermarkets of 1974, Dutch independent supermarkets of 1979 and French supermarkets. The value of the correlation coefficient between the vectors of residuals of equations (2.5.1) and (2.5.2) is quite low. However, it is higher for French than for Dutch supermarkets and it has a positive value for all three French samples. From this we surmise that there is something left to explain [41]. From the large share of non-food sales in French supermarkets we surmise that this has to do with the partitioning between selling area for foods and for non-foods;

c) differences in the values of the coefficients within a shop type can very well be explained by taking into account the characteristics of the establishments. This can be concluded from the fact that only very few of the further hypotheses mentioned in section 2.4 must be rejected: most hypotheses are supported by the data;

d) differences in the values of the coefficients among the shop types can, to a certain extent, be explained;

e) the model used is very simple (simple, that is, when compared with the "real" world) and yet the explanation is fairly high for a cross-section model. See goodness of fit in Tables 2.2 and 2.3. This is in accordance with our intuitive feeling that the characteristics of the establishment itself play a dominant role and that environmental variables may be omitted. However, the explanation of annual sales of Dutch chain establishments is lower than that of independents. In this study, chain establishments are all located in shopping centres of considerable size, whereas independents may also be located in small shopping centres. From this we conclude that it is relevant to take into account the characteristics of the shopping centre to improve the explanation of annual sales [42]. This will be done in chapter four;

ii) an important coefficient is the elasticity of the value of total annual sales with respect to total floorspace, E:

$$(2.8.1) \quad E = \varepsilon\, W_i/(W_i - \gamma_1).$$

E is found to decrease with increasing total available floorspace W_i for all samples except for the Dutch independents (if there is no butcher's shop). This is due to the positive value found for the threshold coefficient of selling area γ_1: threshold space is a certain amount of basic space which must be present in all establishments of a shop type. It is left to specialists to give a precise physical interpretation of threshold, such as it is estimated in our model. Support for the threshold interpretation is given by the fact that

a) for all samples some logical restrictions are not violated: $0 < \text{threshold} < \min C_i$;

b) there is additional threshold space within a shop type if there is reason to believe that it is necessary (presence of a butcher's shop);

c) additional threshold spaces due to the presence of a butcher's shop do not differ significantly among the shop types;

d) threshold space increases if the average size of the shop type increases.

We have no hypothesis for the fact that for Dutch independents no positive value for the threshold coefficient is found (if there is no butcher's shop);

iii) strong support is found for the hypothesis that the asymptotic elasticity of the value of annual sales with respect to total available floorspace ε is not greater than one: ε is even significantly smaller than one for all samples. In section 2.3 hypotheses for these diseconomies are given;

iv) $E < 1$ for all Dutch samples and from a certain small size upwards for all French shop types;

v) selling area intensity of a shop type appears to decrease with increasing average size of shop type establishments;

vi) the threshold coefficient of remaining space is found to be zero for all shop types;

vii) strong support is found for the hypothesis that efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase. The elasticity of efficiency with respect to relative occupancy costs is generally approximately .5 [43];

viii) support is found for the hypotheses that selling area intensity increases if depth of assortment composition increases or if the fresh food sales share increases. Also, in both cases efficiency of total available floorspace appears to increase;

ix) an interesting result is provided by the support for the hypothesis that the efficiency of total available floorspace (with respect to value of total annual sales per weekly opening hour) decreases if opening time increases. This result could help shopkeepers in their opening time decision or government in its decision regarding opening time regulations [44];

x) support is found for the hypothesis that attraction through the presence of a cafeteria, petrol station or other activities increases efficiency of total available floorspace;

xi) no support is found for the hypothesis that effeciency of total available floorspace increased in recent years. A significant increase is found for "magasins populaires" only;

xii) the influence of non-food sales share appears to be very moderate. There tends to be a negative influence on efficiency of total available floorspace for Dutch supermarkets and a positive influence on efficiency of total available floorspace for all French samples;

xiii) for French supermarkets and "magasins populaires" average percentage gross margin appears to have a negative influence on efficiency of total available floorspace. It is demonstrated in chapter six that for supermarkets average percentage gross margin has a positive influence on labour intensity. Then both findings point in the same directon: more labour and floorspace is needed per unit of sales if average percentage gross margin increases. This might imply that average percentage gross margin is a good indicator for the general concept of "service level";

xiv) "average" efficiency of total available floorspace appears to increase with increasing average size of shop type establishments. This might be a reason for the shopkeepers' common desire to transform his shop into one of a larger shop type.

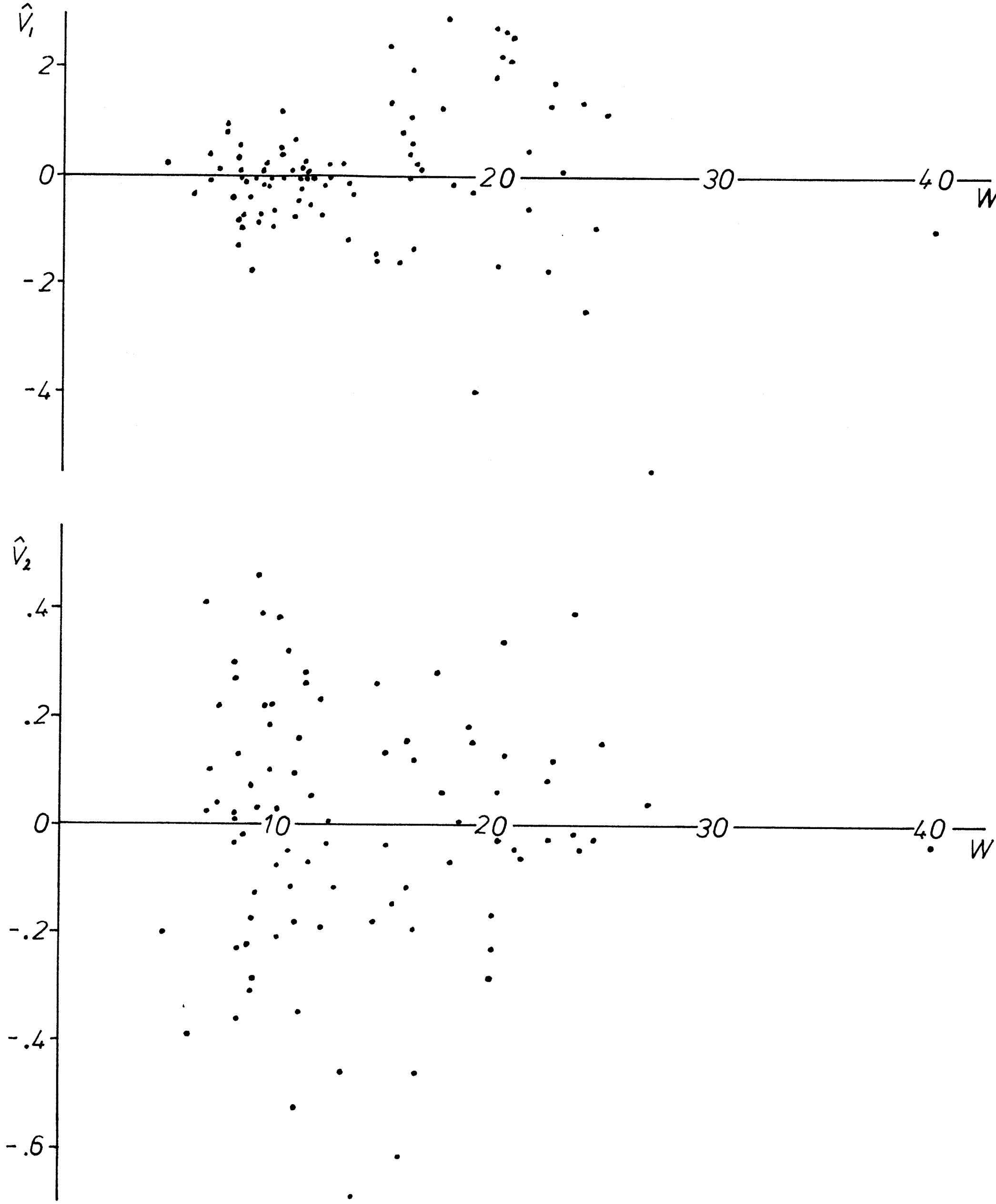

Figure 2.6. Residuals of equations (2.5.1) and (2.5.2) with (2.6.1), (2.6.2) and (2.6.3) for SUP74 (Dutch chain supermarkets of 1974). W: total available floorspace (in 10^2 m^2); $\hat{v}_1$: residual of equation (2.5.1); $\hat{v}_2$: residual of equation (2.5.2).

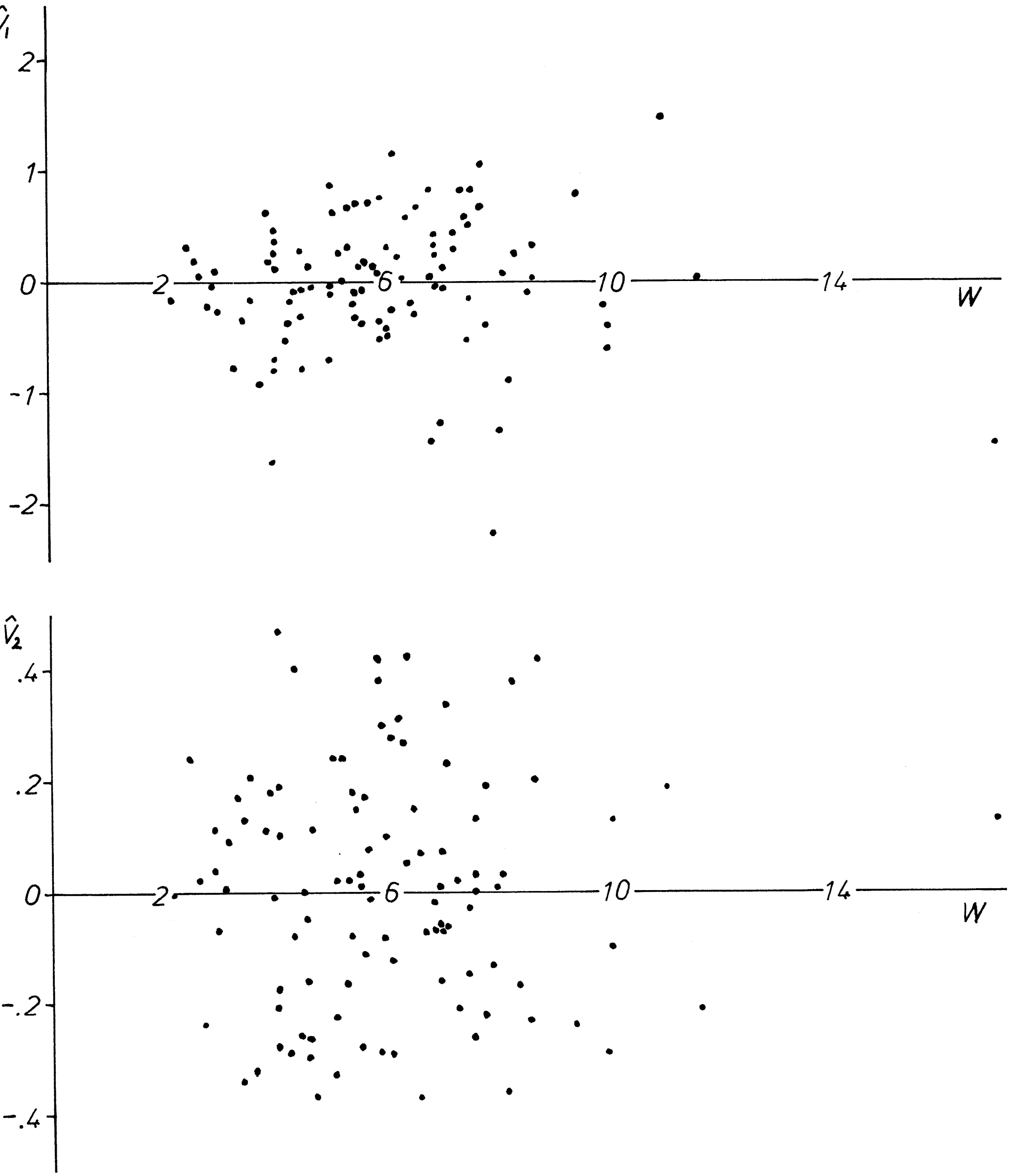

Figure 2.7. Residuals of equations (2.5.1) and (2.5.2) with (2.6.1), (2.6.2) and (2.6.3) for SUP79 (Dutch independent supermarkets of 1979). W: total available floorspace (in 10^2 m^2); $\hat{v}_1$: residual of equation (2.5.1); $\hat{v}_2$: residual of equation (2.5.2).

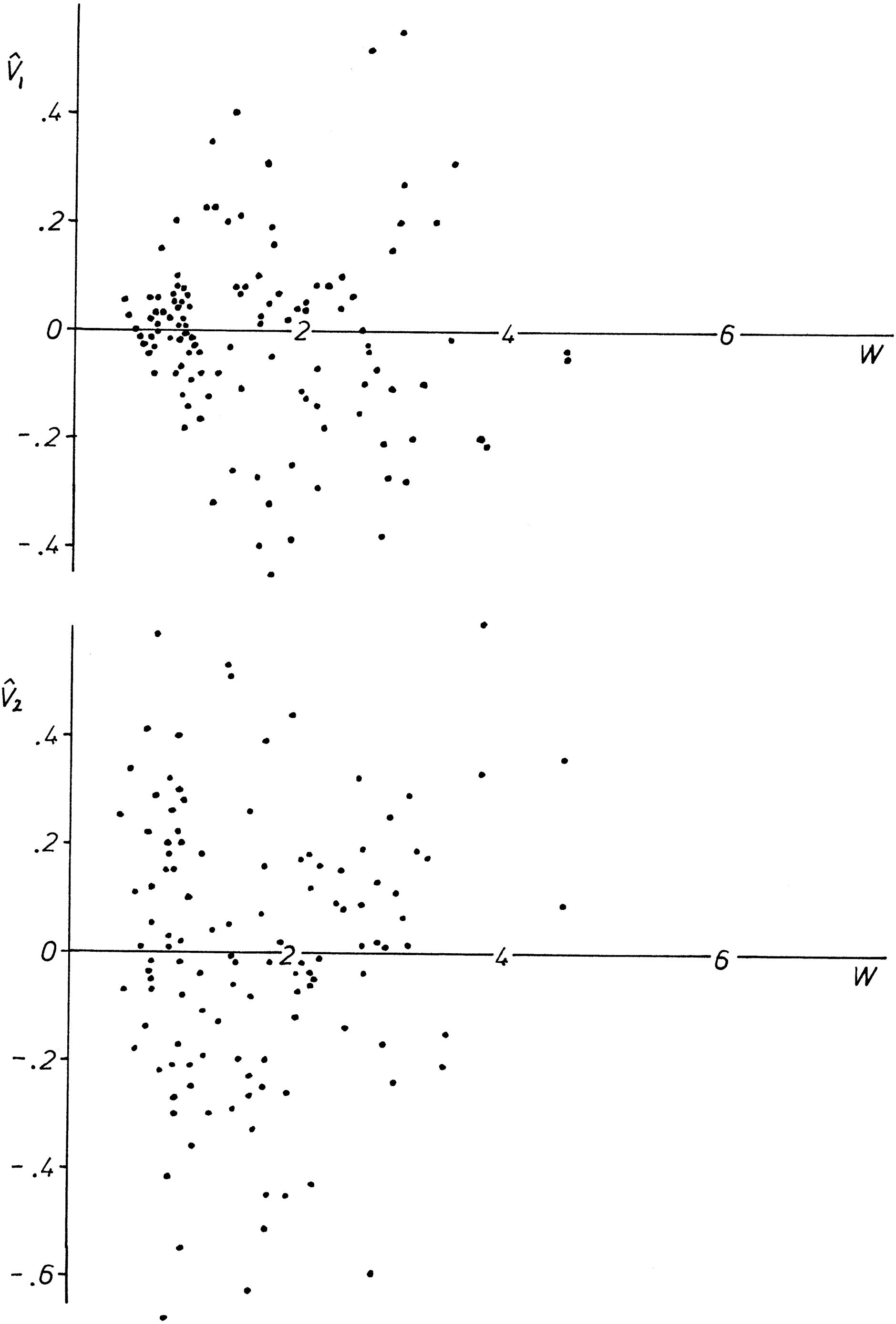

Figure 2.8. Residuals of equations (2.5.1) and (2.5.2) with (2.7.1) and (2.7.2) for SUP7579 (French supermarkets of 1975 through 1979). W: total available floorspace (in 10^3 m^2); $\hat{v}_1$: residual of equation (2.5.1); $\hat{v}_2$: residual of equation (2.5.2).[1]

Footnotes to chapter two.

[1] Our model must be viewed as a comparative static model: it examines the states of temporary equilibrium which occur at successive points of time, but does not describe the intervening change process.

[2] See Van Goor and Leeflang [1981].

[3] These characteristics are sometimes also called: decision, instrumental or marketing variables.

[4] See Thurik [1981a].

[5] See Groen, Thurik and Van der Wijst [1983].

[6] For example in the case of supermarkets: butchering, breadbaking, repairing, packing etc.

[7] See Gist [1968], p. 231 ff. for some notions on shop layout.

[8] The concept of "space which determines sales" is also encountered in spatial interaction models explaining total sales or market shares of shopping centres. See Lichfield [1970] for an extensive summary of these models. This concept is also encountered at an entirely different aggregation level: the relationship between shelf space and sales per product. See Leone and Schultz [1980] for an extensive reference list of studies of (the existence of) this relationship.

[9] The use of remaining space (i.e. non-selling area) as a proxy variable for own production can also be found in Nooteboom [1980], p. 206/207.

[10] We do not use Nooteboom's concept of the relationship between floorspace and sales (see Nooteboom [1980], section 3.9) because

i) the justification of the concept is associated with the causal structure that "sales determine floorspace", which does not honour the exogenous character of floorspace;

ii) the scatter diagrams presented (see p. 62 ff., p. 135 ff. and p. 199 ff.) do not provide conclusive evidence in favour of a linear relationship between floorspace and sales;

iii) we doubt whether space required for receiving and serving customers can be described adequately in terms of queuing theory alone. Customers do more than wait in queues if their "use" of floorspace is considered;

iv) it cannot always be said that space required for displaying goods is proportional to the sales size. See section 2.3 of our study;

v) the use of coefficients such as "fixed space per customer" and "space per customer per guilder sales" is not very convincing.

Individually, these arguments are open to discussion. However, combined they convinced us of the necessity of devising a different concept of the relationship between floorspace and sales.

[11] See Ferguson [1969] p. 91.

[12] $Q_i = Q_i(C_i, R_i) = \beta(C_i - \gamma_1)^{\pi\varepsilon} (R_i - \gamma_2)^{(1-\pi)\varepsilon}$ with $\beta > 0$, $0 \leq \gamma \leq C_i$, $0 \leq \gamma_2 \leq R_i$, $0 < \pi < 1$ and $\varepsilon > 0$ is a continuous function on $D_i \subset \mathbb{R}^2$ with

$$D_i = \{\binom{C_i}{R_i} \mid \begin{matrix}\gamma_1 \leq C_i \\ \gamma_2 \leq R_i\end{matrix}\} \cap \{\binom{C_i}{R_i} \mid W_i = C_i + R_i\}.$$

Then D_i is compact if $W_i \leq B$ for some fixed constant B.

Therefore, a global maximum and a global minimum are attained on D_i. The global minimum is attained in a point with $C_i = \gamma_1$ or $R_i = \gamma_2$ and in this point $Q_i(C_i, R_i) = 0$.

Stationary points (C_i, R_i) so that $Q_i(C_i, R_i) \neq 0$ are candidates for the global maximum. There is only one such point. It is defined by equations (2.2.6) and (2.2.7).

[13] Nooteboom [1980] provides evidence in favour of $\varepsilon = 1$ for various shop types. The results of Tucker's empirical exercises [1975] also imply $\varepsilon = 1$. However, both authors use models which differ considerably from our model and in both studies unexplained variance after regression of floorspace on (a function of) total sales is considerable.

[14] See Gerlach [1976], p. 90, who shows that the number of different items increases with size for German "Verbraucher-Märkte".

[15] See Gerlach [1976], p. 100, who shows that the percentage of establishments of a certain size which carry a certain product group increases with average size. See also Libre Service Actualités [1982a] for French cash-and-carry establishments.

[16] See Cairns [1963], who adds that the relationship between space per item and sales need not be smooth. There may be two points at which discontinuities arise: one when the amount of space allocated is sufficient to make iterested shoppers aware that the item is available and two, when this amount is sufficient to attract impulse buyers.

[17] Leunis and Brams [1978] and Pickering [1972] indicate further reasons for diseconomies.

[18] In other words: it is <u>not</u> assumed that the summary of constraints of a technical nature specified as equation (2.2.2) is identical for all establishments up to neutral disembodied efficiency differences.

[19] See Henksmeier [1960], p. 61.

[20] This may certainly be the case if an implicit monopoly position is granted. See Pickering [1972].

[21] Baumol and Ide [1973] provide a model in which the range of goods carried by a shop is endogenous. They use the shopkeeper's dilemma that on one hand a large range of goods attracts custom, whereas on the other hand the costs of handling goods increase with an increasing range of goods.

[22] Of course, there are opportunity costs involved by the amount of space allocated to these products. See Cairns [1973]. The first non-foods introduced by the shopkeeper are probably goods with a relatively inelastic demand and for which little space is needed.

[23] See Rachman [1969], p. 209.

[24] It is shown in chapter six that labour intensity increases if average percentage gross margin increases for hypermarkets and supermarkets. This is easy to understand because counter service (meat (products) and fresh products), a deep assortment composition and a large share of own production require considerable labour.

[25] Padberg [1968] p. 138: "When rivalry is focused on prices, business success depends on control of costs".

[26] See Epple [1976].

[27] There are some justifications for including disturbance terms (such as v_{1i}, v_{2i} and v_{3i} in equations (2.5.1) to (2.5.3)) in nondefinitional equations. Specification errors may occur due to a wrong functional relationship, wrong variables, omitted variables or measurement errors. Moreover, there may be randomness in behaviour among establishments in the sense that no specification errors occur per establishment, but that the correct specification varies among establishments.
The variables on the left hand side are considered to be endogenous random variables;

[28] Barten [1969] proves that for obtaining maximum likelihood estimates it does not matter which one is omitted, if the singularity occurs in a complete system of equations with a disturbance vector having a multivariate normal distribution. The same result is valid for a subset of a system of equations. See Kooiman [1982].

[29a] See Maddala [1977] p. 487.

[29] As usual, the additive constant $-I \log 2\pi$ is deleted as it plays no role in the location of the maximum of the likelihood function.

[30] See for instance Van der Hoek [1980].

[31] The estimate of Σ is computed independently of the variable metric algorithm, i.e. the approximation of the inverse Hessian matrix generated by the algorithm is not used.

[32] PR* = .20 for SUP75 and ZB75 and PR* = .26 for SUP79 and ZB79. These values approximate sample averages.

[33] A level of significance of 10% is maintained: a coefficient η is called significantly different from zero if $|\hat{\eta}| > 1.64\ \hat{\sigma}(\hat{\eta})$.

[34] Using a different model Nooteboom [1980] p. 202 reports estimations for threshold space which vary from 48 m^2 for Dutch chain superettes of 1973 to 191 m^2 for Dutch independent supermarkets of 1971.

[35] This space does not include space for cafeteria, petrol station, and other activities for hypermarkets. It does not include space for petrol station activities for supermarkets, but includes space for cafeteria activities, which unfortunately is not available separately.

[36] These sales do not include possible cafeteria, petrol station and other activities sales.

[37] NF* = .47 for "magasins populaires", NF* = .63 for hypermarkets and NF* = .18 for supermarkets. These values approximate sample averages.

[38] For the French samples occupancy costs are replaced by total non-labour costs, because the former are not available.

[39] The "Loi Royer" imposes tax according to the amount of selling space for large establishments. See Beaujeu and Garnier [1979] for a description of the history, regulations and impact of the "Loi Royer" in France. It seems worthwhile to study whether the value of π decreased in recent years. This decrease is not found in our data.

[40] We tested our model on French samples not only because they consist of large establishments as opposed to the smaller Dutch establishments or simply to have results from different countries, but also because they play an important role in French retailing. The market share of hypermarkets, supermarkets and "magasins populaires" in total retailing sales grew from 17.9% in 1975 to 21.7% in 1979. See Marenco and Quin [1981], p. 23.

[41] The correlation coefficient between the vectors of residuals is relevant to conclude whether the assumption of a non-diagonal covariance matrix

Ω is meaningful: it would appear that independent estimation of our two equations only yields efficient estimates if their disturbance terms are independent. See Bodkin and Klein [1967].

[42] Urban shopping models often show the following setup (see for instance Lichfield [1970] for an extensive summary of spatial interaction models): total sales per shopping centre depend on size and attractiveness of the shopping centre, on size and attractiveness of competing centres and on the purchasing power of the population. Nooteboom [1980] p. 156 ff. continues this line of thought by assuming that the shopping centre market share per product group per establishment depends on the number of competitors within the shopping centre. However, in a conceptual explanation of sales per product group per establishment, the number of establishments in the shopping centre selling this product group has no obvious positive or negative influence. See Nooteboom [1980] p. 159. The same reasoning seems valid for the influence of the average size of these establishments on sales per product group per establishment. From this we conclude that these aspects of size of a shopping centre (number and size of competitors) have no obvious theoretical influence on sales per establishment. Presumably, aspects of attractiveness of the shopping centre, other aspects of size (e.g. total number of establishments) and size and attractiveness of competing centres are relevant to be taken into account.

[43] McClelland [1966], p. 111 shows a strong correlation between rent per m^2 and sales per m^2 for 21 different trades in West Germany in 1960. Nooteboom [1980], p. 204 ff. reports that the value of the elasticity of scale adjusted efficiency of shop space with respect to rent price is approximately .3 for independent butchers of 1974, independent self-service grocers of 1969 and independent supermarkets of 1971. Its value does not differ from zero in the case of independent self-service grocers of 1971 and chain supermarkets of 1971, 1973 and 1974. In his time-series study using averages per shop type (p. 259 ff.) the value of this elasticity is approximately .6 for the self-service grocery trade and the non-food trade. Its value does not differ from zero for the total food trade. All these samples are Dutch samples. Thurik and Van Schaik [1984] study differences in average floorspace productivity per shop type in the retail trade in the Netherlands in 1981. They report that the value of the elasticity of scale adjusted efficiency of floor-

space with respect to rent price is approximately 1. for 40 shop types. Thurik [1984a] reports the same value using data of 23 South African establishment types in 1979/80.

[44] Recently the French press devoted much attention the the problem of establishing weekly opening time. See Laresse [1980], Libre Service Actualités [1980a], [1980b], [1980c] and [1981] and Vié [1980].

APPENDIX TO CHAPTER TWO.

DATA AND FURTHER EXERCISES WITH DUTCH INDEPENDENTS.

A.2.1. Data.

Table A.2.1. Description of the samples used.

code	number of observations	country	year of collection	shop type	type of organization
SUP73	73	Netherlands	1973	supermarket	chain
SUP74	91	Netherlands	1974	supermarket	chain
ZB7374	39	Netherlands	1973,1974	superette	chain
SUP75	60	Netherlands	1975	supermarket	independent
ZB75	73	Netherlands	1975	superette	independent
SUP79	104	Netherlands	1979	supermarket	independent
ZB79	111	Netherlands	1979	superette	independent
MP7579	71	France	1975,76, 78,79	"magasin populaire"	mainly independent
HYP7577	68	France	1975,76,77	hypermarket	mainly independent
SUP7579	121	France	1975,76, 78,79	supermarket	mainly independent

The difference between superettes and supermarkets in the Netherlands is defined by the sales share of fresh products, particularly meat. In France a supermarket has a selling area smaller than 2500 m^2, a hypermarket has an area larger than 2500 m^2 and a "magasin populaire" has a large share of non-food sales: it can be associated with a variety store, "five-and-ten" store or Dutch "Hema", but it has an integrated supermarket. More precise definitions of the French shop types are given in the appendix to chapter six. The data of the Dutch chain establishments were provided by a large Dutch enterprise on a confidential basis. The remaining Dutch data were gathered by the field force of E.I.M. The type of organisation of an establishment is called independent if the enterprise to which the establishments belongs consists of one establishment. There are exceptions in the Dutch samples: the enterprise consists of a few establishments. The French samples consist of establishments which are primarily independent, but there are also establishments belonging to large chains or operating in cooperative form. The French data were composed on basis of studies of the French weekly Libre Service Actualités ("Point de Repère"). See Table A.6.1. Full data (except chain establishments) are available on request at E.I.M., P.O. Box 96818, The Hague.

Table A.2.2. Further description of the Dutch samples: W_i is total available floorspace, C_i selling area, R_i remaining space, Q_i total annual sales, HV_i occupancy costs per m^2, NF_i non-food sales share, VL_i meat (products) sales share, PR_i fresh food sales share. Floorspace is expressed in 10^2 m^2. Sales is expressed in 10^3 Dutch guilders of 1979. Occupancy costs are expressed in Dutch guilders of 1979.

code	$\min W_i$ $\overline{W}$ $\max W_i$	$\min C_i$ $\overline{C}$ $\max C_i$	$\min R_i$ $\overline{R}$ $\max R_i$	$\min Q_i$ $\overline{Q}$ $\max Q_i$	$\min HV_i$ $\overline{HV}$ $\max HV_i$	$\min NF_i$ $\overline{NF}$ $\max NF_i$	$\min VL_i$ $\overline{VL}$ $\max VL_i$	$\min PR_i$ $\overline{PR}$ $\max PR_i$
SUP73	6.76	4.06	1.10	4406	125		.080	
	13.98	9.36	4.62	9300	225		.132	
	40.00	24.45	15.55	21379	335		.210	
SUP74	4.71	4.06	.49	3272	118		.071	
	13.86	9.33	4.53	8691	210		.119	
	40.00	24.45	15.55	19611	313		.184	
ZB7374	1.40	0.90	.30	1214	117		.000	
	3.06	1.93	1.14	2295	197		.050	
	6.70	3.41	3.29	4740	351		.196	
SUP75	2.71	1.81	.37	1304	78	.010	.080	.090
	5.60	3.77	1.83	3078	166	.063	.222	.193
	10.56	8.56	4.80	5341	278	.170	.370	.330
ZB75	1.10	0.60	.29	408	59	.030		.015
	2.13	1.26	.87	929	113	.103		.183
	4.40	2.85	2.05	2064	218	.140		.450
SUP79	2.21	1.65	.47	1264	72	.040	.000	.150
	5.92	4.20	1.72	3122	177	.087	.200	.258
	16.90	10.00	6.90	7157	287	.140	.330	.390
ZB79	.73	.38	.15	452	43	.010	.000	.050
	2.37	1.53	.84	1083	134	.081	.070	.272
	9.54	6.00	3.54	3759	226	.200	.200	.480

Table A.2.3. Further description of the French samples: W_i is total available floorspace, C_i selling space, R_i remaining space, Q_i total annual sales, HV_i non-labour costs per m^2, DO_i weekly opening time, NF_i non-food sales share. Floorspace is expressed in 10^3 m^2, DO_i in hours, sales in 10^6 French francs and non-labour costs in French francs.

code	$minW_i$ $\bar{W}$ $maxW_i$	$minC_i$ $\bar{C}$ $maxC_i$	$minR_i$ $\bar{R}$ $maxR_i$	$minQ_i$ $\bar{Q}$ $maxQ_i$	$minHV_i$ $\overline{HV}$ $maxHV_i$	$minDO_i$ $\overline{DO}$ $maxDO_i$	$minNF_i$ $\overline{NF}$ $maxNF_i$
MP7579	.943	.591	.303	9.408	28	40	.224
	2.851	1.332	1.519	22.836	62	47.3	.473
	5.960	2.995	4.060	47.901	130	60	.705
HYP7577	3.500	2.500	.462	34.010	14	52	.528
	12.523	5.898	6.625	125.086	58	69.6	.631
	26.214	13.000	20.375	275.120	144	78	.776
SUP7579	.461	0.400	.061	5.230	20	40	.044
	1.717	1.030	.687	19.439	73	49.3	.178
	4.550	2.430	2.120	60.280	159	78	.329

A.2.2. Further exercises with Dutch independents.

In section 2.6 the values found for the selling area threshold of independents are said to be surprisingly low: they do not differ significantly from zero. Two comments can be made with respect to this result:

- most independent supermarkets have a butcher's shop (for SUP75 46 out of 60 and for SUP79 81 out of 104). Probably, there ar not enough observations of supermarkets without a butcher's shop to establish a proper estimation of their threshold;
- for ZB75 all 73 observations have a total floorspace which is larger than 110 m^2 and smaller than 440 m^2; for ZB79 107 out of 111 observations have a

total floorspace which is larger than 104 m^2 and smaller than 488 m^2. Probably, the range of observations of superettes is too limited to establish a proper estimation of their threshold.

The observations of the samples of the independents are grouped together. The results are given in Table A.2.4. Compared with Table 2.2 equation (2.6.1a) is used instead of (2.6.1):

$$(2.6.1a) \qquad \beta_i = \beta_0\left(\frac{HV_i}{\overline{HV}}\right)^{\beta_1} \exp[\beta_2\, f(NF_i) + \beta_3(VL_i - \overline{VL}) + \\ + \beta_4\, DPR_i + \beta_5\, DSU_i],$$

where $DSU_i = 1$ if the establishment is a supermarket and 0 otherwise. The other variables and coefficients are explained in section 2.6. We shall not discuss the results of Table A.2.4 in detail, since they are not surprising in the light of the results of Table 2.2. It is worth noting however, that the value of the threshold coefficient $\hat{\gamma}_{10}$ tends to be negative. Furthermore, it is worth noting that the goodness of fit of the analysis where all supermarkets and superettes of both 1975 and 1979 are grouped, is surprisingly high.

Table A.2.4. Estimates of coefficients on the model consisting of equations (2.5.1) and (2.5.2) with (2.6.1a), (2.6.2) and (2.6.3): Dutch independents.

shop type		SUP75 ∪ SUP79	ZB75 ∪ ZB79	SUP75 ∪ SUP79 ∪ ∪ ZB75 ∪ ZB79
average efficiency	$\log\hat{\beta}_0$	7.19 (.15)	6.63 (.09)	6.58 (.08)
occupancy costs	$\hat{\beta}_1$	.595 (.066)	.614 (.068)	.630 (.048)
non-foods	$\hat{\beta}_2$	-.583 (.658)*	.424 (.581)*	.214 (.438)*
meat products	$\hat{\beta}_3$	.248 (.346)*		.343 (.294)*
fresh products	$\hat{\beta}_4$	.057 (.036)*	.082 (.037)	.068 (.026)
supermarkets	$\hat{\beta}_5$			.497 (.046)
threshold	$\hat{\gamma}_{10}$	-.03 (.40)*	-.26 (.16)*	-.37 (.15)
butcher's shop	$\hat{\gamma}_{11}$	.67 (.22)		.78 (.16)
distribution	$\hat{\pi}_0$	.654 (.024)	.641 (.021)	.664 (.014)
fresh products	$\hat{\pi}_1$	.031 (.017)	.046 (.015)	.035 (.011)
sales elasticity	$\hat{\varepsilon}$	.792 (.079)	.815 (.081)	.845 (.057)
number of observations	I	164	184	348
neg.conc.loglikelihood	L	496.1	465.5	1259.5
goodness of fit 1	r^2	.66	.73	.87
goodness of fit 2	r^2	.85	.86	.93
goodness of fit 3	r^2	.56	.64	.70
correlation of residuals	r	-.01	.22	.07

Note Table A.2.4: see Note Table 2.2.

CHAPTER THREE.

FURTHER STUDY OF THE USE OF RETAIL FLOORSPACE AND ITS EFFICIENCY.

3.1. Introduction.

In chapter two a model is presented which attempts to describe the relation between total available floorspace, the value of total annual sales and the partitioning of total available floorspace into selling area and remaining space. This model consists of three equations: a "production function" which assumes that the value of annual sales is a function of selling area and remaining space and the "shop design expansion path", which assumes that selling area (and hence also its complement, remaining space) is a function of total available floorspace. The model is applied to cross-section samples of supermarket(-like) shop types.

The aim of our present study is to apply this model to other shop types, to examine the influence of some environmental variables and to extend the model by considering the partitioning of total available floorspace into selling area, own production space and remaining space.

In the present chapter the original model is called model one. This model is applied to eleven samples of Dutch shop types [1]. Some of their properties are described in the appendix to this chapter.

Model two is an extension of model one. It consists of four equations: a "production function", which assumes that the value of annual sales is a function of selling area, own production space and remaining space and the "shop design expansion path", which assumes that selling area, own production space (and hence also their complement remaining space) are functions of total available floorspace. This model is applied to three of the eleven samples, for which this detailed partitioning of floorspace is available.

Both models are refined by studying the influence of the specific properties of the establishments on the values of the coefficients of the basic models. Specific properties investigated are: occupancy costs, average percentage gross margin, size of the shopping centre, size of the township etc. Model one is briefly discussed in section 3.2: it is a concise form of sections 2.2 through 2.5 of chapter two. It is adapted to the shop types considered in this chapter. The results of the tests with this model are reported in section 3.3.

Section 3.4 deals with model two. The results of the tests with this model are reported in section 3.5. The final section gives conclusions and a summary. Generally, these are the same as those reported in the supermarket study of chapter two.

3.2. Model one.

This section is a concise form of sections 2.2 through 2.5. It is adapted to the shop types considered in this chapter. A brief enumeration of the maintained hypotheses is given, as well as the basic three equations-model in which they result. The maintained hypotheses of this chapter are the same as those of chapter two, in other words: the same model is applied to supermarket-like shop types in chapter two and to other shop types in the present chapter. See Table A.3.1 of the appendix to this chapter for an enumeration of these shop types.
Next, some figures are given in an attempt to support these assumptions. Further hypotheses are discussed unless they have been dealt with in section 2.4. Finally, the estimation procedure and some preliminary exercises are reported.

The following five assumptions are maintained in model one of the relation between total available floorspace and the value of total annual sales and the partitioning of total available floorspace into selling area and remaining space for establishments of a certain shop type:

i) the value of annual sales of a retail establishment depends on characteristics of the establishment itself and of the environment of the establishment. The latter are left out of consideration, because the former are assumed to play a predominant role and because the latter are hardly available in a consistent manner. In this chapter however, size of the shopping centre and size of the township are taken into account;

ii) total available floorspace of establishment i, W_i, equals the sum of selling area C_i and remaining space R_i:

$$(3.2.1) \quad W_i \triangleq C_i + R_i;$$

iii) total available floorspace is exogenous;

iv) the value of annual sales in establishment i, Q_i, depends on the size of its selling area and of its remaining space:

(3.2.2) $$Q_i = \beta(C_i - \gamma_1)^{\pi\varepsilon} (R_i - \gamma_2)^{(1-\pi)\varepsilon}$$

with $\beta > 0$, $0 \leq \gamma_1 < C_i$, $0 \leq \gamma_2 < R_i$, $0 < \pi < 1$ and $\varepsilon > 0$.
The coefficients in (3.2.2) have the following interpretation: β denotes efficiency; ε gives the degree of homogeneity, if $C - \gamma_1$ and $R - \gamma_2$ are regarded as input factors. The value one indicates constant returns to scale, and increasing or decreasing returns are indicated by values greater or less than unity; π indicates the degree to which an establishment is selling area intensive. It is called distribution coefficient; γ_1 and γ_2 can be associated with threshold spaces: space which must be present in every establishment of a shop type, its size being equal for all establishments. The vector of coefficients is called θ with $\theta' =$
$= (\beta\ \gamma_1\ \gamma_2\ \pi\ \varepsilon)$;

v) a shopkeeper tries to maximize the value of annual sales by manipulating the partitioning of total available floorspace. The first order conditions give

(3.2.3) $$C_i = \gamma_1 + \pi(W - \gamma_1 - \gamma_2)$$

and

(3.2.4) $$R_i = \gamma_2 + (1-\pi)(W - \gamma_1 - \gamma_2).$$

Substituting (3.2.3) and (3.2.4) in (3.2.2), the elasticity of the value of annual sales with respect to total floorspace, E, reads

(3.2.5) $$E \triangleq \frac{d\log Q}{d\log W} = \varepsilon\ W/(W - \gamma_1 - \gamma_2).$$

E decreases with scale W, if indeed $\gamma_1 + \gamma_2 > 0$.
It is assumed that $\varepsilon \leq 1$: diseconomies arise because changes in the nature of the assortment composition, caused by increasing scale, produce diseconomies. See section 2.3. Counterforces due to increasing price level [2] and attractiveness are not capable of producing conclusive economies.
Coefficient ε determines, together with $\gamma_1 + \gamma_2$, the scale of an establishment above which diseconomies arise. Rearranging (3.2.5) we get

(3.2.8) $W = (\gamma_1 + \gamma_2)\ E/(E-\varepsilon).$

We see that $E \gtrless 1$ for all $W \lessgtr W^*$, where W^* denotes the scale of an establishment where $E = 1$.
Hypotheses H1 ($\gamma_1 + \gamma_2 > 0$) and H2 ($\varepsilon \leq 1$) are also tested in the present chapter.

Scatter diagrams are presented in Figure 3.1 (greengrocers: GRE78), Figure 3.2 (independent clothes shops: CLI79) and Figure 3.3 (florist's shops: FLO80) to give some justification for the maintained hypotheses: linearity of the relationship between selling area and total available floorspace cannot be rejected. No clear relationship is apparent between value of annual sales and total available floorspace.

Differences in the characteristics of establishments within a shop type will also be discussed in this chapter as well as consequences regarding the value of the coefficients of our model. Most specific properties are assumed to influence the efficiency coefficient; others are assumed to influence the distribution coefficient. The choice of which specific properties are used depends largely on availablitly of data: the influence of occupancy costs, average percentage gross margin, size of the shopping centre and size of the township are studied for all eleven samples; the influence of men's wear sales share is studied for independent and chain clothes shops; the influence of own production is studied for photographer's shops, florist's shops and electrotechnical retailers.

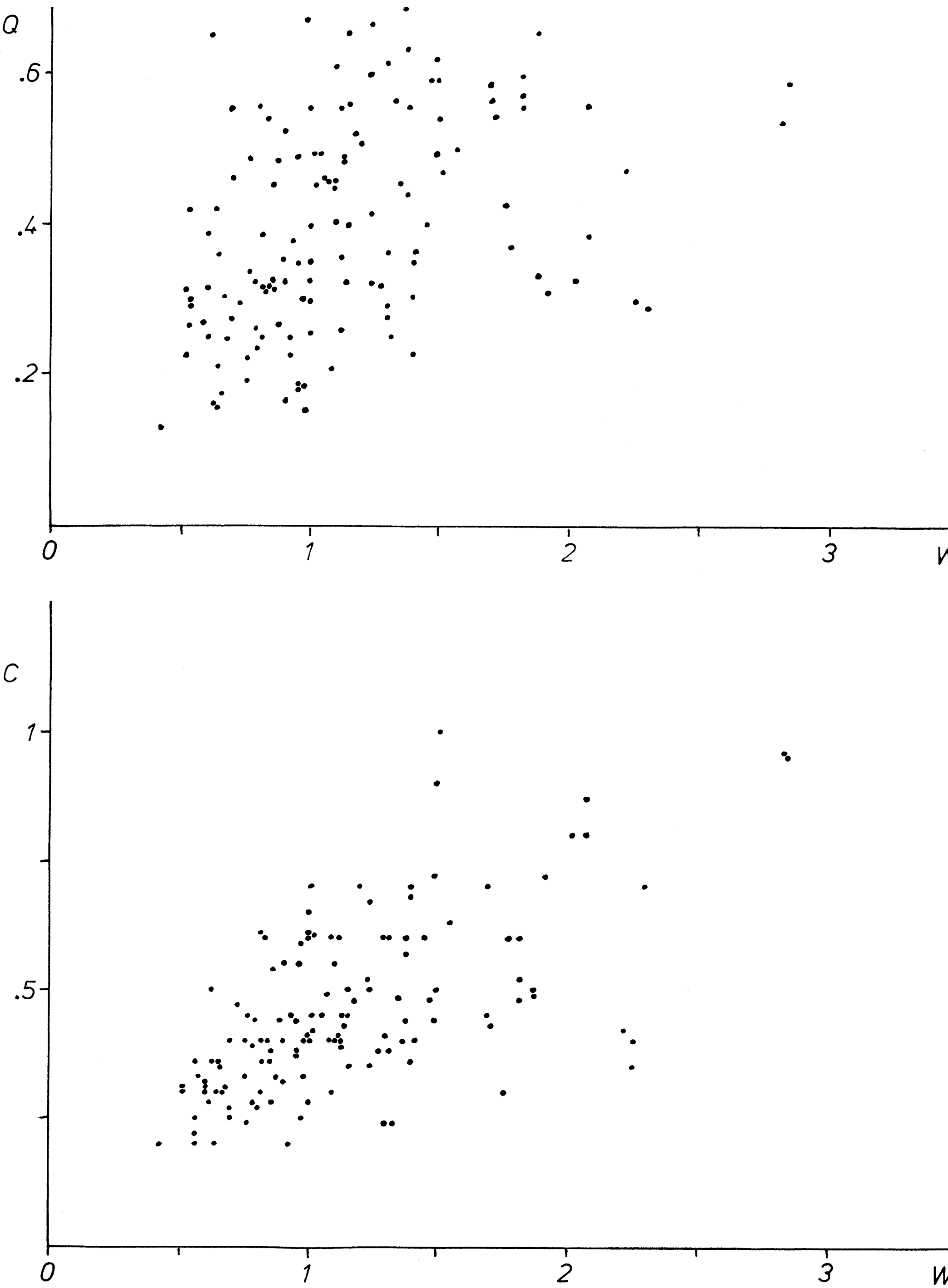

Figure 3.1. Scatter diagrams for GRE78 (Dutch greengrocers of 1978). W: total available floorspace (in 10^2 m^2); C: selling area (in 10^2 m^2); Q: value of annual sales (in 10^6 Dutch guilders).

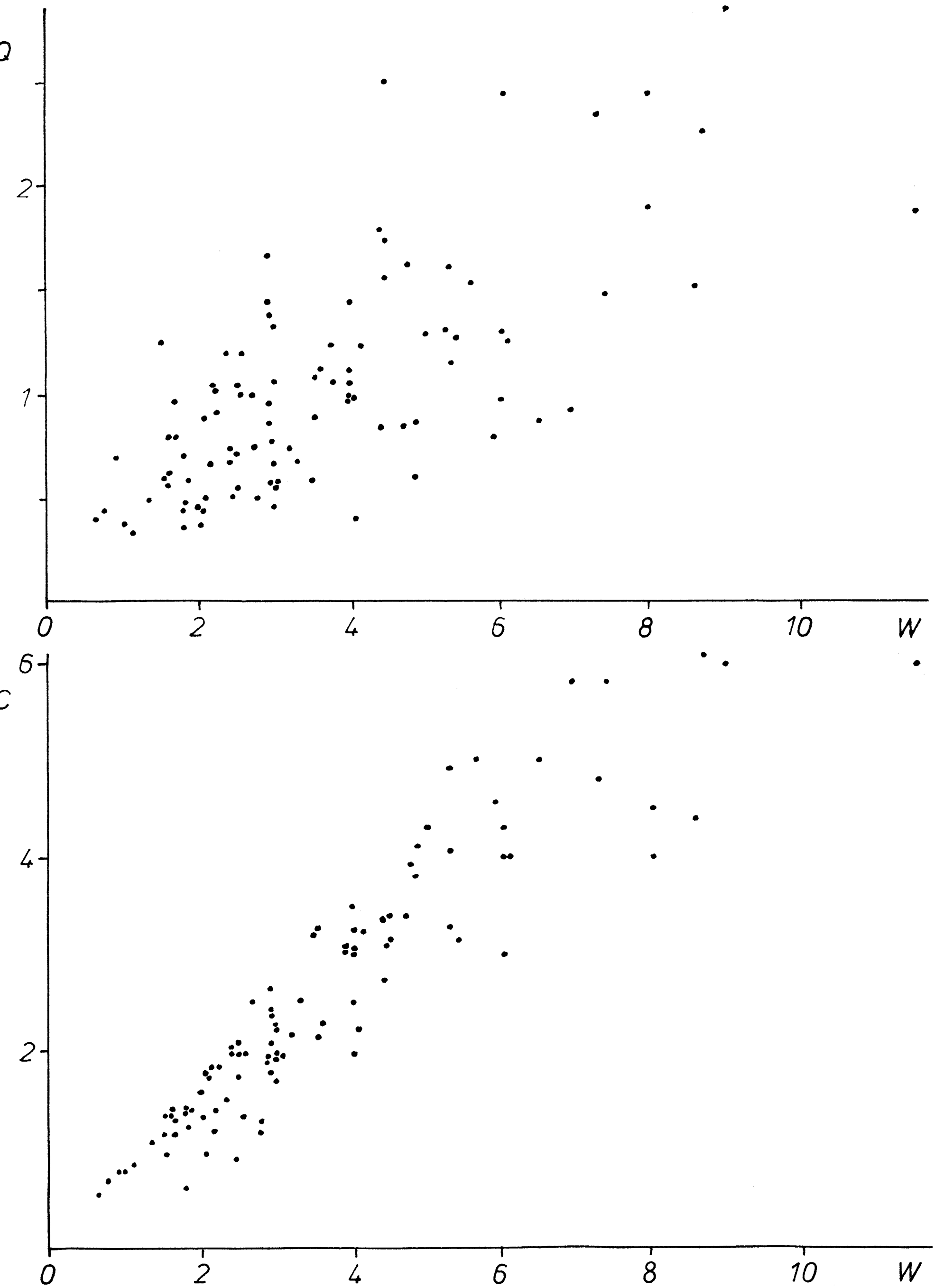

Figure 3.2. Scatter diagrams for CLI79 (Dutch independent clothes shops of 1979). W: total available floorspace (in 10^2 m^2); C: selling area (in 10^2 m^2); Q: value of annual sales (in 10^6 Dutch guilders).

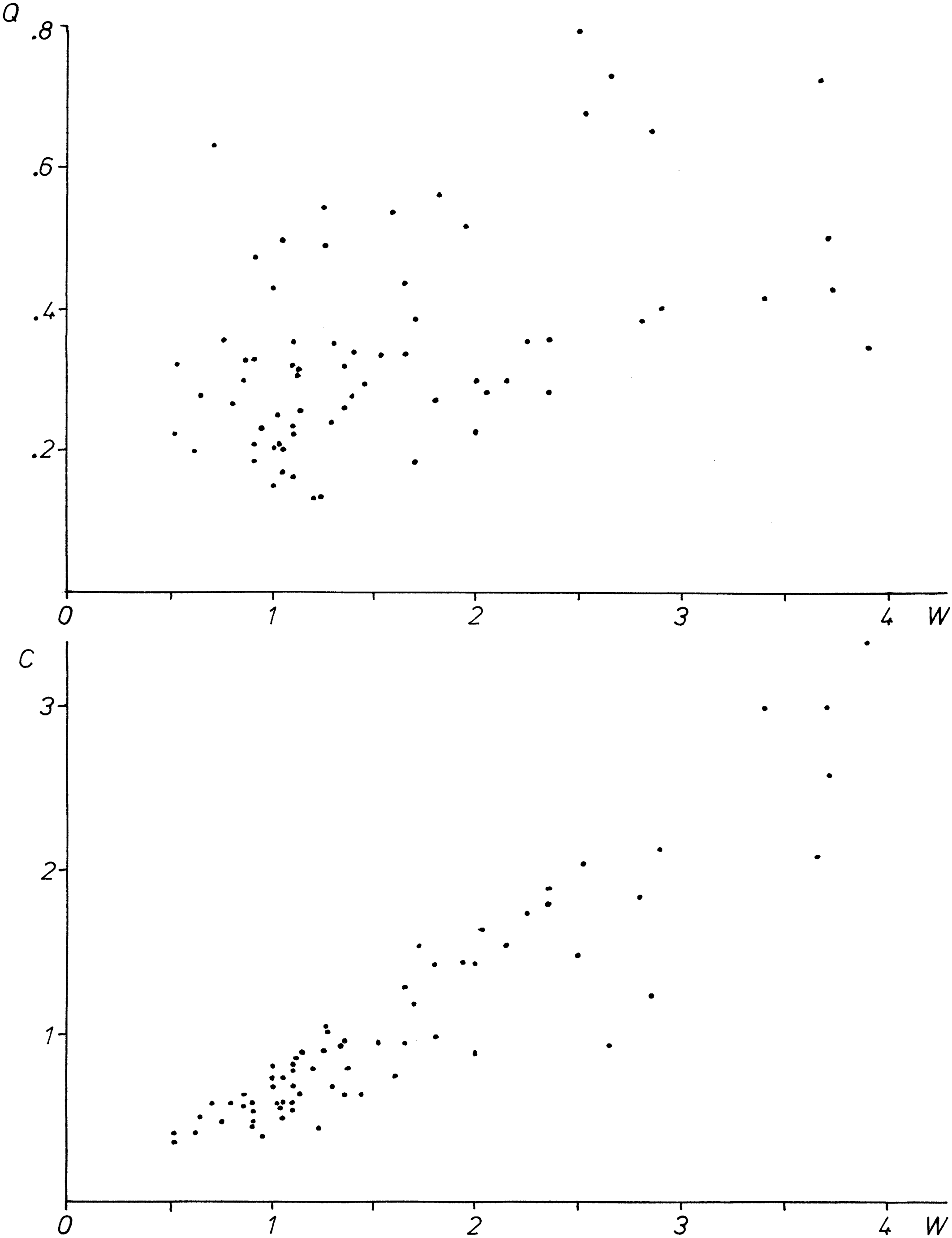

Figure 3.3. Scatter diagrams for FL080 (Dutch florist's shops of 1980). W: total available floorspace (in 10^2 m^2); C: selling area (in 10^2 m^2); Q: value of annual sales (in 10^6 Dutch guilders).

Occupancy costs.

Hypothesis H3 (efficiency of total available floorspace increases if occupancy cotst per unit of floorspace increase) is also tested in the present chapter. See section 2.4 and footnote 43 of chapter two.

Gross margin.

Hypotheses H11 (efficiency of total available floorspace decreases if average percentage gross margin increases) is also tested in the present chapter. See section 2.4.

Shopping centre.

The size of a shopping centre is defined as the number of retail establishments it consists of. If the size of a shopping centre increases, attractiveness increases and thereby the efficiency of total available floorspace of its establishments. The possible number of competitors also increases and then the efficiency of total available floorspace decreases. We have no hypothesis about the influence of the size of a shopping centre on the efficiency of total available floorspace. However, it is interestng to study its influence.

Township.

The size of a township is defined by its population number. If the size of a township increases, its purchasing power increases and then the efficiency of total available floorspace of its establishments is likely to increase. The possible number of competitors also increases and then the efficiency of total available floorspace decreases. We have no hypothesis about the influence of the size of a township on the efficiency of total available floorspace. Important variables in conjunction with the size of a township seem to be: number of competitors, pupulation density, purchasing power per inhabitant or the regional function of the township. These variables are lacking in the present samples. However, it is interesting to study the influence of the size of a township.

Men's wear.

The sales of clothes shops consist of men's wear, ladies and children's wear and other apparel.
Without stating a hypothesis we study the influence of men's wear sales share on efficiency of total available floorspace for the two clothes shop types.

Own production.

The own production sales share plays a role in differences of efficiency of total available floorspace and in the partitioning of floorspace. The concept of own production has largely differing meanings for the shop types studied in this chapter. If a florist's shop selling area consists for a large part of a greenhouse, it is assumed that selling area intensity increases and that efficiency of total available floorspace decreases (a shopkeeper cannot afford to build a greenhouse on a favourable, expensive site).

H13A: efficiency of total available floorspace decreases if selling area of a florist consists for a large part of a greenhouse.

H13B: selling area intensity increases if selling area of a florist's shop consists for a large part of a greenhouse.

If an electro-technical retailer also deals in electronic installations and repairs, selling area intensity is assumed to decrease, because the preparations for these installations will take remaining space. The influence on efficiency of total available floorspace is assumed twofold: if an electro-technical retailer is also involved in installations and repairs, it could be said that sales are generated outside the establishment so that efficiency will increase. However, such a retailer is not likely to allocate space for the preparations of installations and repairs if he occupies a favourable expensive site. We have no hypothesis about the influence on efficiency of total available floorspace.

H14: selling area intensity decreases if an electro-technical retailer is also involved in installations and repairs.

Total sales of photographer's shops consists of retail sales (including developing and printing, which is usually contracted out to a laboratory) and own production sales, for which a studio and/or dark room is used. Regarding the influence of the retail sales share of photographer's shops the following hypotheses are made:

H15A: efficiency of total available floorspace increases if the retail sales share of photographer's shops increases.

H15B: selling area intensity increases if the retail sales share of photographer's shops increases.

We ignore the implication of the further hypotheses discussed in the previous part of this section. The coefficients of the model consisting of equations (3.2.2), (3.2.3) and (3.2.4) are estimated after taking logarithms in (3.2.2), omitting (3.2.4) and specifying an additive disturbance structure:

$$\text{(3.2.7)} \qquad \log Q_i = \log\beta + \pi\varepsilon\log\frac{\pi}{1-\pi} + \varepsilon\log(W_i - \gamma_1 - \gamma_2)(1-\pi) + v_{1i};$$

$$\text{(3.2.8)} \qquad C_i = \gamma_1 + \pi(W_i - \gamma_1 - \gamma_2) + v_{2i},$$

where $V_i = \binom{v_{1i}}{v_{2i}} \sim N(0,\Omega)$ for $i = 1, \ldots, I$: bivariate normal distribution with zero means and constant, positive definite and symmetric covariance matrix $\Omega = \begin{pmatrix}\omega_{11} & \omega_{12}\\ \omega_{21} & \omega_{22}\end{pmatrix}$. In addition, it is assumed that $E(V_i V_{i'}') = 0$ for $i \neq i'$.

Full information maximum likelihood estimates are found by locating a maximum of the likelihood function with respect to θ after concentrating this function with respect to Ω [3].

It is assumed in the remaining part of this study that $\gamma_2 = 0$. This is assumed because in preliminary exercises $\hat{\gamma}_2$ did not differ significantly from zero and because we are more interested in the selling area threshold than in the remaining space threshold (selling area is more important than remaining space; the threshold hypothesis developed by Nooteboom [1980] refers to selling area; the value of the remaining space threshold may never be large, since $\gamma_2 < \min R_i$ and generally $\min R_i \ll \min C_i$ [4]).

The disturbance terms are assumed to have a homoskedastic structure: their variance is not assumed to increase according to a function of an explanatory variable or to the expectation of the variable to be explained. This assumption is made because

- a heteroskedastic structure is not decisively indicated by the scatter diagrams (of Figures 3.1 through 3.3). These scatter diagrams indicate that the disturbance variance increases primarily at the lower end of the scale range;
- in the determination of the estimates such a heteroskedastic structure assigns a high weight to the observations at the lower end of the scale. This may be a drawback, because sometimes our samples are not randomly collected at the lower end of the scale: lower limits are set to value of annual sales or size of floorspace or selling area.

3.3. Tests with model one.

The hypotheses mentioned in section 3.2 will be tested. Occupancy costs, average percentage gross margin, shopping centre size and town size are assumed to influence efficiency of total available floorspace, β.
Various other factors are also assumed to play a role. For the time being, these factors are described using the dummy variables DX1, DX2, DX3 and DX4. We shall use a model consisting of equations (3.2.7) and (3.2.8) where β, π and ε are substituted by β_i, π_i and ε_i:

$$(3.3.1) \qquad \beta_i = \beta_0\left(\frac{HV_i}{\overline{HV}}\right)^{\beta_1} [\exp\beta_2(M_i - \bar{M})] \left(\frac{SC_i}{\overline{SC}}\right)^{\beta_3} \left(\frac{TS_i}{\overline{TS}}\right)^{\beta_4} \times$$

$$\times \exp(\beta_5 DX1_i + \beta_6 DX2_i);$$

$$(3.3.2) \qquad \pi_i = \pi_0 + \pi_1 DX3_i;$$

$$(3.3.3) \qquad \varepsilon_i = \varepsilon_0 + \varepsilon_1 DX4_i,$$

where W_i: total available floorspace (in 10^2 m^2) of establishment i;
C_i: selling area (in 10^2 m^2);
Q_i: value of annual sales (in 10^3 Dutch guilders);
HV_i: occupancy costs per m^2 (in Dutch guilders);
$\overline{HV} = (\sum_{i=1}^{I} HV_i)/I$: sample average occupancy costs per m^2;
M_i: average percentage gross margin divided by 100. See equation (2.2.9);

SC_i: indicator of size of shopping centre: SC_i increases if the size of the shopping centre (expressed in number of establishments) increases;

TS_i: indicator of size of township: TS_i increases if the size of the township (expressed in population number) increases;

$\bar{M}$, $\overline{SC}$ and $\overline{TS}$: sample averages defined in the same manner as $\overline{HV}$;

$DX1_i$: dummy variable which has different interpretations according to the sample where it is used and which describes factors influencing β_i:

- columns CLI79, CLC79 and CLI79 ∪ CLC79 of Table 3.2 (independent and chain clothes shops)
  $DX1_i$ = 1 if men's wear sales share is less than 60% and 0 otherwise;
- column SHO76 of Table 3.3 (shoe shops)
  $DX1_i$ = 1 if selling area is smaller that $50m^2$ and 0 otherwise;
- column IMO77 of Table 3.3 (ironmonger's shops)
  $DX1_i$ = 1 if selling area is relatively small and 0 otherwise;
- column PHO80 of Table 3.3 (photographer's shops)
  $DX1_i$ = 1 if the retail sales share exceeds 85% and 0 otherwise;
- column FLO80 of Table 3.3 (florist's shops)
  $DX1_i$ = 1 if selling area consists for a large part of a greenhouse and 0 otherwise;
- column ELE80 of Table 3.3 (electro-technical retailers)
  $DX1_i$ = 1 if electric installations are also made and 0 otherwise;

$DX2_i$: dummy variable which indicates the shop type of an establishment and which describes factors influencing β_i:

- column BAK77 ∪ CON77 of Table 3.1
  $DX2_i$ = 1 if the establishment is a confectioner's shop and 0 otherwise (establishment is a baker's shop);
- column CLI79 ∪ CLC79 of Table 3.2
  $DX2_i$ = 1 if the establishment belongs to a chain and 0 otherwise (establishment is independent);

$DX3_i$: dummy variable with different interpretations, which is either equal to $DX2_i$ or to $DX1_i$, according to the sample where it is used and which describes factors influencing π_i:
- column BAK77 ∪ CON77 of Table 3.1
  $DX3_i = DX2_i$;
- column CLI79 ∪ CLC79 of Table 3.2
  $DX3_i = DX2_i$;
- Table 3.3
  $DX3_i = DX1_i$;

$DX4_i$: dummy variable used in column BAK77 ∪ CON77 of Table 3.1, which describes a factor influencing ε_i: $DX4_i = DX2_i$ (= $DX3_i$).

The definition of the dummy variables $DX1_i$ to $DX4_i$ depends primarily on restrictions of our data sources. However, $DX1_i$ for ironmonger's shops (describing the relative size of selling area) is introduced assuming that shops are involved in lending equipment to customers, if $DX1_i = 1$.

Interpretation of coefficients of (3.1), (3.2) and (3.3):
β_0: measure for the average efficiency of floorspace;
β_1: elasticity of β_i with respect to $HV_i/\overline{\overline{HV}}$;
β_2: influence of average percentage gross margin;
β_3: elasticity of β_i with respect to $SC_i/\overline{\overline{SC}}$;
β_4: elasticity of β_i with respect to $TS_i/\overline{\overline{TS}}$;
β_5: various influences;
β_6: influence of shop type;
π_0: distribution coefficient if $DX3_i = 0$ or if $DX3_i$ is not available;
$\pi_0 + \pi_1$: distribution coefficient if $DX3_i = 1$;
ε_0: asymptotic total floorspace elasticity of annual sales if $DX4_i = 0$ or if $DX4_i$ is not available;
$\varepsilon_0 + \varepsilon_1$: asymptotic total floorspace elasticity of annual sales if $DX4_i = 1$.

The following conclusions can be drawn from Table 3.1 (food shop types), Table 3.2 (clothes shop types) and Table 3.3 (other shop types) regarding the hypotheses formulated above:

H1: $\hat{\gamma}_1 > 0$ in twelve out of thirteen cases [5] and significantly [6] in seven: $\hat{\gamma}_1 < 0$ but not significantly for ironmonger's shops. We do not understand this low value [7]. $\hat{\gamma}_1 > 0$ but not significantly in five cases, but always $\hat{\gamma}_1 > \hat{\sigma}(\hat{\gamma}_1)$. Ignoring the result for ironmonger's shops, we conclude that a positive value is found for the selling area threshold: its value ranges from 12 to 30 m^2. Support is found for the hypothesis that the elasticity of the value of annual sales with respect to total available floorspace, E, decreases with scale for all shop types.

H2: $\hat{\varepsilon} < 1$ in all thirteen cases and significantly in ten: $\hat{\varepsilon}$ is not significantly different from one for confectioner's shops, ironmonger's shops and electro-technical retailers. Support is found for the hypothesis that the asymptotic elasticity of the value of annual sales with respect to total available floorspace is not greater than one: a value less than one is inferred from the estimations. The shop size below which $E > 1$, W^*, can be computed with (3.2.6). Their values are given in Table 3.4. Their values are not reliable when placed between brackets. The values not placed between brackets generally do not differ much from $\min W_i$: no evidence is found that $E > 1$ for the shop types studied.

H3: $\hat{\beta}_1 > 0$ and significantly for all thirteen cases. Strong support is found for the hypothesis that efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase. The elasticity of β_i with respect to relative occupancy costs per m^2 $HV_i/\overline{\overline{HV}}$, β_1, varies between .292 for women's underwear shops and .812 for confectioner's shops. Ignoring the results for greengrocers ($\hat{\beta}_1 = .434$) and for women's underwear shops ($\hat{\beta}_1 = .292$), the remaining eleven $\hat{\beta}_1$ do not differ significantly from .65.

H11: $\hat{\beta}_2 < 0$ in eleven of our thirteen cases and significantly in seven: $\hat{\beta}_2 > 0$ for women's underwear shops and shoe shops and significantly only for women's underwear shops. We have no clear explanation for this last result. A hypothesis is that a women's underwear shop can only be run succesfully (i.e. high floorspace efficiency), if the assortment composition is deep (high margins), whereas less succesful shops continue to exist. Ignoring the result for women's underwear shops, we conclude that support is found for the hypothesis that efficiency of total available floorspace decreases if average percentage gross margin increases. There is considerable variation in the values found for β_2 among the shop types. This variation and the high errors are assumed to result from the fact that average percentage gross margin is a far from ideal indicator for assortment composition or labour intensity. See section 2.4. From the results concerning we conclude that the explanation of equation

(3.2.2) is likely to increase, if gross margin is taken instead of annual sales as the left-hand variable, because $\hat{\beta}_2$ differs significantly from -1 in only two out of thirteen cases. We would like to emphasize that the use of average percentage gross margin is a mere experiment. Further experiments pointed out that

i) estimation results hardly change, if average percentage gross margin is ommited;

ii) average percentage gross margin does not appear to influence the value of the distribution coefficient.

The former result is reassuring for those who object justifiably to the use of average percentage gross margin. The latter is disturbing the role of the distribution coefficient as a marketing mix indicator.

Note Table 3.1: the asymptotic distribution of the maximum likelihood estimates is assumed to be multivariate normal. Estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficients. An asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$, i.e. if η is not significantly different from zero at a 10% level of significance. The square of the correlation coefficient between the vectors of the dependent variable and its estimation is taken as a measure of goodness of fit: 1 refers to the antilog form of equation (3.2.7), 2 to equation (3.2.8) and 3 to equation (3.2.4). The correlation coefficient between the vectors of residuals of equations (3.2.7) and (3.2.8) is computed. Its value is relevant to conclude whether our assumption of a non-diagonal covariance matrix Ω is meaningful.

π_1 and ε_1 in column BAK77 $\cup$ CON77 are associated with the influence whether or not the establishment is a confectioner's shop.

Table 3.1. Estimates of coefficients of the model consisting of equations (3.2.7) and (3.2.8) with (3.3.1), (3.3.2) and (3.3.3): food shop types.

shop type		GRE78	BAK77	CON77	BAK77 ∪ CON77	
average efficiency	$\log\hat{\beta}_0$	6.35 (.05)	5.98 (.04)	6.11 (.04)	6.05 (.04)	
occupancy costs	$\hat{\beta}_1$	.445 (.066)	.564 (.092)	.812 (.121)	.662 (.076)	
% gross margin	$\hat{\beta}_2$	-1.174 (.490)	-.692 (.680)*	-1.348 (.530)	-.952 (.421)	
shopping centre	$\hat{\beta}_3$	.039 (.070)*	.195 (.091)	.175 (.181)*	.210 (.086)	
township	$\hat{\beta}_4$	.100 (.059)	.017 (.049)*	.327 (.092)	.107 (.046)	
confectioner's shop	$\hat{\beta}_6$				-.007 (.064)*	
threshold	$\hat{\gamma}_1$	.240 (.030)	.118 (.045)	.137 (.041)	.127 (.030)	
distribution	$\hat{\pi}_0$	.244 (.022)	.141 (.024)	.182 (.022)	.136 (.017)	$\hat{\pi}_1$ = .050 (.012)
sales elasticity	$\hat{\varepsilon}_0$	.485 (.059)	.727 (.099)	.974 (.101)	.774 (.100)	$\hat{\varepsilon}_1$ = .188 (.129)*
number of observations	I	133	89	77	166	
neg.conc.loglikelihood	L	208.4	95.7	80.1	298.4	
goodness of fit 1	r^2	.40	.55	.73	.64	
goodness of fit 2	r^2	.49	.27	.47	.40	
goodness of fit 3	r^2	.90	.93	.95	.90	
correlation of residuals	r	.01	.15	.01	.07	

Note Table 3.1: see preceding page.

Table 3.2. Estimates of coefficients of the model consisting of equations (3.2.7) and (3.2.8) with (3.3.1) and (3.3.2): clothes shop types.

shop type		CLI79	CLC79	CLI79 ∪ CLC79	WUN77
average efficiency	$\log\hat{\beta}_0$	6.58 (.10)	6.52 (.09)	6.59 (.08)	6.22 (.07)
occupancy costs	$\hat{\beta}_1$	.505 (.113)	.682 (.089)	.572 (.073)	.292 (.102)
% gross margin	$\hat{\beta}_2$	-.443 (.689)*	-1.913 (.889)	-.421 (.540)*	2.404 (1.020)
shopping centre	$\hat{\beta}_3$	.022 (.132)*	-.703 (.225)	-.136 (.110)*	.413 (.265)*
township	$\hat{\beta}_4$	.118 (.077)*	-.053 (.112)*	.034 (.063)*	.257 (.124)
men's wear	$\hat{\beta}_5$	-.041 (.064)*	.054 (.067)*	-.042 (.047)*	
chain establishment	$\hat{\beta}_6$			-.077 (.047)*	
threshold	$\hat{\gamma}_1$	.241 (.173)*	.230 (.177)*	.193 (.134)*	.297 (.106)
distribution	$\hat{\pi}_0$	.667 (.019)	.717 (.012)	.672 (.016) $\hat{\pi}_1$ = .045 (.017)	.573 (.046)
sales elasticity	$\hat{\varepsilon}_0$	.716 (.093)	.721 (.064)	.748 (.059)	.402 (.105)
number of observations	I	98	75	173	54
neg.conc.loglikelihood	L	267.3	152.8	551.9	60.9
goodness of fit 1	r^2	.63	.80	.72	.56
goodness of fit 2	r^2	.86	.97	.93	.57
goodness of fit 3	r^2	.70	.84	.77	.57
correlation of residuals	r	.06	-.41	-.05	-.12

Note Table 3.2: see Note Table 3.1.

π_1 in column CLI79 ∪ CLC79 is associated with the influence whether or not the establishment belongs to a chain.

Table 3.3. Estimates of coefficients of the model consisting of equations (3.2.7) and (3.2.8) with (3.3.1) and (3.3.2): shop types other than food or clothes.

shop type		SHO76	IMO77	PHO80	FLO80	ELE80
average efficiency	$\log\hat{\beta}_0$	6.26 (.04)	5.77 (.28)	6.65 (.07)	6.14 (.08)	6.75 (.09)
occupancy costs	$\hat{\beta}_1$	.619 (.078)	.488 (.129)	.540 (.099)	.733 (.117)	.636 (.094)
% gross margin	$\hat{\beta}_2$	.183 (.634)*	-2.155 (.763)	-1.835 (.697)	-1.071 (.586)	-.534 (.854)*
shopping centre	$\hat{\beta}_3$	.002 (.108)*	-.228 (.151)*	-.146 (.147)*	-.129 (.104)*	-.218 (.094)
township	$\hat{\beta}_4$	.107 (.064)	.308 (.104)	.150 (.093)	.143 (.115)*	.190 (.059)
other influences on efficiency	$\hat{\beta}_5$	.027 (.092)*	.010 (.133)*	.078 (.081)*	-.284 (.102)	.013 (.106)*
threshold	$\hat{\gamma}_1$	.141 (.081)	-.465 (.577)*	.249 (.062)	.120 (.114)*	.146 (.145)*
distribution	$\hat{\pi}_0$	.497 (.021)	.672 (.035)	.307 (.033)	.565 (.039)	.528 (.023)
other influences on distribution	$\hat{\pi}_1$	-.216 (.087)	-.202 (.055)	.047 (.026)	.212 (.036)	-.064 (.026)
sales elasticity	$\hat{\varepsilon}_0$	.719 (.075)	.838 (.154)	.515 (.090)	.621 (.104)	.911 (.083)
number of observations	I	118	49	83	68	102
neg.conc.loglikelihood	L	229.2	123.4	118.5	89.1	263.5
goodness of fit 1	r^2	.77	.68	.57	.53	.76
goodness of fit 2	r^2	.82	.88	.58	.92	.81
goodness of fit 3	r^2	.82	.70	.86	.67	.83
correlation of residuals	r	-.01	.13	.14	-.17	-.19

Note Table 3.3: see Note Table 3.1.

π: before discussing further results, we first examine the values found for the distribution coefficient π_0. $0 < \hat{\pi}_0 < 1$ and significantly, which is in accordance with the theoretical requirements. Its value varies largely among the shop types: $\hat{\pi}_0 = .14$ for baker's shops and $\hat{\pi}_0 = .72$ for independent clothes shops.

H13B: $\hat{\pi}_1 > 0$ and significantly for florist's shops. See column FLO80 in Table 3.3. The hypothesis is supported that selling area intensity increases if selling area of a florist consists for a large part of a greenhouse.

H14: $\hat{\pi}_1 < 0$ and significantly for electro-technical retailers. See column ELE80 in Table 3.3. The hypothesis is supported that selling area intensity decreases if an electro-technical retailer is also involved in electric installations.

H15B: $\hat{\pi}_1 > 0$ and significantly for photographer's shops. See column PHO80 in Table 3.3. The hypothesis is supported that selling area intensity increases if the retail sales share of a photographer's shop is high.

H13A: $\hat{\beta}_5 < 0$ and significantly for florists. See column FLO80 in Table 3.3. The hypothesis is supported that floorspace efficiency decreases if selling area of a florist consists for a large part of a greenhouse [8].

H15A: $\hat{\beta}_5 > 0$, but not significantly for photographer's shops. See column PHO80 in Table 3.3. The hypothesis is not rejected that floorspace efficiency increases if the retail sales share of a photographer's shop is high [9].

From Tables 3.1, 3.2 and 3.3 it can also be seen that

i) floorspace efficiency for food shop types appears to increase with increasing size of the shopping centre [10]: $\hat{\beta}_3 > 0$ in all four cases in Table 3.1 and significantly in two;

ii) there is a tendency for floorspace efficiency for non-food shop types to decrease with increasing size of the shopping centre: $\hat{\beta}_3 < 0$ in six out of nine cases in Tables 3.2 and 3.3, but significantly in only two. We surmise that food shops have more problems than non-food shops to exist in an environment with few shops. The results concerning the influence of the size of the shopping centre can also be interpreted as follows: in five out of six cases of shop types with an average selling area of less than 100 m^2, floorspace efficiency appears to increase with increasing size of the shopping centre. In four out of five cases of shop types with an average selling area of more than 100 m^2, floorspace efficiency appears to decrease with increasing size of the shopping centre. We surmise that small shops have more problems than larger ones to exist in an environment with few shops;

iii) floorspace efficiency appears to increase with increasing population of the township [11]: $\hat{\beta}_4 > 0$ in twelve out of thirteen cases and significantly in eight. This is a very interesting result which requires further research. For instance, it might partly be due to the fact that in small townships and villages there are many shopkeepers who do not abandon business in spite of a low sales level;

iv) men's wear sales share does not appear to influence floorspace efficiency;

v) there is a tendency that π increases with increasing average size per shop type, $\bar{W}$. See also Table 3.4. It is noted in chapter two that for supermarket-like shop types π decreases with increasing average size per shop type;

vi) selling area intensity (π) is found to be very low for baker's and confectioner's shops, for photographer's shops and greengrocers: the remaining space of baker's and confectioner's shops contains a bakery, that of photographer's shop usually a studio and/or dark-room. The fact that the greengrocers' estimated selling space threshold is high ($\hat{\gamma}_1 =$ $= .24$) may explain their low selling area intensity;

vii) floorspace efficiency does not differ significantly between baker's and confectioner's shops: $\hat{\beta}_6$ does not differ significantly from zero in column BAK77 ∪ CON77 in Table 3.1. Baker's shops are less selling area intensive than confectioner's shops: $\hat{\pi}_1 > 0$ and significantly. The asymptotic elasticity of the value of annual sales with respect to total available floorspace is higher (but not significantly) for confectioner's than for bakery's shops: cf. $\hat{\varepsilon}_1$;

viii) floorspace efficiency does not differ significantly between independent and chain clothes shops: cf. $\hat{\beta}_6$ in column CLI79 ∪ CLC79 of Table 3.2. Selling area intensity is lower for independent than for chain clothes shops. This is easy to understand, since chain shops have the possibility to have tasks performed outside the establishment (in a central administrative or warehouse establishment);

ix) extremely small shoe shops (with a selling area smaller than 50 m^2) tend to have a lower selling area intensity than larger ones: $\hat{\pi}_1 < 0$ and significantly in column SH076 of Table 3.3. On account of the "boutique" character of extremely small shoe shops, no stock whatsoever is present (or displayed) in the selling area. Therefore, it is probable that relatively more remaining space is needed;

x) some ironmonger's shops appear to have a considerably lower selling area intensity than others: $\hat{\pi}_1 < 0$ and significantly in column IM077 of table 3.3. We are not able to trace the reason for this. One hypothesis is that these shops may also be involved in lending equipment to customers. Additional remaining space is needed for this activity.

It should be noted that the values of $\hat{\beta}_3$ and $\hat{\beta}_4$ cannot be compared among the shop types, because the definitions of SC_i and TS_i differ among the shop types.

The final remarks of this section involve the threshold coefficient of selling area γ_1. Support for the threshold interpretation of γ_1 is provided by the fact that

- $\hat{\gamma}_1 < minC_i$ for eleven out of thirteen cases: $\hat{\gamma}_1 > minC_i$ but not significantly for greengrocers and photographer's shops. See Table 3.4;
- $\hat{\gamma}_1 > 0$ in twelve out of thirteen cases and significantly in seven;
- average value for $\hat{\gamma}_1$ among all shop types (ignoring ironmonger's shops) is approximately .2. Twenty square meters seem a very reasonable area for the following interpretation of a threshold: area for a counter with a cash stand, area for a shopkeeper and one or two customers and area for some essential products.

Table 3.4. Comparison of several coefficients. W^* is the shop size below which $E > 1$, $\min W_i$ is sample minimum floorspace, $\bar{W}$ is sample average floorspace, $\min C_i$ is sample minimum selling area. W_i and C_i are expressed in $10^2\ m^2$.

shop type	W^*	$\min W_i$	$\hat{\pi}$	$\bar{W}$	$\hat{\gamma}_1$	$\min C_i$
GRE78	.47	.42	.24	1.16	.24	.20
BAK77	.43	.61	.14	1.64	.12	.15
CON77	(5.27)	.65	.18	1.56	.14	.18
CLI79	(.86)	.65	.67	3.67	(.24)	.55
CLC79	(.82)	.70	.72	3.72	(.23)	.50
WUN77	.50	.45	.57	1.29	.30	.40
SHO76	.51	.50	.50	1.75	.14	.30
IMO77	—	.75	.67	4.30	(-.47)	.28
PHO80	.52	.43	.31	1.50	.25	.20
FLO80	(.32)	.52	.57	1.58	(.12)	.36
ELE80	(1.64)	.80	.53	3.14	(.15)	.40

Note Table 3.4: $\hat{\gamma}_1$ is placed between brackets if $\hat{\gamma}_1$ does not differ significantly from zero. W^* is placed between brackets if $\hat{\gamma}_1$ does not differ significantly from zero or $\hat{\varepsilon}$ from one.

3.4. Model two.

Remaining space of baker's and confectioner's shops can be partitioned into bakery space (own production) and other space (administration, stockholding etc.). Remaining space of photographer's shops can be partitioned into space for a studio and/or laboratory = dark-room (own production) and other space. In this section a model will be presented which takes into account this partitioning of remaining space for baker's shops, confectioner's shops and photographer's shops.

In this section the notion of remaining space will refer to total available floorspace minus selling area minus space for own production.

The second, the fourth and the fifth of the five assumptions of section 3.2 need futher discussion in the light of the new partitioning of total available floorspace:

(ii) (3.4.1) $W_i \triangleq C_i + RA_i + RB_i$,

where W_i: total available floorspace of estblishment i;
C_i: selling area;
RA_i: remaining space;
RB_i: space for own production.

(iv) The value of annual sales in establishment i depends on the sizes of its selling area, of its remaining space and of its space for own production:

$$(3.4.2)\quad Q_i = Q_i(C_i, RA_i, RB_i) = \beta(C_i - \gamma_1)^{\pi_1 \varepsilon}(RA_i - \gamma_2)^{\pi_2 \varepsilon}(RB_i - \gamma_3)^{\pi_3 \varepsilon}$$

with $\beta > 0$, $0 \leq \gamma_1 < C_i$, $0 \leq \gamma_2 < RA_i$, $0 \leq \gamma_3 < RB_i$, $\pi_1 > 0$, $\pi_2 > 0$, $\pi_3 > 0$, $\pi_1 + \pi_2 + \pi_3 = 1$ and $\varepsilon > 0$.

The justificaton of (3.4.2) is comparable to that of (3.2.2): it is assumed that selling area, remaining space as well as own production space contribute to establish the value of annual sales and that these inputs can be substituted for one another. This substitution is associated with different marketing or operational strategies within a shop type: a certain value of annual sales can be obtained with a high share of own production (RB is relatively large and C is relatively small) or with a low share of own production (RB is relatively small and C is relatively large, because usually products which are not self-produced will take display space). To a certain extent a shopkeeper is free to use selling area and space for own production on the one hand or remaining space on the other for handling goods, stockkeeping etc. A multiplicative specification is chosen because it is felt that the effect of a change of one input factor on the value of annual sales depends on the level of the other input factors.
The coefficients have the following interpretation: $\beta > 0$ is a coefficient which can be used to denote efficiency; $\varepsilon > 0$ gives the degree of homogeneity, if $C - \gamma_1$, $RA - \gamma_2$ and $RB - \gamma_3$ are regarded as input fac-

tors; $\pi_1 > 0$, $\pi_2 > 0$ and $\pi_3 > 0$ with $\pi_1 + \pi_2 + \pi_3 = 1$ indicate the degree to which an establishment of a certain shop type is selling area, remaining space and own production space intensive. These coefficients are called distribution coefficients; γ_1, γ_2 and γ_3 can be associated with threshold spaces. They are called threshold coefficients and using them scale effects can be studied in the elasticity of the value of annual sales with respect to floorspace parts.

(v) a shopkeeper tries to maximize the value of annual sales by manipulating the partitioning of total available floorspace. Of course, this maximization is subject to restriction (3.4.1). The Lagrangean function LF_i with the Lagrange multiplier λ_i reads [12]:

$$(3.4.3) \qquad LF_i = Q_i(C_i, RA_i, RB_i) + \lambda_i(W_i - C_i - RA_i - RB_i).$$

The first order conditions $\frac{\partial LF_i}{\partial C_i} = \frac{\partial LF_i}{\partial RA_i} = \frac{\partial LF_i}{\partial RB_i} = \frac{\partial LF_i}{\partial \lambda_i} = 0$ give

$$(3.4.4) \qquad \pi_1 \varepsilon Q_i = \lambda_i(C_i - \gamma_1);$$

$$(3.4.5) \qquad \pi_2 \varepsilon Q_i = \lambda_i(RA_i - \gamma_2);$$

$$(3.4.6) \qquad \pi_3 \varepsilon Q_i = \lambda_i(RB_i - \gamma_3);$$

$$(3.4.7) \qquad W_i = C_i + RA_i + RB_i.$$

Summation of (3.4.4), (3.4.5) and (3.4.6) and application of (3.4.7) give

$$(3.4.8) \qquad \lambda_i = \varepsilon Q_i/(W_i - \gamma_1 - \gamma_2 - \gamma_3),$$

which is used to eliminate λ_i from (3.4.4), (3.4.5) and (3.4.6):

$$(3.4.9) \qquad C_i = \gamma_1 + \pi_1(W_i - \gamma_1 - \gamma_2 - \gamma_3);$$

$$(3.4.10) \qquad RA_i = \gamma_2 + \pi_2(W_i - \gamma_1 - \gamma_2 - \gamma_3);$$

$$(3.4.11) \qquad RB_i = \gamma_3 + \pi_3(W_i - \gamma_1 - \gamma_2 - \gamma_3).$$

It is easy to show that the stationary point defined by (3.4.9), (3.4.10) and (3.4.11) refers to a maximum [13].

The reduced form of the model is obtained after substitution of equations (3.4.9), (3.4.10) and (3.4.11) into (3.4.2). It consists of equations (3.4.9), (3.4.10), (3.4.11) and (3.4.13).

(3.4.13) $$Q_i = \beta\pi_1^{\pi_1\varepsilon}\pi_2^{\pi_2\varepsilon}\pi_3^{\pi_3\varepsilon}(W_i - \gamma_1 - \gamma_2 - \gamma_3)^{\varepsilon}.$$

The endogenous variables are value of annual sales of establishment i, Q_i, size of its selling area C_i, of its remaining space RA_i and of its own production space RB_i; the exogenous variable is total available floorspace.The vector of coefficients is called θ with $\theta' = (\beta\ \gamma_1\ \gamma_2\ \gamma_3\ \pi_1\ \pi_2\ \pi_3\ \varepsilon)$. The restrictions on these coefficients are given in equation (3.4.2).

The elasticity of the value of annual sales with respect to total floorspace E now reads:

(3.4.14) $$E \triangleq \frac{d\log Q}{d\log W} = \varepsilon W/(W - \gamma_1 - \gamma_2 - \gamma_3).$$

For model two the following hypotheses will also be tested:

H1: the elasticity of the value of annual sales with respect to total available floorspace, E, decreases with size, i.e. $\gamma_1 + \gamma_2 + \gamma_3 > 0$;

H2: the asymptotic elasticity of the value of annual sales with respect to total available floorspace, ε, is less than or equal to one.

We conclude from the scatter diagrams in Figure 3.4 (confectioner's shops: CON77) that the linearity of the relationship between selling area, remaining and own production space on the one hand and total available floorspace on the other hand cannot be rejected. Concerning model two the same further hypotheses will be tested as concerning model one.

The last part of this section is devoted to the estimation of coefficient vector θ. Taking logarithms in (3.4.13), specifying an additive disturbance structure and applying restriction $\pi_1 + \pi_2 + \pi_3 = 1$, we obtain the following stochastic reduced form:

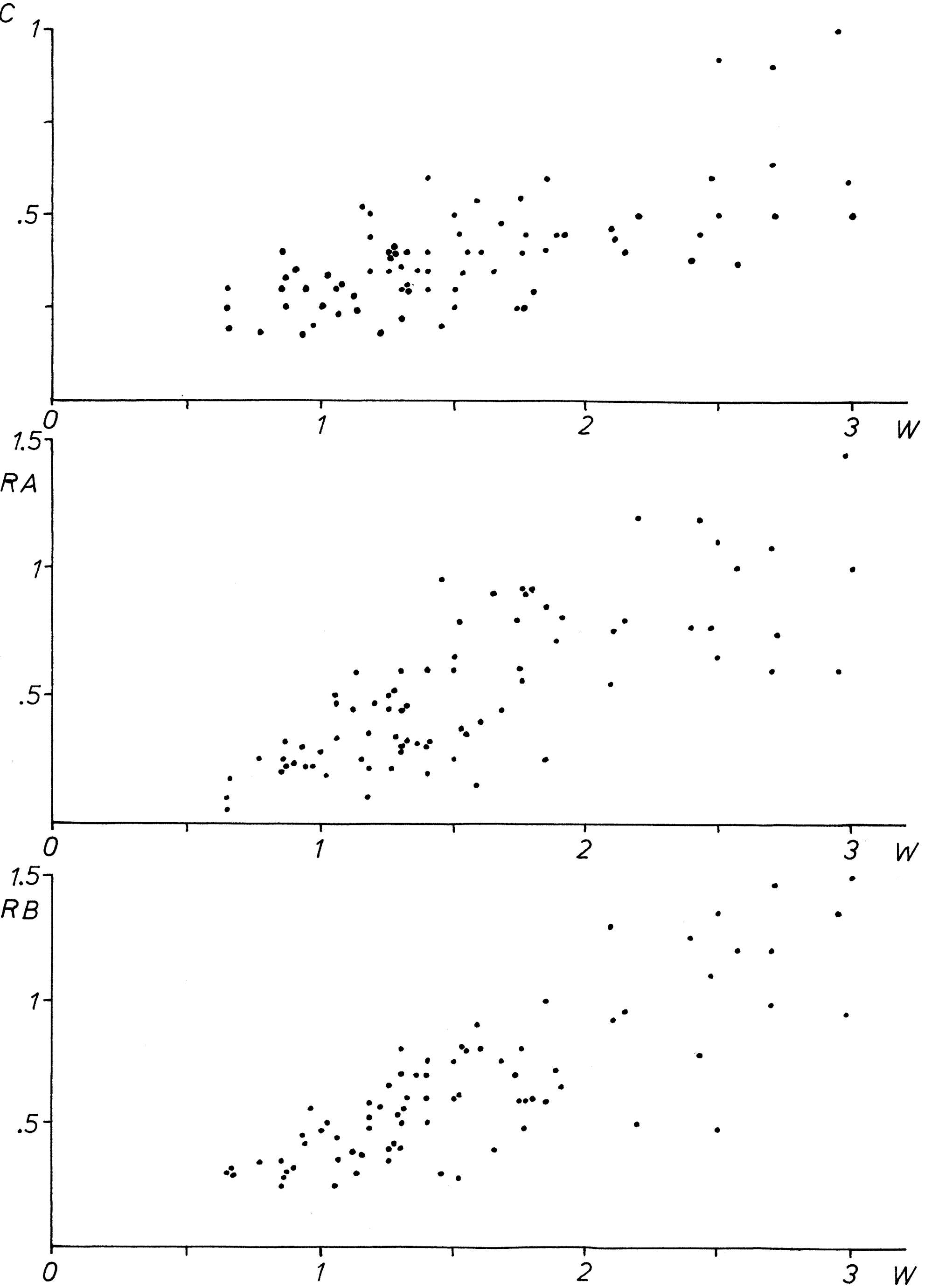

Figure 3.4. Scatter diagrams for CON77 (Dutch confectioner's shops of 1977). W: total available floorspace (in 10^2 m^2); C: selling area (in 10^2 m^2); RA: remaining space (in 10^2 m^2); RB: own production space (= bakery space) (in 10^2 m^2).

$$(3.4.15) \quad \log Q_i = \log\beta + \pi_1\varepsilon \log \frac{\pi_1}{1 - \pi_1 - \pi_3} + \pi_3\varepsilon \log \frac{\pi_3}{1 - \pi_1 - \pi_3} + $$

$$+ \varepsilon \log(W_i - \gamma_1 - \gamma_2 - \gamma_3)(1 - \pi_1 - \pi_3) + v_{1i};$$

$$(3.4.16) \quad C_i = \gamma_1 + \pi_1(W_i - \gamma_1 - \gamma_2 - \gamma_3) + v_{2i};$$

$$(3.4.17) \quad RA_i = \gamma_2 + (1 - \pi_1 - \pi_3)(W_i - \gamma_1 - \gamma_2 - \gamma_3) + v_{3i};$$

$$(3.4.18) \quad RB_i = \gamma_3 + \pi_3(W_i - \gamma_1 - \gamma_2 - \gamma_3) + v_{4i}.$$

It should be noted that $v_{2i} + v_{3i} + v_{4i} = 0$ in equations (3.4.16), (3.4.17) and (3.4.18). Therefore, one of these equations can be deleted in our estimation procedure. We choose to leave out (3.4.17) [14].

We now define V_i with $V_i' = (v_{1i}\ v_{2i}\ v_{4i})$. We assume that $V_i \sim N(0,\Omega)$ for $i = 1, \ldots, I$: trivariate normal distribution with zero means and constant, positive definite and symmetric covariance matrix

$$\Omega = \begin{bmatrix} \omega_{11} & \omega_{12} & \omega_{14} \\ \omega_{21} & \omega_{22} & \omega_{24} \\ \omega_{41} & \omega_{42} & \omega_{44} \end{bmatrix}.$$

In addition, it is assumed that $E(V_i V_{i'}') = 0$ for $i \neq i'$.

Full information maximum likelihood estimates are found by locating a maximum of the likelihood function with respect to θ after concentrating this function with respect to Ω [3].

3.5. Tests with model two.

Model two is estimated using equations (3.4.15), (3.4.16) and (3.4.18) where β, π_1, π_3 and ε are substituted by β_i, π_{1i}, π_{3i} and ε_i:

$$(3.5.1) \quad \beta_i = \beta_0 \left(\frac{HV_i}{\overline{HV}}\right)^{\beta_1} [\exp \beta_2(M_i - \overline{M}) \left(\frac{SC_i}{\overline{SC}}\right)^{\beta_3} \left(\frac{TS_i}{\overline{TS}}\right)^{\beta_4};$$

$$(3.5.2) \quad \pi_{1i} = \pi_{10} + \pi_{11}DX3_i;$$

(3.5.3) $\pi_{3i} = \pi_{30} + \pi_{31}DX3_i$;

(3.5.4) $\varepsilon_i = \varepsilon_0 + \varepsilon_1 DX3_i$,

where W_i: total available floorspace (in 10^2 m^2) of establishment i;
C_i: selling area (in 10^2 m^2);
RB_i: own production area (in 10^2 m^2);
Q_i: value of annual sales (in 10^3 Dutch guilders);
HV_i: occupancy costs per m^2 (in Dutch guilders);
M_i: average percentage gross margin divided by 100;
SC_i: indicator of size of shopping centre;
TS_i: indicator of size of township;
$DX3_i$ = 1 if the etablishment is a confectioner's shop and 0 otherwise (establishment is a baker's shop);
$\overline{HV}$, $\overline{M}$, $\overline{SC}$ and $\overline{TS}$ are sample averages.

See section 3.3 for further explication of the variables.
It is also assumed in the present model that remaining space threshold $\gamma_2 = 0$. See section 3.2.

The following conclusions can be drawn from Table 3.5:

H1: $\hat{\gamma}_1 > 0$ and significantly in all four cases. This result is also obtained with model one. $\hat{\gamma}_3 > 0$ in all four cases and significantly in two. Support is found for the hypothesis that the elasticity of the value of annual sales with respect to total available floorspace, E, decreases with scale for all shop types considered.

H2: $\hat{\varepsilon}_0 < 1$ in all four cases and significantly in three: $\hat{\varepsilon}_0$ is not significantly different from one for confectioner's shops. This result is also obtained with model one. Support is found for the hypothesis that the asymptotic elasticity of the value of annual sales with respect to total available floorspace is not greater than one: a value less than one is inferred from the estimations.

The results concerning average efficiency, the influence of occupancy costs, of average percentage gross margin, of the size of the shopping centre and of the size of the township will not be discussed. They do not differ from those obtained with model one.

Examining columns BAK77 and CON77 in Table 3.5 it is seen that

- the bakery threshold $\hat{\gamma}_3$ of bakery's shops is significantly higher than that of confectioner's shops. We do not understand this result, assuming that bakeries of baker's shops and those of confectioner's shops will not differ drastically;
- sales elasticity of baker's shops estimated with model one is significantly higher than that estimated with model two.

Therefore, observations of baker's shops and confectioner's shops are grouped together, assuming that the type of establishment can only influence the distribution coefficients and the sales elasticity. The results are given in column BAK77 $\cup$ CON77. From the examination of this column it is seen that:

i) threshold coefficients obtained for both selling area $\hat{\gamma}_1$ and bakery space $\hat{\gamma}_3$ seem very realistic ($\hat{\gamma}_1$ = .16 and $\hat{\gamma}_3$ = .22);

ii) selling area intensity is higher for confectioner's shops than for baker's shops; confectioner's shops carry a larger diversity of products, which needs display space;

iii) bakery space intensity is higher for confectioner's shops than for baker's shops: confectioner's shops produce a larger diversity of products, which needs production space;

iv) sales elasticity does not differ significantly between baker's shops and confectioner's shops. This seems more realistic than the largely differing values of columns BAK77 and CON77.

Model two does not provide a better explanation of value of annual sales and size of selling area. Cf. goodness of fit 1 and 2 of Tables 3.1, 3.3 and 3.5. The high absolute value of the correlation coefficient between the vectors of residuals of equation (3.4.17) and (3.4.18), r_{34}, insinuates that there is something left to explain concerning the partitioning between own production space and remaining space.

Table 3.5. Estimates of coefficients of the model consisting of equations (3.4.15), (3.4.16) and (3.4.18) with (3.5.1) through (3.5.4).

shop type		BAK77	CON77	BAK77 ∪ CON77		PHO80
average efficiency	$\log\hat{\beta}_0$	6.39	6.67	6.51		6.84
		(.08)	(.09)	(.08)		(.08)
occupancy costs	$\hat{\beta}_1$	.584	.818	.679		.530
		(.098)	(.123)	(.080)		(.100)
% gross margin	$\hat{\beta}_2$	-.495	-1.322	-.807		-1.225
		(.690)*	(.534)	(.428)		(.708)
shopping centre	$\hat{\beta}_3$	.204	.180	.218		-.189
		(.093)	(.182)*	(.086)		(.144)*
township	$\hat{\beta}_4$	-.001	.327	.102		.074
		(.050)*	(.092)	(.047)		(.091)*
confectioner's shop	$\hat{\beta}_6$			.082		
				(.112)*		
threshold	$\hat{\gamma}_1$	.157	.145	.161		.168
		(.033)	(.048)	(.028)		(.092)
threshold	$\hat{\gamma}_3$	.348	.050	.217		-.014
		(.049)	(.099)*	(.052)		(.100)*
distribution	$\hat{\pi}_{10}$	.152	.183	.137	$\hat{\pi}_{11}$ = .058	.350
		(.024)	(.022)	(.017	(.014)	(.031)
distribution	$\hat{\pi}_{30}$	.273	.434	.338	$\hat{\pi}_{31}$ = .037	.336
		(.032)	(.032)	(.027)	(.022)	(.035)
sales elasticity	$\hat{\varepsilon}_0$	.466	.924	.592	$\hat{\varepsilon}_1$ = .152	.595
		(.081)	(.146)	(.092)	(.104)*	(.137)
number of observations	I	89	77	166		71
neg.conc.loglikelihood	L	151.5	112.2	450.3		114.8
goodness of fit 1	r^2	.53	.73	.63		.53
goodness of fit 2	r^2	.27	.47	.40		.62
goodness of fit 3	r^2	.70	.58	.65		.43
goodness of fit 4	r^2	.26	.68	.48		.47
correlation of residuals	R	.14 .10 -.19 -.44 -.11 -.84	.01 .01 -.02 -.48 -.11 -.82	.07 .05 -.10 -.44 -.12 -.84		.09 .08 -.18 -.54 -.17 -.74

Note Table 3.5: see next page.

Note Table 3.5: the asymptotic distribution of the maximum likelihood estimates is assumed to be multivariate normal. Estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficients. An asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$, i.e. if η is not significantly different from zero at a 10% level of significance. The square of the correlation coefficient between the vectors of the dependent variable and its estimation is taken as measure of goodness of fit: 1 refers to the antilog form of (3.4.15), 2 to (3.4.16), 3 to (3.4.17) and 4 to (3.4.18).

R is the matrix of correlation coefficients between the vectors of residuals of equations (3.4.15) through (3.4.18):

$$R = \begin{bmatrix} r_{12} & r_{13} & r_{14} \\ - & r_{23} & r_{24} \\ - & - & r_{34} \end{bmatrix}$$

: 1 refers to (3.4.15), 2 to (3.4.16), 3 to (3.4.17) and 4 to (3.4.18).

π_{11}, π_{31} and ε_1 in column BAK77 $\cup$ CON77 are associated with the influence whether or not the establishment is a confectioner's shop.

3.6. Conclusions and summary.

In this chapter two models are presented. Model one tries to explain the relation between the value of total annual sales and total available floorspace as well as partitioning between selling area and remaining space. Model two is an extension of model one in that it tries to explain the partitioning between selling area, own production space and remaining space. Model one is applied to eleven samples of Dutch shop types, model two to three of these samples. Generally, the main conclusions of this study are the same as those reported in chapter two, where only supermarket(-like) shop types were treated:

i) the models serve their purpose very well because
   a) the samples studied are from largely differing shop types and yet the values found for the vector of basic coefficients θ (see sections 3.2 and 3.4) do not contradict the logical restrictions in any case;
   b) no specification test is performed. However, examination of the values of the residuals does not reveal any structure. See Figures 3.5 to 3.7. In model one the values of the correlation coefficient between the vectors of residuals of both equations are quite low and both negative and positive. In model two the absolute value of the correlation coefficient between the vectors of residuals of equations

(3.4.17) and (3.4.18) is high in all four cases. We surmise that the explanation of the partitioning between own production space and remaining space can still be improved;

c) differences in the values of the coefficients within a shop type can be explained very well by taking into account the characteristics of the establishments;

d) differences in the values of the coefficients among the shop types can, to a certain extent, be explained;

e) the explanation of our cross-section models is fairly high. See goodness of fit in Tables 3.1, 3.3 and 3.5 [15]. For example in the case of model one $r^2 < .5$ in only five out of thirty-nine cases. This is a very promising result considering that largely differing shop types are dealt with using cross-section data;

ii) the value of the threshold coefficient of selling area, γ_1, in model one is found to be positive in twelve out of thirteen cases: threshold space is a certain amount of basic space which must be present in all establishments of a shop type. Ignoring the result for ironmonger's shops where $\hat{\gamma}_1 < 0$ but not significantly, it is seen that the value of $\hat{\gamma}_1$ ranges from 12 to 30 m^2, with an average value of approximately 20 m^2. This seems a very reasonable size for the following interpretation of selling area threshold: area for a counter with a cash stand, area for a shopkeeper and one or two customers and area for some essential products. In model two the own production (= bakery) space threshold for baker's and confectioner's shops is found to be 20 m^2; that for photographer's shops is found to be 0 m^2.
Therefore, the elasticity of the value of total annual sales with respect to total floorspace, E, decreases with increasing total available floorspace. See equations (3.2.5) and (3.4.14);

iii) strong support is found for the hypothesis that the asymptotic elasticity of the value of annual sales with respect to total available floorspace, ε, is not greater than one: ε is even significantly smaller than one in most cases. This is also reported in our supermarket study in chapter two;

iv) there is no evidence that $E > 1$ for any shop type;

v) the selling area intensity of the shop types studied differs largely: $\hat{\pi}$ varies from .14 for baker's shops to .72 for independent clothes shops;

vi) strong support is found for the hypothesis that efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase. In our supermarket study the elasticity of efficiency with respect to relative occupancy costs has an average value of .52. In this chapter (model one) this value is .57 [16];

vii) support is found for the hypothesis that the efficiency of total available floorspace decreases if average percentage gross margin increases. Only for women's underwear shops the opposite effect is found;

viii) the influence of shopping centre size and township size is studied as a first approach of a more detailed study of the influence of environmental variables:

- floorspace efficiency for food shop types appears to increase with increasing shopping centre size;
- there is a tendency that floorspace efficiency for non-food shop types decreases with shopping centre size;
- floorspace efficiency appears to increase with increasing township size.

Environmental variables will be dealt with in more detail in chapter four.

Reviewing both the results of the supermarket study and the present study we conclude that:

i) model one appears to have a very wide applicability, because in both studies an extremely wide range of shop types is considered;

ii) the asymptotic elasticity of the value of annual sales with respect to total available floorspace is found to be less than one;

iii) the concept of a threshold in selling area appears relevant: generally, the value found for this threshold is positive and smaller that the minimum size of the selling area of the shop type;

iv) the efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase: the elasticity of average efficiency with respect to relative occupancy costs has an average value of approximately .55 (though some variation occurs among shop types) [16].

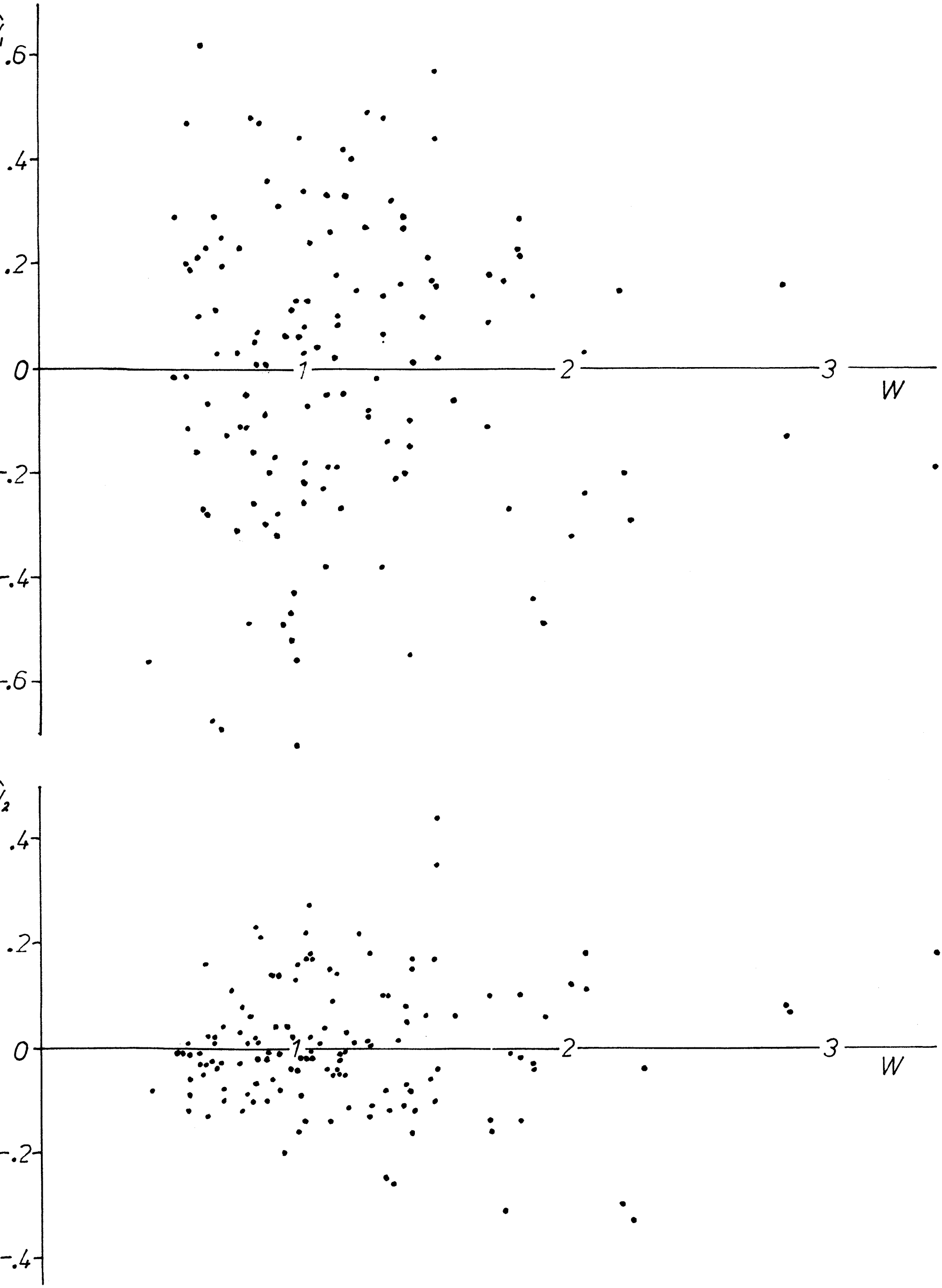

Figure 3.5. Residuals of the model consisting of equations (3.2.7) and (3.2.8) with (3.3.1), (3.3.2) and (3.3.3) for GRE78 (Dutch greengrocers of 1978). W: total available floorspace (in 10^2 m^2); $\hat{v}_1$: residual of equation (3.2.7); $\hat{v}_2$: residual of equation (3.2.8).

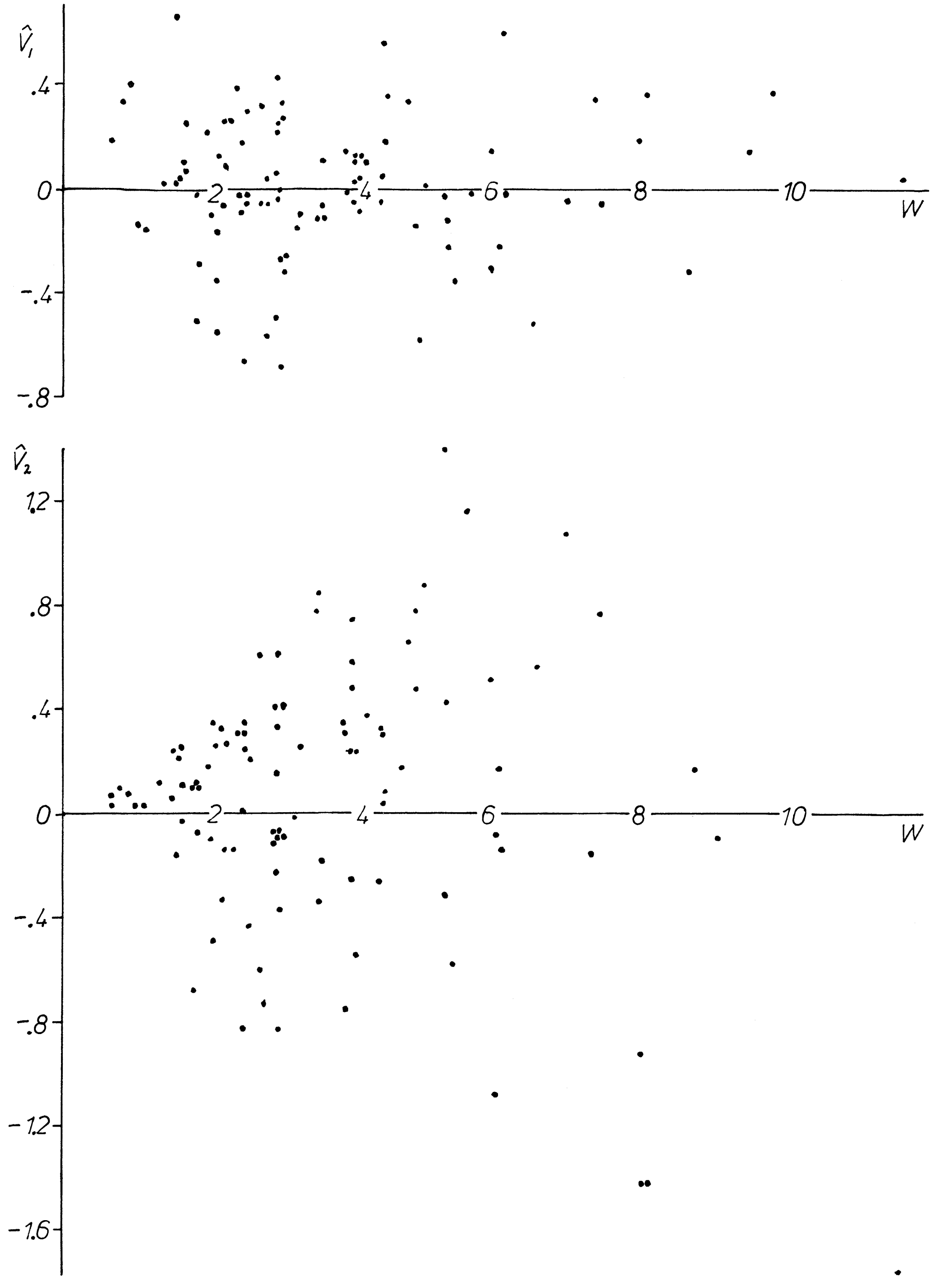

Figure 3.6. Residuals of the model consisting of equations (3.2.7) and (3.2.8) with (3.3.1) and (3.3.2) for CLI79 (Dutch independent clothes shops of 1979). W: total available floorspace (in 10^2 m^2); $\hat{v}_1$ residual of equation (3.2.7); $\hat{v}_2$: residual of equation (3.2.8).

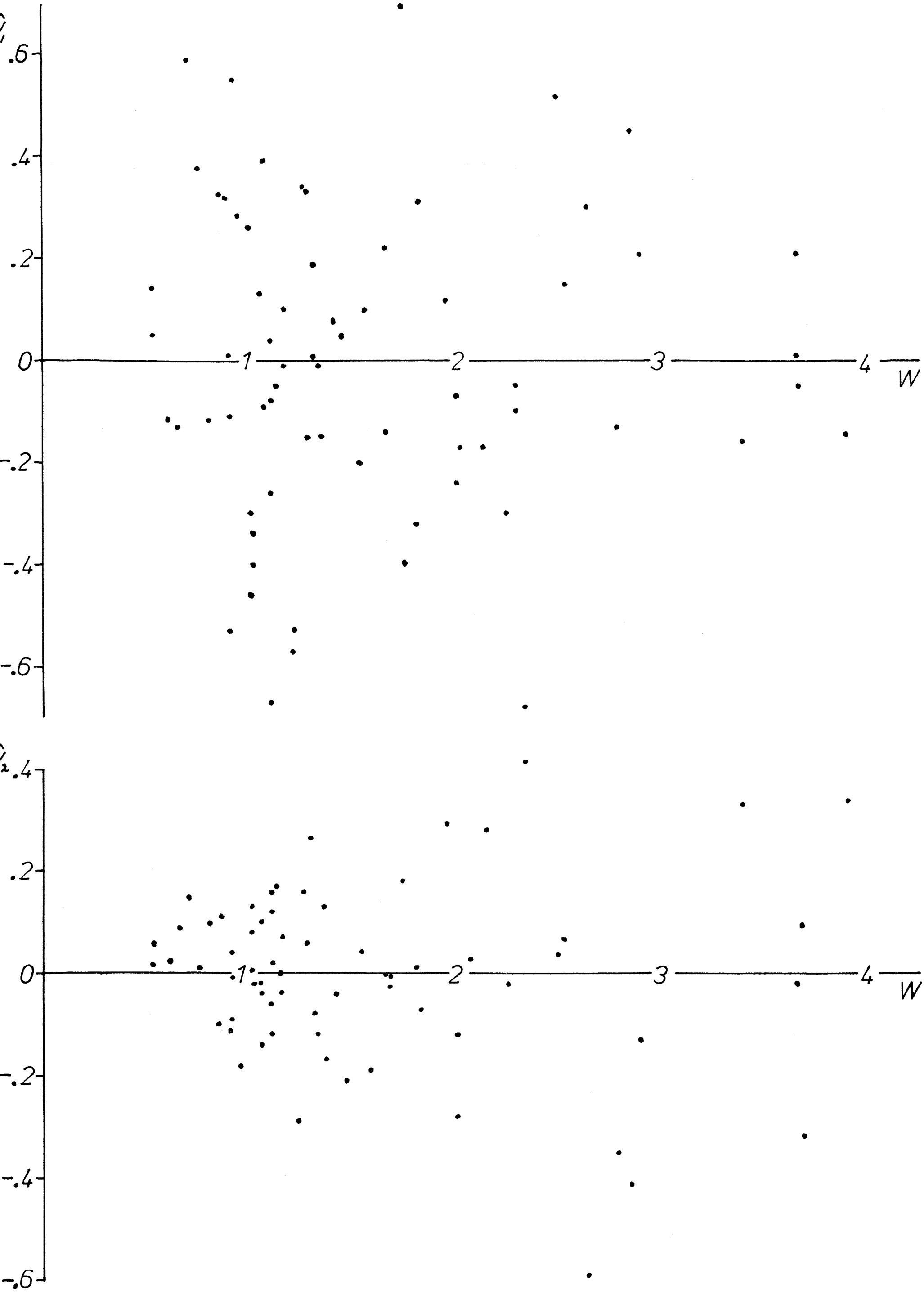

Figure 3.7. Residuals of the model consisting of equations (3.2.7) and (3.2.8) with (3.3.1) and (3.3.2) for FL080 (Dutch florist's shops of 1980). W: total available floorspace (in 10^2 m^2); $\hat{v}_1$: residual of equation (3.2.7); $\hat{v}_2$: residual of equation (3.2.8).

Footnotes to chapter three.

[1] A shop type is defined as a group of establishments which has a certain homogeneity regarding assortment composition, mode of service (counter service versus self-service), extent of own production (the character of which may differ largely among shop types: e.g. breadbaking for baker's shops or use of a darkroom for photographer's shops) and type of organization (chain, cooperative, independent).

[2] In our analysis Q is defined in money terms (value of annual sales).

[3] See section 2.5 for further details. The numerical maximization is performed by the variable metric algorithm of Broyden, Fletcher, Goldfarb and Shanno.

[4] However, $\min R_i > \min C_i$ for baker's and confectioner's shops. In section 3.5 we will show that for these shop types a positive threshold exists for a part of remaining space (bakery space).

[5] We realize that there are only eleven independent samples: column BAK77 $\cup$ CON77 of Table 3.1 and column CLI79 $\cup$ CLC79 of Table 3.2 refer to samples which are the union of other samples.

[6] A level of significance of 10% is maintained: a coefficient η is called significantly different from zero if $|\hat{\eta}| > 1.64\ \hat{\sigma}(\hat{\eta})$.

[7] One drawback of the ironmonger's shop sample is that there are only few observations (49) over a very large size range ($\min W_i = 75\ m^2$ and $\max W_i = 1590\ m^2$).

[8] From equation (2.3.1) we derive that $\frac{\partial Q}{\partial \pi} \lesseqgtr 0$ if $\pi \lesseqgtr .5$.
For florist's shops $\pi > .5$ and π increases if there is a greenhouse. Consequently, Q increases if there is a greenhouse: it can be calculated that this effect represents only a small counterface.

[9] For photographer's shops $\pi < .5$ and π increases if the retail sales share is high. Consequently, Q decreases if the retail sales share is high: it can be calculated that this effect represents only a small counterface. See footnote 8.

[10] Nooteboom [1980] p. 208 does not find any influence of the size of the shopping centre for independent Dutch butchers of 1974.

[11] Nooteboom [1980] p. 207 reports the same result for independent Dutch butcher's shops of 1974.

[12] If equation (3.4.1) is substituted into (3.4.2) before deriving the first order conditions, then the Lagrangean function is not needed and only two first order conditions remain. Cf. our discussion of model one. This is not done here to facilitate our derivations.

[13] Cf. footnote 12 of chapter two: equation (3.4.2) describes a continuous function on $D_i \subset \mathbb{R}^3$ with

$$D_i = \left\{ \begin{bmatrix} C_i \\ RA_i \\ RB_i \end{bmatrix} \middle| \begin{array}{l} \gamma_1 \leq C_i \\ \gamma_2 \leq RA_i \\ \gamma_3 \leq RB_i \end{array} \right\} \cap \left\{ \begin{bmatrix} C_i \\ RA_i \\ RB_i \end{bmatrix} \middle| \; W_i = C_i + RA_i + RB_i \right\}.$$

D_i is compact if $W_i \leq B$ for some fixed constant B.
Therefore, a global maximum and a global minimum are attained on D_i. The global minimum is attained in a point with $C_i = \gamma_1$, $RA_i = \gamma_2$ or $RB_i = \gamma_3$ and in this point $Q_i(C_i,RA_i,RB_i) = 0$.
Stationary points (C_i,RA_i,RB_i), so that $Q_i(C_i,RA_i,RB_i) \neq 0$, are candidates for the global maximum. There is only one such point.It is defined by equations (3.4.9), (3.4.10) and (3.4.11).

[14] Cf. footnote 28 of chapter two.

[15] The only shop type with a relatively disappointing explanation is the baker's shop. See Tables 3.1 and 3.5. Especially the explanation of equations (3.4.16) and (3.4.18) is quite low. Probably, this is due to a varying share of confectioner's products.

[16] Cf. footnote 43 of chapter two.

APPENDIX TO CHAPTER THREE.

DATA.

Table A.3.1. Description of the samples used.

code	number of observations	year of collection	shop type
GRE78	133	1978	greengrocer
BAK77	89	1977	baker's shop
CON77	77	1977	confectioner's shop
CLI79	98	1979	clothes shop (independent)
CLC79	75	1979	clothes shop (small chain)
WUN77	54	1977	women's underwear shop
SHO76	118	1976	shoe shop
IMO77	49	1977	ironmonger's shop
PHO80	83	1980	photographer's shop
FLO80	68	1980	florist's shop
ELE80	102	1980	electro-technical retailer

These Dutch data were gathered by the field force of E.I.M. The shop types consist primarily of independent establishments. An establishment is called independent if the enterprise to which the establishment belongs consists of one establishment. There are enterprises which consist of a few establishments. For clothes shops the sample is divided in two subsamples: one consisting of independent establishments and one consisting of small chain establishments.

Table A.3.2. Further description of the samples: W_i is total available floorspace, C_i selling area, R_i remaining space, Q_i total annual sales, HV_i occupancy costs per m^2 and M_i gross profits divided by total annual sales. Floorspace is expressed in 10^2 m^2. Sales are expressed in 10^3 Dutch guilders of the year of collection and occupancy costs in Dutch guilders of the year of collection.

code	$\min W_i$ $\bar{W}$ $\max W_i$	$\min C_i$ $\bar{C}$ $\max C_i$	$\min R_i$ $\bar{R}$ $\max R_i$	$\min Q_i$ $\bar{Q}$ $\max Q_i$	$\min HV_i$ $\overline{HV}$ $\max HV_i$	$\min M_i$ $\bar{M}$ $\max M_i$
GRE78	.42	.20	.12	134	47	.194
	1.16	.46	.69	398	158	.300
	3.60	1.25	2.35	685	397	.451
BAK77	.61	.15	.45	161	59	.427
	1.64	.33	1.30	393	189	.596
	2.90	.85	2.60	1190	429	.707
CON77	.65	.18	.35	105	77	.421
	1.56	.40	1.16	403	189	.600
	3.00	1.00	2.50	1019	391	.750
CLI79	.65	.55	.07	331	59	.210
	3.67	2.59	1.08	1029	204	.372
	11.50	6.07	5.50	2884	609	.526
CLC79	.70	.50	.10	324	99	.311
	3.72	2.76	.96	1066	234	.374
	20.40	13.60	7.00	4952	588	.465
WUN77	.45	.40	.05	152	60	.286
	1.29	.88	.41	376	197	.399
	2.54	1.90	1.35	766	424	.477
SHO76	.50	.30	.15	154	72	.279
	1.75	.92	.82	434	214	.359
	4.80	2.85	2.60	1195	514	.493
IMO77	.75	.28	.25	203	36	.204
	4.30	2.50	1.81	649	92	.348
	15.90	12.20	9.25	2213	222	.732
PHO80	.43	.20	.18	254	92	.196
	1.50	.66	.84	638	260	.363
	3.07	1.43	2.20	1492	891	.493
FLO80	.52	.36	.10	134	69	.318
	1.58	1.07	.51	350	171	.477
	3.90	3.40	1.70	793	311	.653
ELE80	.80	.40	.10	289	61	.169
	3.14	1.68	1.46	1205	157	.277
	9.51	5.43	5.21	3782	331	.434

Note Table A.3.2: for shoe shops occupancy costs per m^2 are not available: non-labour costs per m^2 are taken instead.

Table A.3.3. Further description of the samples: RA_i is bakery space for baker's and confectioner's shops and space for studio and laboratory for photographer's shops, RB is remaining space i.e. total available floorspace minus (selling area + RA). Floorspace is expressed in 10^2 m^2.

code	$minRA_i$ $\overline{RA}$ $maxRA_i$	$minRB_i$ $\overline{RB}$ $maxRB_i$
BAK77	.05 .64 1.60	.25 .67 1.11
CON77	.05 .52 1.45	.25 .64 1.50
PHO80	.05 .44 1.78	.10 .47 1.25

CHAPTER FOUR.

EFFICIENCY OF RETAIL FLOORSPACE AND ENVIRONMENT.

4.1. Introduction.

In chapters two and three the relation is studied between total available floorspace, the value of total annual sales and the partitioning of total available floorspace into selling area and remaining space. It is said that the value of annual sales of a retail establishment depends on two groups of variables: characteristics of the establishment itself and characteristics of the environment of the establishment. The environment is left out of consideration, because it is claimed that characteristics of the establishment itself play a predominant role, that the environment does influence the characteristics of the establishment and that few environmental variables are consistently available. The first claim is an intuitive one and not supported by theoretical or empirical evidence.
An enormous amount of labour was invested in collecting environmental data systematically, i.e. variables are equally available for all samples. Unfortunately, we had to restrict ourselves to Dutch data: supermarkets and superettes (chains as well as independents) and clothes shops (small chains as well as independents). Nevertheless, seven samples with (a maximum of) fifteen environmental variables are available.

The aim of this chapter is to use the environmental data to explain differences in efficiency of total available floorspace. The specification used for this investigation is not the result of an explanatory model in the theoretical sense: at most it describes the results of shoppers' movements, not their intentions. Neither is it the result of extensive research in the wide empirical literature on spatial consumer behaviour. A list of desired variables is presented in section 4.2. In section 4.3 hypotheses to be tested are listed, these are feasible considering the data collected. In section 4.4 some of the tests conducted are described and commented on. An extensive report of one of these empirical tests is given in the appendix to this chapter.
We expected to find few but certainly some influences of environmental variables. To our surprise, practically no influence was found. We were reluctant

to accept this finding. Therefore, numerous exercises were performed. All resulted in the same finding.
The report of our exercises is limited compared with the other chapters and in the light of the huge amount of work done. It is kept limited because its main message is simple: practically no influences of environmental variables are found.

4.2. Environment and retail sales.

In section 2.2 it is assumed that the value of annual sales of a retail establishment depends on two groups of variables: characteristics of the establishment itself and characteristics of the environment. In the present section those characteristics of the environment are discussed which are assumed relevant. We discern three groups of variables of environmental characteristics: variables describing

i) general demand characteristics;
ii) characteristics of the shopping centre relative to other shopping centres;
iii) environmental characteristics of the establishment relative to its competitors in the shopping centre.

This classification is used, because it is felt that a customer, in deciding what establishment she goes to, first chooses the shopping centre and then the particular shop in the centre [1]. Of course the shopping centre patronage is not realistic for very specialized goods. First, we shall give a list of variables which we assume to be ideal for our purposes. Subsequently, in the next section a series of hypotheses to be tested is given, which is realizable in the light of the data actually acquired for our study.

List of environmental variables needed for the explanation of the value of annual sales of a retail establishment (this establishment E sells product group P and is located in shopping centre S in area A):

i) general demand characteristics:
   - consumption per head of product group P in area A;
   - population density in area A (number of inhabitants per km^2);
   - competitive density in area A (number of shopping centres per km^2 selling product group P);

ii) characteristics of the shopping centre (attractiveness) relative to competing shopping centres:
   - variety (number of different products sold in shopping centre S);
   - choice (number of establishments selling product group P);
   - price (price level of establishments selling product group P);
   - ease of access (e.g. number of parking-places, degree of traffic congestion in the neighbourhood, connections with public transport etc.);
   - advertising and promotional efforts (aggregated efforts for shopping centre S);
   - atmosphere (shopping centre S is roofed-in, modern, consists of a pedestrian precinct etc.);

iii) environmental characterictics of the establishment (attractiveness) relative to its competitors in the shopping centre:
   - choice (number of establishments selling product group P);
   - location (description whether the location of establishment E is relatively advantageous or not);
   - other variables which are essentailly characteristics of the establishment itself, but which become environmental variables if their values are compared with those of the shopping centre competitors: relative price level of E, relative advertising and promotional efforts of E, relative service level of E, relative variety of E, relative image [2] of E etc.

A few remarks are required concerning the above list:

i) generally, the sign of the effect of the variable mentioned on the value of annual sales of establishment E will be obvious. However, some clarification is needed: choice as one of the characteristics of the shopping centre has a positive influence on its attractiveness and hence a positive influence on the value of annual sales of establishment E. Choice as one of the environmental characteristics of establishment E has a negative influence on its attractiveness and hence also a negative influence on the value of annual sales;

ii) the above list is incomplete and arbitrary. For instance, area A (town, township, village) may have a regional function resulting in higher sales than those which can be expected on basis of area data, because additional purchases are made by hinterland custom. Another example is that the variable "choice" is expressed in number of establishments. Average size of these establishments will also play a role;

iii) a well-known variable in buying and patronage models is distance [3]. This variable is not taken into account in the above list, because it is a complicating factor.
Different groups of consumers may have distinct reactions to distance. Shopping movement behaviour may be influenced by income differences [4] or social status (convenience versus recreational attitude [5]). One shopper's movement behaviour may vary in time according to different shopping attitudes depending on the package of desired goods. Moreover, the variable "distance" is simply not available. Ideally, the complete geographical pattern of the location of competitors and possible customers should be available per establishment;

iv) there is often a discrepancy between the goods a priori desired and a posteriori bought. There are two main effects: in a certain shop a customer also purchases luxury goods, although she intended to buy only necessities. This is often the case in food shops. On a shopping trip to buy durables or luxury goods, necessities are bought as well, while shopping movements are regulated primarily by the intention to buy the durables or luxury goods. The latter effect may cause irregularities in shopping movements. Generally, interdependencies in shopping movement behaviour regarding different product groups are accounted for by the variety of shopping centres;

v) the model using the above list of variables is by no means intended to be explanatory in the theoretical sense: at most it describes the results of shoppers' movements, not their intentions;

vi) the above list depends on the product group considered, especially concerning characteristics of the shopping centre and environmental characteristics of the establishment. For necessities, variety, choice and atmosphere play a minor role, whereas price and ease of access seem important. For durables, choice and atmosphere will probably dominate other characteristics.

4.3. Hypotheses to be tested.

In this section hypotheses to be tested, which are realizable in the light of the data actually acquired for our study, will be formulated. These hypotheses are formulated using the concept of efficiency of total available floorspace, which can be associated with the value of annual sales per unit of total available floorspace. See section 2.2. The hypotheses refer to individual establishments.

H16: efficiency of total available floorspace increases if the retail sales per caput in the surrounding area of the product groups sold increases.

H17: efficiency of total available floorspace increases if the population density of the surrounding area increases.

H18: efficiency of total available floorspace increases if the number of competitive establishments per caput in the surrounding area decreases.

H19: efficiency of total available floorspace increases if the total number of establishments of the shopping centre increases.

H20: efficiency of total available floorspace increases if the average size of the total number of establishments of the shopping centre increases.

H21: efficiency of total available floorspace increases if the number of parking places of the shopping centre increases.

H22: efficiency of total available floorspace is higher if the shopping centre is not intersected by roads (than if it is intersected).

H23: efficiency of total available floorspace increases if the impression of the exterior of an establishment becomes more favourable (i.e. modern versus obsolete).

H24: efficiency of total available floorspace increases if the impression of the interior of an establishment becomes more favourable (i.e. modern versus obsolete).

Impression of the interior of an establishment is no environmental variable. However, it is interesting to study its influence and that of the exterior at the same time.

The influence of the following variables on efficiency of total available floorspace will be studied without an a priori hypothesis:

i) number of competing establishments (offering the same product group) in the shopping centre;

ii) average size of the competing establishments in the shopping centre;

iii) impression of the standing of the location of the establishment;

iv) total inhabitants of the town in which the establishment is located;

v) the fact whether the establishment is located in the centre of the town or not;

vi) prosperity level of the population of the surrounding area.

In section 4.2 it is explained that we have no a priori hypothesis on the influence of number of competing establishments in the shopping centre and their average size. The influence of number of inhabitants of the town is studied because some results with this variable are also obtained in chapter three. The remaining variables (standing, town centre and prosperity level) are taken into account, because they are available in our data material.

4.4. Tests.

In this section we will not report our test results as comprehensively as in the remaining chapters. The report is limited because the message resulting from the tests is short: environmental variables do not influence efficiency of total floorspace.

A detailed example of an empirical test is given in the appendix to this chapter. This test examines the hypotheses and further influences given in section 4.3. Seven samples of a total of 451 Dutch establishments (mostly supermarkets and clothes shops) are used. The conclusion drawn from this test, that environmental variables do not influence efficiency of total available floorspace, is very surprising. Therefore, numerous additional analyses were performed.

Firstly, analyses were performed which tried to reduce the number of variables. Variables were omitted which

- do not seem to have any influence (e.g. population density);
- are strongly intercorrelated with other variables (e.g. impression of interior which is strongly correlated with impression of exterior);
- have no unambiguous theoretical influence (e.g. number of competitors in the shopping centre).

Secondly, observations of establishments in large towns were deleted. This was done, because the value of a variable as a town average may differ largely from the value taken in the immediate vicinity of the establishment. These latter values are often not at our disposal and the difference between the former and the latter probably diminishes with decreasing town size.

Thirdly, samples were grouped together, definitions of variables were amended and new variables were included, which were not consistently available among the samples. We do not report on these exercises in detail, because our basic conclusion remains unaltered: environmental variables do not influence efficiency of total available floorspace.

Finally, a new technique, called Constraint Analysis, is used to study the influence of environmental variables on efficiency of floorspace [6]. This technique deals with nominal variables and has no presumptions with regard to the nature of the interdependencies. Approximately the same samples are studied with the exclusion of chain supermarkets and superettes, but with the inclusion of more clothes shops. A total of 550 Dutch retail establishments is investigated. This study shows that efficiency of floorspace is only weakly related with impression of standing, impression of interior and size of the shopping centre.

Our basic conclusion, that environmental variables do not influence efficiency of total available floorspace, may have several causes:

i) bad variables or bad observations are used:
  - all observations of the samples SUP73, SUP74, ZB7374, ZS75 ∪ ZS79 and CL79 are located in newly built shopping centres. These shopping centres were founded after 1960 and contain at least four establishments. See Table A.4.1 for an indication of the number of establishments in the shopping centre. Therefore, our samples are no random samples. However, the population percentage of food establishments with a solitary location or located in a small shopping centre is not high. The population percentage of food establishments which is located in shopping centres founded before 1960 will also be low. We surmise that the elimination of this shortcoming will not alter the results drastically. Exercises with samples SUP75 and ZB75, which contain solitary as well as old estabishments do not produce results which differ from those obtained with the remaining (non-random) samples;
  - some variables do not describe the neighbourhood of the establishment, but are more town averages. This is a clear disadvantage, if the town is large.No sufficient description is obtained of the local market of the establishment. However, a fair amount of other variables do describe the immediate vicinity (shopping centre) of the establishment;
  - detailed data are lacking on the competitors of an establishment. Only their number and average size are available as far as the shopping centre is concerned. Competitors may also be located outside the shopping centre and further variables (price level, promotional efforts, service level etc.) seem necessary to describe the competitive environment satisfactorily;

- the reach of other data drawbacks (intercorrelation between variables, small number of observations in the light of the number of variables used etc.) was studied with the numerous additional analyses. The essence of these analyses is set out briefly above, where it is concluded that these drawbacks do not seem serious. In our opinion, it is not justified to state that our results are strongly influenced by bad variables or bad observations;

ii) environmental variables never influence efficiency of total available floorspace. In our opinion the proposition of this cause is premature because a limited number of shop types is studied and some data drawbacks remain present;

iii) characteristics of the establishment itself play a predominant role in establishing efficiency of total available floorspace. The analyses in chapters two and three are based on this intuitive idea. The high explanation of the models used in these chapters as well as the easy interpretation of the influence of characteristics of the establihsment on efficiency of total available floorspace, give credibility to this idea. The absence of influence of environment variables on efficiency of total floorspace again supports this idea. However, we do not think that the environment has no influence at all. We surmise that there are two effects. The first is that the environment influences the characteristics of the establishment, while they influence the efficiency of total available floorspace. For example, a favourable location results in high rent costs, a solitary location necessitates a wide assortment composition, the proximity of a considerably larger competitor requires a deep or at least distinct assortment composition. It is very interesting to study these aspects of retail behaviour. Nevertheless, we will not burden our research with such a study [7]. The second is that the remaining influences of the environment have no unambiguous sign [8];

iv) no appropriate model is used. The model presented in chapter two can be viewed as a description of only the supply side of the relation between the value of annual sales and floorspace. Adding a demand side, we propose the following model:

(4.4.1) $Q_i^S = f(C_i, R_i, X_i);$

(4.4.2) $$W_i \triangleq C_i + R_i;$$

(4.4.3) $$\frac{dQ_i^S}{dC_i} = 0 \quad \text{and} \quad \frac{dQ_i^S}{dR_i} = 0;$$

(4.4.4) $$Q_i^D = g(C_i, Y_i);$$

(4.4.5) $$Q_i \triangleq \min(Q_i^S, Q_i^D),$$

where Q_i^S: value of annual supplied sales of establishment i;

C_i: selling area;

R_i: remaining space;

W_i: total available floorspace;

X_i: vector of characteristics of the establishment;

Q_i^D: value of annual demanded sales;

Q_i: value of annual sales;

Y_i: vector of environmental variables and sometimes also characteristics of the establishment (e.g. average price).

Equations (4.4.1), (4.4.2) and (4.4.3) are dealt with in chapter two. Equation (4.4.4) is a demand equation: value of annual demanded sales depends on size of the selling area and environmental variables. Equation (4.4.5) is a definition saying that actual sales equal either supplied sales (capacity) or demanded sales, depending on which are lower. If $Q_i^S < Q_i^D$, then environmental variables play no role in equation (4.4.1). If $Q_i^S > Q_i^D$, then the influence of environmental variables on the relation between sales and floorspace should be established in equation (4.4.4). Assuming that for all establishments i, $Q_i^S < Q_i^D$, we can understand the result that environmental variables do not influence efficiency of total available floorspace. It is not likely, however, that there is no overcapacity in retail floorspace. Exercises with models like the one presented above, may answer this last question. These exercises will not be performed in the scope of the present studies.

4.5. Conclusion.

A study is made of the influence of environmental variables on differences in efficiency of total available floorspace for seven samples of Dutch retail establishments: supermarkets, superettes and clothes shops. One variable, prosperity level of the surrounding population appears to influence (but not always significantly) floorspace efficiency: floorspace efficiency is higher if the prosperity level is high (than if it is low). On the whole, no other influences are found. This finding remains unaltered despite numerous exercises, ample considerations of their possible improvement and the use of various research methods. Our initial intuitive claim, that characteristics of the establishment itself play a predominant role in establishing the value of total annual sales, is certainly not disproven. We surmise that the environment influences these characteristics, while they, in turn, influence the value of total annual sales or efficiency of total available floorspace. These aspects of retail behaviour will not be studied here.

Footnotes to chapter four.

[1] Shopping centres play an important role in aggregate shopping behaviour, cf. central place theory (based on the work of the German scholars Christaller and Lösch), spatial interaction models (based on the work of Reilly and Huff) or other studies (for example, using canonical analysis, Bellenger, Robertson and Greenberg [1977] dealt with shopping centre rather than individual shop patronage motives and are then able to distinguish between two shopper types: the convenience and the recreational shopper). Nooteboom [1980] p. 156 proposes a detailed two-stage distribution mechanism for consumer spending in which the establishment share in shopping centre sales and the shopping centre share in neighbourhood sales are explained.

[2] Rich and Portis [1964] and Doyle and Fenwick [1974] study the effect of image in retailing; the former of department stores and the latter of grocery chains.

[3] For example, in spatial interaction models (see Lichfield et. al. [1970] p. 34 for a survey) or in the decision type models of Bacon [1971], Baumol and Ide [1956] and Pankhurst and Roe [1978]. Sometimes however, it is doubted whether spatial consumer behaviour of a mobile and urbanized population, having at its disposal a highly developed road system, is considerably influenced by distance. See Clark [1968], Doyle and Fenwick [1974] and Thompson [1967].

[4] See Davies [1969].

[5] See Bellenger, Robertson and Greenberg [1977].

[6] See Groen, Thurik and Van der Wijst [1983] who study the relations between labour productivity, efficiency of floorspace and environmental variables.

[7] We could not refrain from performing two obvious tests:

i) equation (A.4.1) of the appendix to this chapter is reestimated with $\zeta_1 = 0$: occupancy costs are left out of consideration. We expected a stronger influence of environmental variables. However, compared with the results in Table A.4.2, no drastic differences appeared;

ii) occupancy costs per unit of total available floorspace are explained using the remaining right-hand variables of equation (A.4.1). The average explanation among the seven samples is moderate: the average value of the coefficient of determination is approximately .25. It is interesting to note that

- for chain supermarkets and clothes shops, population density has a positive influence on occupancy costs;
- for all shop types, number of establishments per caput has a negative influence on occupancy costs;
- for SUP75, ZB75 and ZS75 ∪ ZS79, a central location has a negative influence on occupancy costs, whereas prosperity level has a positive one;
- for SUP75, ZB75, ZS75 ∪ ZS79 and CL79, impression of standing has a positive influence on occupancy costs;
- for SUP75 impression of interior has a positive and impression of exterior a negative influence on occupancy costs. For ZB75 the inverse influences are observed.

The above results invite further theoretical considerations and empirical testing.

[8] Both Hall et al. [1961] p. 131 ff. and Nooteboom [1980] p. 148 ff. point out the complexity of the causal structure that links environmental variables to characteristics of the shop, which may involve environmental variables having no influence (i.e. their influence has no unambiguous sign) on specific characteristics to be explained. They distinguish between remote causes (macro level environmental characteristics) and proximate causes (micro level shop characteristics) to draw a picture how the latter characteristics depend upon the former. This distinction is particularly useful when shop characteristics are not observable. Such pictures may sometimes be very complex. Cf. the causal structure of the relation between per capita income and sales per person engaged given by Hall et al. [1961] p. 135.

We shall now illustrate the possible complexity of causal structures using the example of the influence of number of parking places. Attractiveness of the shopping centre increases and therefore its total sales and also the sales of the shop investigated when the number of parking places increases. However, the proportion of motorized customers increases when the number of parking places increases, which may cause an increasing peak in the distribution of customers' arrivals due to the limited availability of cars during working hours. Such peaks may cause inefficiency in the use of floorspace. The argument given above is conditional upon the fact that parking places are indeed meant for the customers of the shopping centre and not for a nearby business centre or town centre.

APPENDIX TO CHAPTER FOUR.

DATA AND EXAMPLE OF SOME TESTS.

A.4.1. Data.

Exercises are performed with
- Dutch chain supermarkets of 1973 (SUP73);
- Dutch chain supermarkets of 1974 (SUP74);
- Dutch chain superettes of 1973 and 1974 (ZB7374);
- Dutch independent supermarkets of 1975 (SUP75);
- Dutch independent superettes of 1975 (ZB75);
- Dutch independent supermarkets and superettes of 1975 (ZS75 $\subset$ SUP75 $\cup$ ZB75);
- Dutch independent supermarkets and superettes of 1979 (ZS79 $\subset$ SUP79 $\cup$ ZB79);
- Dutch independent and chain clothes shops of 1979 (CL79 $\subset$ CLI79 $\cup$ CLC79).

See appendices to chapters two (section A.2.1) and three for a further description of these samples.

The environmental variables stem from

i) research by the field force of E.I.M.: all variables unless otherwise indicated, except observations from the Dutch grocery chain (SUP73, SUP74 and ZB7374);

ii) large Dutch enterprise (SUP73, SUP74 and ZB7374): all variables unless otherwise indicated;

iii) carthotheek nieuwe winkelcentra (E.I.M.);

iv) material from Centraal Bureau voor de Statistiek:
   a) Centraal Bureau voor de Statistiek, 1981, Ruimtelijke structuur en spreiding van de detailhandel in voedings- en genotmiddelen 1974 (Staatsuitgeverij, 's Gravenhage);
   b) Centraal Bureau voor de Statistiek, 1974, Bevolking der gemeenten van Nederland op 1 januari 1974 (Staatsuitgeverij, 's Gravenhage);
   c) Centraal Bureau voor de Statistiek, 1980, Bevolking der gemeenten van Nederland op 1 januari 1980 (Staatsuitgeverij, 's Gravenhage).

An indication of the range of some environmental variables is given in Table A.4.1.

Table A.4.1. Further description of the samples: RS_i is total food retail sales per caput in the town (in Dutch guilders of 1974), PD_i is number of inhabitants per km^2 in the town, NE_i is number of food retail establishments per caput in the town (× 100), NI_i is total number of establishments in the shopping centre, SI_i is their average total floorspace (in m^2), NIC_i is number of competing establishments in the shopping centre, SIC_i is their average total floorspace (in m^2) and TS_i is number of inhabitants of the town (divided by 100).

code	$minRS_i$ $\overline{\overline{RS}}$ $maxRS_i$	$minPD_i$ $\overline{\overline{PD}}$ $maxPD_i$	$minNE_i$ $\overline{\overline{NE}}$ $maxNE_i$	$minNI_i$ $\overline{\overline{NI}}$ $maxNI_i$	$minSI_i$ $\overline{\overline{SI}}$ $maxSI_i$	$minNIC_i$ $\overline{\overline{NIC}}$ $maxNIC_i$	$minSIC_i$ $\overline{\overline{SIC}}$ $maxSIC_i$	$minTS_i$ $\overline{\overline{TS}}$ $maxTS_i$
SUP73	1463	66	.167	4	146	0	0	127
	1786	2231	.320	36	320	2.5	426	1677
	2408	7406	.443	108	1303	11	1689	7708
SUP74	1346	13	.155	4	102	0	0	106
	1761	2090	.311	36	307	2.6	429	1609
	2408	7406	.443	108	1303	11	1689	7708
ZB7374	1133	152	.190	9	80	0	0	150
	1718	2144	.294	28	166	2.9	195	1952
	3131	4891	.426	82	468	12	640	7708
SUP75	832	41	.171					40
	1644	1052	.288					485
	3131	6921	.439					1918
ZB75	643	55	.161					25
	1636	1348	.331					1169
	2429	7406	.681					7708
ZS75 ∪	605	41	.061	5	90	0	0	88
ZS79	1628	1395	.276	17	179	1.7	205	865
	2513	6527	.480	51	488	6	1332	7169
CL79		144		24	103	0	0	157
		1785		53	262	6.8	291	729
		3764		138	588	30	955	5792

A.4.2. Example of some tests.

The hypotheses mentioned in section 4.3 are tested using the following specification:

$$(A.4.1) \quad RES_i = \zeta_0 + \zeta_1 \log \frac{HV_i}{\overline{\overline{HV}}} + \zeta_2 \log \frac{RS_i}{\overline{\overline{RS}}} + \zeta_3 \log \frac{PD_i}{\overline{\overline{PD}}} + \zeta_4 \log \frac{NE_i}{\overline{\overline{NE}}} +$$
$$+ \zeta_5 (NI_i - \overline{\overline{NI}}) + \zeta_6 (SI_i - \overline{\overline{SI}}) + \zeta_7 (PP_i - \overline{\overline{PP}}) +$$
$$+ \zeta_8 IR_i + \zeta_9 \log \frac{IE_i}{\overline{\overline{IE}}} + \zeta_{10} \log \frac{II_i}{\overline{\overline{II}}} + \zeta_{11} (NIC_i - \overline{\overline{NIC}}) +$$
$$+ \zeta_{12} (SIC_i - \overline{\overline{SIC}}) + \zeta_{13} \log \frac{IS_i}{\overline{\overline{IS}}} + \zeta_{14} \log \frac{TS_i}{\overline{\overline{TS}}} +$$
$$+ \zeta_{15} CE_i + \zeta_{16} PL_i + v_i,$$

where RES_i: value of the residue of the relationship in logarithmic form between value of annual sales and total available floorspace used in chapters two and three (cf. relationship 2.5.1). The influence of HV_i is omitted in establishing this residue, i.e. $\beta_1 = 0$ in equations (2.6.1) and (3.3.1); that of TS_i is also omitted, i.e. $\beta_4 = 0$ in equation (3.3.1);

HV_i: occupancy costs per m^2 (in Dutch guilders of 1979);

RS_i: total food retail sales per caput in the town (in Dutch guilders of 1974);

PD_i: population density of the town (inhabitants per km^2);

NE_i: number of food retail establishments per caput in the town;

NI_i: total number of establishments (retail and other, i.e. handicrafts, restaurants, banks etc.) in the shopping centre;

SI_i: average total available floorspace of total number of establishments in the shopping centre (in 10^3 m^2). For the analyses with SUP75 and ZB75, $SI_i = SC_i$, where SC_i is an indicator of size of shopping centre. See section 3.3: SC_i increases if the size of the shopping centre (expressed in number of establishments) increases;

PP_i: number of parking place of the shopping centre divided by 1000;

IR_i = 1 if the shopping centre is not intersected by roads and = 0 otherwise (intersected);

IE_i: impression of exterior. A five point scale is used: from IE = 1 for obsolete to IE = 5 for modern;

II_i: impression of interior. The same scale is used as for IE_i;

NIC_i: number of competitive establishments (offering the same product group) in the shopping centre;

SIC_i: average total available floorspace of competing establishments in the shopping centre (in 10^3 m^2);

IS_i: impression of standing of the location. A five point scale is used: from IE = 1 for cheap to IE = 5 for expensive;

TS_i: total inhabitants of the town;

CE_i = 0 if the establishment is located in the centre of the town and = 1 otherwise;

PL_i = 1 if the prosperity level of surrounding population is high and = 0 if this level is low;

v_i: independently normally distributed stochastic variable with zero expectation and constant variance.

Specification (A.4.1) results after taking logarithms of a multiplicative specification of the type of (2.6.1) or (3.3.1). Logarithms are taken, because RES_i is the value of the residue of the relationship between value of annual sales and total available floorspace, which is also taken in logarithmic form. A multiplicative specification is chosen because such a specification accounts for interaction between variables. The analysis of environmental variables using (A.4.1) is practically equivalent to an analysis in which the right-hand sides of (2.6.1) and (3.3.1) are extended with the antilog form of the right-hand side of (A.4.1).

In establishing the residue RES_i, the influence of occupancy costs per m^2, HV_i, is omitted and taken into account again in the right-hand side of (A.4.1). This is done because it is assumed in secton 2.4 that, to a certain extent, occupancy costs per unit of total floorspace correlate with the attraction of the establishment. The use of (A.4.1) including HV_i enables a study of whether environmental variables have a direct influence on efficiency of total available floorspace or whether this influence is accounted for by rent costs per unit of total floorspace (which is a part of occupancy costs). The value of ζ_1 in (A.4.1) should be approximately equal to that of β_1 in (2.6.1) and (3.3.1) in the latter case. In the original multiplicative specification an exponential specification is chosen for variables, the value of which may also be zero: NI_i, SI_i, PP_i, NIC_i, SIC_i, CE_i and PL_i.

Exercises are performed with:

- Dutch chain supermarkets of 1973 (SUP73);
- Dutch chain supermarkets of 1974 (SUP74);
- Dutch chain superettes of 1973 and 1974 (ZB7374);
- Dutch independent supermarkets of 1975 (SUP75);
- Dutch independent superettes of 1975 (ZB75);
- Dutch independent supermarkets and superettes of 1975 (ZS75) which is a subsample of SUP75 ∪ ZB75;
- Dutch independent supermarkets and superettes of 1979 (ZS79) which is a subsample of SUP79 ∪ ZB79. See Table A.2.1;
- Dutch independent and chain clothes shops of 1979 (CL79) which is a subsample of CLI79 ∪ CLC79. See Table A.3.1.

The following conclusions can be drawn from Table A.4.2:

i) environmental variables do not seem to influence efficiency of total available floorspace. Neglecting the estimates of ζ_0 (intercept) and ζ_1 (occupancy costs) we see that only seven of the remaining estimated coefficients differ significantly from zero at a ten percent level of significance, whereas in two out ot these seven cases (ζ_4 and ζ_6 of ZB7374) the sign of the coefficient is contrary to what is expected on basis of our hypotheses to be tested;

ii) if we neglect the aspect of significancy, we see that impression of exterior has an influence on efficiency of total available floorspace which is consistently positive among the shop types, impression of interior has one which is consistently negative, impression of the standing of the location has one which is consistently negative and prosperity level of the surrounding population has one which is consistently positive. In the light of the standard error of the coefficient, the positive influence of prosperity level on floorspace efficiency is the most promising. Our hypothesis is that the price level of products increases with increasing prosperity level, so that floorspace efficiency (expressed in money terms) increases. Apparently, a high service level needed to serve a prosperous population is no significant counterforce;

iii) in chapter three it is found that floorspace efficiency of food shop types increases with increasing shopping centre size (expressed in number of establishments). We see that for the food shop types in Table A.4.2

$\hat{\zeta}_5 > 0$ in four out of six cases, $\hat{\zeta}_5$ does not differ significantly from zero in any case, but $\hat{\zeta}_5 > \hat{\sigma}(\hat{\zeta}_5)$ in three out of four cases for which $\hat{\zeta}_5 > 0$. The finding of chapter three need not be rejected;

iv) in chapter three it is also found that floorspace efficiency increases with increasing township size. For independent supermarkets and superettes only, very weak support is found for this hypothesis: $\hat{\zeta}_{14} > 0$ for SUP75, ZB75 and ZS75 $\cup$ ZS79. We must emphasize that in chapter three township size is taken into account, while in the present chapter town size is taken into account. For large towns a township is taken to be a part (several quarters, independent nucleus, side of a river) of the town. Both township size and town size are expressed in number of inhabitants;

v) $\hat{\zeta}_1 > 0$ and significantly in all seven cases. The values of $\hat{\zeta}_1$ are approximately equal to that of $\hat{\beta}_1$ in Tables 2.2 and 3.2.

Table A.4.2. Estimates of the coefficients of relationship (A.4.1).

shop type		SUP73	SUP74	ZB7374	SUP75	ZB75	ZS75 ∪ ZS79	CL79
intercept	$\hat{\zeta}_0$	-.07 (.06)*	-.05 (.06)*	-.13 (.11)*	-.07 (.09)*	.09 (.08)*	.18 (.10)	-.15 (.22)*
occupancy costs	$\hat{\zeta}_1$	.38 (.12)	.47 (.12)	.82 (.20)	.41 (.12)	.60 (.12)	.43 (.13)	.35 (.19)
retail sales per caput	$\hat{\zeta}_2$	.11 (.34)*	.30 (.30)*	-.51 (.39)*	.10 (.16)*	.15 (.19)*	-.26 (.23)*	
population density	$\hat{\zeta}_3$	.00 (.04)*	-.01 (.04)*	-.01 (.11)*	-.00 (.03)*	-.04 (.04)*	-.02 (.04)*	-.00 (.07)*
establishments per caput	$\hat{\zeta}_4$	.06 (.21)*	.25 (.18)*	.90 (.50)	-.19 (.13)*	-.10 (.14)*	.16 (.15)*	
shopping centre establishments	$\hat{\zeta}_5$	-.04 (.15)*	.21 (.15)*	.24 (.43)*	.09 (.08)*	-.02 (.10)*	.58 (.37)*	-.00 (.41)*
their size	$\hat{\zeta}_6$	.23 (.20)*	.19 (.18)*	-1.96 (.99)			- .69 (.46)*	-.29 (.94)*
parking places	$\hat{\zeta}_7$	-.05 (.10)*	.03 (.09)*	.89 (.90)*			-.11 (.43)*	.15 (.34)*
road intersection	$\hat{\zeta}_8$	.04 (.06)*	-.01 (0.6)*	.16 (.12)*			-.00 (.07)*	.00 (.19)*
exterior	$\hat{\zeta}_9$				.32 (.26)*	.17 (.18)*	.07 (.22)*	.05 (.69)*
interior	$\hat{\zeta}_{10}$				-.31 (.29)*	-.29 (.22)*	-.09 (.21)*	-.27 (.48)*
shopping centre competitors	$\hat{\zeta}_{11}$	1.06 (3.05)*	-1.42 (3.01)*	-2.62 (6.32)*			-2.81 (5.57)*	1.20 (2.27)*
their size	$\hat{\zeta}_{12}$	-.04 (.08)*	-.08 (.08)*	.10 (.29)*			-.09 (.11)*	-.33 (.32)*
standing	$\hat{\zeta}_{13}$				-.31 (.14)	-.00 (.14)*	-.39 (.16)	-.54 (.43)*
town size	$\hat{\zeta}_{14}$	.01 (.04)*	-.03 (.03)*	-.09 (.11)*	.01 (.04)*	.07 (.04)	.05 (.04)*	-.17 (.11)*
central location	$\hat{\zeta}_{15}$				-.02 (.07)*	-.06 (.07)*	-.04 (.10)*	.04 (.14)*
prosperity	$\hat{\zeta}_{16}$	.24 (.06)	.20 (.06)		.11 (.08)*	.03 (.08)*	.07 (.06)*	
number of observations	I	73	91	39	60	73	77	38
coefficient of determination	R^2	.33	.32	.52	.40	.41	.35	.47

Note Table A.4.2: the estimates are produced by an ordinary multiple linear least squares fit. Estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficients. An asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$.

CHAPTER FIVE.

THE RELATIONSHIP BETWEEN VOLUME OF LABOUR AND VALUE OF ANNUAL SALES.

5.1. Introduction.

The second part of our study deals with the explanation of differences in labour productivity per establishment. The emphasis of this part lies on empirical findings. It uses the relationship between volume of labour and value of sales for retail establishments developed by Nooteboom [1].
The basis ingredients of his analysis are:

i) there is a linear non-homogeneous relationship between volume of labour and value of sales for establishments belonging to a certain shop type;
ii) the intercept of this relationship is associated with threshold labour, i.e. minimum labour capacity which must be present during total opening time;
iii) theoretically, this relationship can be derived for groups of shops which are very narrowly defined. However, empirically, promising results are obtained for shop types having a practical definition [2];
iv) theoretically, this relationship can be derived noting that there are two types of labour: labour to serve customers and labour for other activities.

This relationship is used here, because

i) it is based on a theoretical justification;
ii) it is supported by ample evidence concerning many largely differing Dutch shop types;
iii) scale effects are easily studied;
iv) in its basic form it is a simple linear model [3].

In this chapter, the basic elements of the relationship will be discussed briefly (section 5.2). Also, the basic empirical relationship, which we will use to study labour productivity, will be presented (section 5.3). The evidence provided by Nooteboom refers primarily to small shops. Therefore, some attention will be devoted in section 5.3 to the relationship which will be used for larger shops. Moreover, it is shown empirically in the appendix to this chapter that for various French shop types of large establishments

i) linearity of the labour cost curve cannot be rejected;

ii) the intercept of this relationship is positive and can be associated with threshold labour.

The basic relationship presented in section 5.3 will be used in chapters six, seven, eight and nine: in chapter six to analyse labour productivity in large French supermarket(-like) establishments, in chapter seven to analyse the influence of the share of part-time labour in total labour on labour productivity, in chapter eight to analyse the influence of average transaction per customer on labour productivity and in chapter nine for our study on entrepreneurial behaviour.

5.2. Nooteboom's analysis.

Nooteboom developed a relationship between volume of labour and value of annual sales for retail establishments belonging to a certain shop type. His analysis consists of two parts: an empirical study and a theoretical foundation of the results found in the empirical study.
In the empirical study, a linear non-homogeneous relationship is consistently found for retail establishments:

(5.2.1) $$L = \phi_0 + \phi_1 Q \qquad \text{with } \phi_0 > 0 \text{ and } \phi_1 > 0,$$

where L: volume of labour (for example expressed in labour hours);
Q: value of annual sales (for example expressed in Dutch guilders).

Cross-section data of different shops of the same shop type in a given year are used [4].
The positive value for the intercept ϕ_0 is intuitively appealing: there is a minimum (threshold) labour capacity, which must be present during total opening time, no matter how low the use made of its capacity.
In the theoretical part, a derivation is developed that the labour cost curve for small retail establishments is approximately linear with a positive intercept and continuous and that the intercept equals the sum of opening times of all independently staffed departments in the shop. Two basic notions are introduced to provide this theoretical derivation:

firstly, a precise definition is given of the groups of shops considered (shop type), to which the labour cost relationship is applied. The shops are identical with respect to

i) number of departments. A department is a cash desk, service counter for specialized goods, information desk etc. or, strictly, a unit which requires at least one attendant and which operates independently;
ii) annual opening time;
iii) average service time per value unit of sales;
iv) target concerning relative waiting time (= ratio between average waiting time and average service time per customer);
v) amount of labour per value unit of sales, required for the handling of products, i.e. activities other than those vis-à-vis customers (e.g. stockkeeping, own production, administration etc.).

secondly, in retailing two types of labour can be distinguished: labour to serve customers in the light of the target concerning relative waiting time (see first notion) and labour for activities other than serving customers. We will argue in section 5.3 that the adjustment of available to required labour may be relatively easy and necessary. Nevertheless, it is certainly not instantaneous. Therefore, shopkeepers will use a certain proportion of idle service capacity in between customer's arrivals for activities other than those vis-à-vis customers. Furthermore, it is assumed that this proportion decreases as the share of idle service capacity in total capacity decreases because then the average duration of idle periods, and hence their usefulness, decreases.

This precise definition of a shop type does not leave room for a significant possibility for substitution of capital for labour. If capital is regarded as floorspace or as being closely related to it, this consequence is based on the fact that different proportions of capital and labour are associated with different shop types (i.e. marketing strategies). Moreover, substitution possibilities are reduced after instalment of the shop, assuming that total available floorspace is then hardly flexible anymore. Consequently, the relation between volume of labour and value of annual sales can be studied disregarding the use of capital.

Queuing theory is used (in conjunction with some weak assumptions concerning its application) and a plausible assumption is made concerning the specification of the relationship between the proportion of idle service capacity used for activities other than those vis-à-vis customers and the share of idle service capacity. It is then derived that the labour cost curve is approximated by a (linear) asymptote with intercept α_0 and slope α_1 for shops belonging to a certain shop type (precise definition) with one department, where

(5.2.2) $\alpha_0 = DO$ if relative waiting time is .75

and

(5.2.3) $\alpha_1 = (\tau_1 + \tau_2)$ with $\tau_1 > 0$ and $\tau_2 > 0$,

where DO: annual opening time;

τ_1: average service time per value unit of sales;

τ_2: average labour time per value unit of sales for activities other than serving customers.

There is a straightforward generalization applying to shop types with more than one department per shop:

(5.2.4) $\alpha_0 = \sum_{j=1}^{J} DO_j$,

where J: number of departments;

DO_j: annual opening time of department j.

5.3. Basic test specification.

The notions used to derive the linear asymptote and equations (5.2.2) and (5.2.3) are too stringent for empirical research purposes. Therefore, the following specification is proposed for a shop type with shops carrying one group of products and having one department and equal opening time:

(5.3.1) $L_i^R = \alpha_0 + \alpha_{1i} Q_i + v_{1i}$, where L_i^R: volume of required labour in establishment i;

Q_i: value of annual sales in establishment i;

α_0: threshold coefficient. Its value is associated with the annual opening time of this shop type. Its value is equal for all shops;

α_{1i}: scale adjusted labour intensity (sli). This terminology becomes clear after rewriting (5.3.1). Ignoring disturbance term v_{1i}, (5.3.1.) is equivalent to $L_i^R/Q_i = \alpha_{1i} + \alpha_0/Q_i$, where L_i^R/Q_i represents labour intensity (the inverse of labour productivity), α_{1i} the scale (= sales) independent share and α_0/Q_i the scale dependent share. The value of α_{1i} depends on a vector X_i, the elements of which describe specific properties of establishment i. These properties are associated with type of labour, type of product, method of service, method of shop operation, mode of supply to the shop, characteristics of demand etc. [5];

v_{1i}: disturbance term [6]. This disturbance term is introduced because firstly, existing theory indicates an approximative, and not exact, linearity of the relationship, secondly, specification errors are unavoidable because the functional relationship underlying α_{1i} is not entirely known and, if it were, not all variables are available. In addition, measurement errors always occur.

Shopkeepers are now able to accomplish an easy adjustment of available labour to required labour. This may be assumed, because generally,

i) variations (daily, weekly, monthly and yearly) in required labour are predictable to a considerable extent;

ii) the nature of retail labour enables systematic regulation and accurate observation which are the essence of experimentation [7];

iii) retail labour is flexible in the sense that its volume can be varied in time (part-time labour) and in the sense that one employee can perform various tasks;

iv) retail labour is available.

The last two assumptions are justified because

a) part-time labour is common in retailing;
b) family labour is common in retailing;
c) relatively little specific knowledge is required by most of the people employed in retailing;
d) generally, shopping centres are not located far from residential areas;
e) on the whole, no long term contracts are concluded.

Furthermore, the accomplishment of this adjustment is not only easy, but also necessary, because retail labour is expensive (retail costs are primarily labour costs) and, to a considerable extent, indispensable [7]. Therefore, a shopkeeper will always try to reduce the divergence between available and required labour.
A simple labour adjustment equation is proposed:

(5.3.2) $$L_i - L_i^R = v_{2i},$$

where L_i: volume of available labour in establishment i;
v_{2i}: disturbance term: it is assumed that the difference between available and required labour contains no structural part.

Then

(5.3.3) $$L_i = \alpha_0 + \alpha_{1i}Q_i + v_{3i},$$

where v_{3i}: disturbance term: it is assumed that v_{1i} and v_{2i} are independently distributed.

Equation (5.3.3) may be rewritten as

(5.3.4) $$L_i = \alpha_0 + \alpha_1 g(X_i)Q_i + v_{3i},$$

where $\alpha_1\ g(X_i) \triangleq \alpha_{1i}$ and α_1 is called "average" sli, whilst $g(X_i)$ denotes the function of the specific properties X_i, which influence α_{1i}. It represents the difference between sli of a certain shop and "average" sli, which is attributable to the specific properties of the shop.

The generalization to shop types with more than one assortment group is straightforward. Again equation (5.3.3) is proposed, where now

(5.3.5) $$\alpha_0 = \sum_{k=1}^{K} \alpha_{0k}$$

and

$$(5.3.6) \qquad \alpha_{1i} = \sum_{k=1}^{K} s_{ki}\alpha_{1ki}$$

or

$$(5.3.7) \qquad \alpha_{1i} = \sum_{k=1}^{K} s_{ki}\alpha_{1k}g_k(X_i),$$

where α_{0k}: threshold labour of assortment group k. Its value is associated with the number of departments in assortment group k and their annual opening time;

K: total number of assortment groups;

$s_{ki} = Q_{ki}/Q_i$: sales share of assortment group k;

Q_{ki}: value of annual sales of assortment group k. Clearly, $\sum_{k=1}^{K} Q_{ki} = Q_i$;

α_{1ki} is called the partial sli of assortment group k;

α_{1k} is called the partial "average" sli of assortment group k.

or

$$(5.3.8) \qquad L_i = \sum_{k=1}^{K} \alpha_{0k} + \sum_{k=1}^{K} \alpha_{1k}g_k(X_i)Q_{ki}.$$

Equation (5.3.8) will be used as a basic relationship in our analyses in the succeeding chapters [8].

Footnotes to chapter five.

[1] See Nooteboom [1982] for a concise theoretical explanation and Nooteboom [1980] for an extensive theoretical explanation with empirical evidence.

[2] A shop type is defined as a group of establishments which has a certain homogeneity regarding assortment composition, mode of service (counter service, self-selection, self-service), extent of own production (the definition of which depends largely on the shop type: e.g. bread baking for baker's shops, butchering for butcher's shops, the use of a dark room for photographer's shops, etc.) and type of organization (chain, cooperative, independent).

[3] In its basic form, the model is easily aggregated, so that also regional averages can be studied consistently. See Nooteboom [1980] p. 216 ff. On p. 225 through 229, the linearity of the labour cost relationship is demonstrated for British, American and Canadian regional averages. See also Thurik and Van Schaik [1984] and Thurik and Vollebregt [1984], who study differences in labour productivity per shop type in the retail trade in the Netherlands and in France, and Thurik [1984a], who studies differences in labour productivity among small business trade groups in Pretoria (R.S.A.).

[4] See Nooteboom [1980] p. 42 through 48, and p. 50, 51, 183 and 184.

[5] See Nooteboom [1980] p. 151 ff. He also proposes a detailed specification for α_{1i} (p. 128).

[6] A disturbance term is defined here as an independently distributed stochastic variable with zero expectation and constant variance.

[7] See Moyer [1972] p. 7.

[8] Van der Hoeven and Thurik [1983] also use this relationship for their analysis of labour costs in the hotel trade.

APPENDIX TO CHAPTER FIVE.

TWO TESTS ON STRUCTURAL CHANGE.

A.5.1. Introduction.

In this appendix the hypothesis to be studied is whether a linear non-homogeneous relationship exists between volume of labour and value of annual sales for some French shop types of large establishments and whether this relationship has a positive intercept:

(A.5.1.1) $L_i = \alpha_0 + \alpha_1 Q_i$,

where L_i: volume of labour (in full-time equivalents);
Q_i: value of annual sales (in 10^6 French francs).

We shall try to tackle this problem with simple analytical means.
A description of the test problem is given in section A.5.2. and the test pocedures are developed in section A.5.3., where special attention is also devoted to a heteroskedastic disturbance structure which is often encountered in cross-section studies. The results of the tests are discussed in section A.5.4. A description of the shop types, the source of the data used as well as a description of the samples is given in section A.5.5. In this appendix, matrices are denoted by underlined symbols (e.g. $\underline{\Omega}$).

A.5.2. Description of the test problem.

For a test on linearity it is assumed that the disturbance term added to equation (A.5.1.1) is normally distributed:

(A.5.2.1) $L = \underline{W}\alpha + V$,

where $\underline{W} = [\iota \; Q]$ and $\alpha = \begin{pmatrix} \alpha_0 \\ \alpha_1 \end{pmatrix}$, with ι an I × 1 vector of ones and L and Q I × 1 vectors of volume of labour and value of annual sales and where V is an I × 1 vector of normally distributed stochastic variables with E(V) = 0 and $E(VV') = \sigma^2\underline{\Omega} = \sigma^2[\omega_{ii'}]$ with $\omega_{ii'} = 0$ if $i \neq i'$ and $\omega_{ii} = Q_i^{2\lambda}$.

It is assumed that a sample, S, of I independent observations is available. The observations are ordered according to the value of Q_i in such a way that $Q_i < Q_{i'}$, if and only if $i < i'$.
The sample of I observations is partitioned into two subsamples so that one subsample, S_1, consists of the first I_1 observations and the other, S_2, of the last $I_2 = I - I_1$ observations.
The following two tests can be distinguished:

- a test on structural change in the broad sense:
  assume the linear model (A.5.2.1) for S_1 and test whether the additional observations of S_2 come from the same linear model;
- a test on structural change in the narrow sense:
  assume the linear model (A.5.2.1) for both S_1 and S_2 and test whether the coefficients are equal.

Simple well-known test statistics can be derived for these two test problems.

A.5.3. Test procedures.

Consider the following model:

$$\text{(A.5.3.1)}\quad \underline{Y}^{(j)} = \underline{X}^{(j)}\beta^{(j)} + \underline{Z}^{(j)}\gamma^{(j)} + V^{(j)} \quad \text{for } j = 1,\ 2,$$

where $\underline{Y}^{(j)}$ and $\underline{X}^{(j)}$ are $I_j \times 1$ and $I_j \times k$ observation matrices, $\underline{Z}^{(j)}$ some arbitrary unknown matrices with maximum size $I_j \times (I_j - k)$, $\beta^{(j)}$ and $\gamma^{(j)}$ are $k \times 1$ and $(I_j - k) \times 1$ coefficient vectors and $V^{(j)}$ $I_j \times 1$ vectors of normally distributed stochastic variables with $E(V^{(j)}) = 0$ and $E(V^{(j)}V^{(j)'}) = (\sigma^{(j)})^2\, \underline{I}_{I_j}$ where $\underline{I}_{I_j}$ is an $I_j \times I_j$ unit matrix, and $\hat{V}^{(j)}$ are $n_j \times 1$ least squares residual vectors associated with (A.5.3.1).

Consider also

$$\text{(A.5.3.2)}\quad Y = \underline{X}\beta + V,$$

where $Y = \begin{bmatrix} Y^{(1)} \\ \hline Y^{(2)} \end{bmatrix}$, $\underline{X} = \begin{bmatrix} \underline{X}^{(1)} \\ \hline \underline{X}^{(2)} \end{bmatrix}$, $V = \begin{bmatrix} V^{(1)} \\ \hline V^{(2)} \end{bmatrix}$ and where $\hat{V}$ is the least squares residual vector associated with (A.5.3.2).

The following tests can be performed. See Chow [1960], Fisher [1970], Harvey [1976] and Wilson [1978].

Chow-test:

with the maintained hypothesis

$$H_M: \gamma^{(j)} = 0 \text{ for } j = 1 \text{ in (A.5.3.1)} \wedge (\sigma^{(1)})^2 = (\sigma^{(2)})^2$$

the hypothesis

$$H_0: \beta^{(1)} = \beta^{(2)} \wedge \gamma^{(2)} = 0$$

can be tested against

$$H_1: \beta^{(1)} \neq \beta^{(2)} \vee \gamma^{(2)} \neq 0.$$

This test is based on the statistic

$$\text{(A.5.3.3)} \quad F_c = \frac{[\hat{V}'\hat{V} - \hat{V}^{(1)'}\hat{V}^{(1)}]/I_2}{[\hat{V}^{(1)'}\hat{V}^{(1)}]/(I_1 - k)},$$

which has a central F-distribution with $(I_2, I_1 - k)$ degrees of freedom under hypothesis H_0.

Analysis of covariance-test:

with the maintained hypothesis

$$H'_M: \gamma^{(j)} = 0 \text{ for } j = 1, 2 \text{ in (A.5.3.1)} \wedge (\sigma^{(1)})^2 = (\sigma^{(2)})^2$$

the hypothesis

$$H'_0: \beta^{(1)} = \beta^{(2)}$$

can be tested against

$$H'_1: \beta^{(1)} \neq \beta^{(2)}$$

This test is based on the statistic

$$(A.5.3.4) \quad F_a = \frac{[\hat{V}'\hat{V} - \hat{V}^{(1)'}\hat{V}^{(1)} - \hat{V}^{(2)'}\hat{V}^{(2)}]/k}{[\hat{V}^{(1)'}\hat{V}^{(1)} + \hat{V}^{(2)'}\hat{V}^{(2)}]/(I_1 + I_2 - 2k)},$$

which has a central F-distribution with $(k, I_1 + I_2 - 2k)$ degrees of freedom under hypothesis H_0'.

The procedures are used in the following obvious way to test on the linearity of the relationship between volume of labour and value of annual sales: $j = 1$ is associated with S_1, $j = 2$ with S_2, $Y = L$, $\underline{X} = \underline{W}$ and $\beta = \alpha$.

The choice whether to use the analysis of covariance-test or the Chow-test should depend on the assumptions under the alternative hypothesis.
If relationship (A.5.1.1) cannot be assumed for all $Q_i \in S$, this can be caused by a structural change in the relation between volume of labour and value of sales. This change does not have to find its cause in a shift of α_0 and/or α_1. It might also find its cause in a supplementary factor, $\underline{Z}$, the influence of which becomes important with increasing scale. There are arguments for both causes. For example, large establishments may have a large number of departments (α_0 is high) with a high productivity (α_1 is low in comparison with small establishments). Then H_M' can be assumed. If, with increasing scale, there is an increasing possibility for substitution of capital for labour, H_M' cannot be assumed, because new factors enter the relation between labour and sales. However, if the shift in the number of departments is regarded to be continuous with scale, the Chow-test is always superior. The consequences of conducting a test in the light of the importance of the supplementary factor $\underline{Z}$, can be summarized as follows:

- when the analysis of covariance-test is conducted and $\gamma^{(2)} \neq 0$, the probability of a type II error is larger than expected on the basis of the chosen type I error. See Wilson [1978];
- when the analysis of covariance-test is conducted and $\gamma^{(2)} = 0$, this test is UMP in its class for testing H_0' against H_1' given H_M';
- when the Chow-test is conducted and $\gamma^{(2)} = 0$, its power is lower than the power of the analysis of covariance-test. See Chow [1960];

- when the Chow-test is conducted and $\gamma^{(2)} \neq 0$, rejection of (A.5.3.2) can be caused by the fact that there is a shift of the regression coefficients or a new effect is influencing the relationship. One cannot discriminate between the two causes. The test is UMP in its class for testing H_0 against H_1 given H_M.

It is obvious that neither test is superior, when no conclusive theoretical arguments are available with respect to the presence of $\underline{Z}$. The assumption of linearity is basic for a correct interpretation of the value of the coefficients. It is therefore preferable to have a low probability of a type II error. Neither test is in accordance with this preference: the analysis of covariance-test is not in accordance with this preference when $\gamma^{(2)} \neq 0$ and the Chow test when $\gamma^{(2)} = 0$. Therefore both tests are performed in spite of a disadvantage of the Chow-test which we shall explain below.

It should be emphasized that F_a no longer has an F-distribution if $(\sigma^{(1)})^2 \neq (\sigma^{(2)})^2$. See Toyoda [1974] and Schmidt and Sickles [1977]. The distribution of F_c also depends on the assumption $(\sigma^{(1)})^2 = (\sigma^{(2)})^2$. Therefore we shall perform a test on the equality of variance first. As a result of this test we shall multiply the original equations by an appropriate diagonal matrix $\underline{\tilde{\Omega}} = [Q_i^{-\tilde{\lambda}}]$, where $\tilde{\lambda}$ is an approximation of the λ of $\underline{\Omega}$, to obtain a homoskedastic disturbance structure. We want to decide between the following three values of $\tilde{\lambda}$: 0, .5 and 1. A test on the equality of variance will be used, which is proposed by Goldfeld and Quandt [1965]. The Chow-test has one disadvantage when compared with the analysis of covariance-test: it is better not to use a test for heterovariance which makes use of assumption (A.5.3.2), i.e. of the assumption of the equality of the regression coefficients of S_1 and S_2 and the assumption of the absence of any supplementary influence $\underline{Z}$. The test proposed by Goldfeld and Quandt does not make use of the assumption of the equality of the regression coefficients of S_1 and S_2. However, it does make use of the assumption of equality in specification. Consequently, this test is appropriate only in the case of the maintained hypothesis H'_M. Nevertheless, both the Chow-test and the analysis of covariance-test will be performed.

For the equality of variance-test we consider equation (A.5.2.1) multiplied by the diagonal matrix $\underline{\tilde{\Omega}} = [Q_i^{-\tilde{\lambda}}]$:

$$\text{(A.5.3.5)} \quad \underline{\tilde{\Omega}}^{(j)} L^{(j)} = \underline{\tilde{\Omega}}^{(j)} W^{(j)} \alpha^{(j)} + V^{(j)} \text{ for } j = 1, 2,$$

where $V^{(j)}$ are now $I_j \times 1$ vectors of normally distributed stochastic variables with $E(V^{(j)}) = 0$ and $E(V^{(j)}V^{(j)'}) = (\sigma^{(j)})^2 \underline{I}_{I_j}$ and $\hat{V}^{(j)}$ are $I_j \times 1$ least squares residual vectors associated with (A.5.3.5).

Let $\tilde{\lambda} = 0$. Then

$$H_0'': (\sigma^{(1)})^2 = (\sigma^{(2)})^2$$

can be tested against

$$H_1'': (\sigma^{(1)})^2 < (\sigma^{(2)})^2.$$

This test is based on the statistic:

$$\text{(A.5.3.6)} \quad F_g = \frac{[\hat{V}^{(2)'}\hat{V}^{(2)}]/(I_2 - 2)}{[\hat{V}^{(1)'}\hat{V}^{(1)}](/I_1 - 2)},$$

which has a central F-distribution with $(I_2 - 2, I_1 - 2)$ degrees of freedom under hypothesis H_0''.

Let $\tilde{\lambda} = 1$. Then

$$H_0''': (\sigma^{(1)})^2 = (\sigma^{(2)})^2$$

can be tested against

$$H_1''': (\sigma^{(1)})^2 > (\sigma^{(2)})^2.$$

This test is based on the statistic:

$$\text{(A.5.3.7)} \quad F_g^{-1} = \frac{[\hat{V}^{(1)'}\hat{V}^{(1)}]/(I_1 - 2)}{[\hat{V}^{(2)'}\hat{V}^{(2)}]/(I_2 - 2)},$$

which has again a central F-distribution with $(I_1 - 2, I_2 - 2)$ degrees of freedom under the hypothesis H_0'''.

The following strategy will be maintained:

- reject H_0'' and do not reject H_0''', then $\tilde{\lambda} = 1$
- do not reject H_0'' and reject H_0''', then $\tilde{\lambda} = 0$
- reject both H_0'' and H_0''', then $\tilde{\lambda} = .5$.

A.5.4. Results of the tests.

We choose $I_1 = I_2 = I/2$ for convenience. The results of the test of equality of variance are given in the second column of Table A.5.1. (choice of λ). For the transformed relationship, the test statistics for the tests on structural change F_a and F_c are given in the third and fifth column of Table A.5.1. From Table A.5.1 it can be concluded that

- the hypothesis of no structural change in the narrow sense (F_a) has to be rejected in three out of thirty-five cases at a 5% level of significance: for "magasins populaires" of 1977, for "magasins de bricolage" of 1979 and for Euromarché hypermarkets of 1976;
- the hypothesis of no structural change in the broad sense (F_c) cannot be rejected in any one case out of thirty-five cases at a 5% level of significance.

In each case of a rejection of no structural change in the narrow sense, this hypothesis cannot be rejected for the preceding and succeeding years. Therefore, we conclude that the hypothesis of a linear relationship between volume of labour and value of annual sales cannot be rejected for the shop types considered.

The estimates of α_0 and α_1 are given in columns seven and nine of Table A.5.1. It can be seen that

i) $\hat{\alpha}_0 > 0$ in thirty-three out of thirty-five cases and significantly (at a 5% level of significance) in twenty-two cases;

ii) $\hat{\alpha}_0 < 0$ in two out of thirty-five cases and significantly in one: $\hat{\alpha}_0 < 0$ for "magasins populaires" of 1975 and 1976;

iii) the average value for the threshold coefficient α_0 is

   a) 4.7 for supermarkets (SUP75 through SUP79)
   b) 39.8 for (mainly) independent hypemarkets (HYP75 through HYP77 and HYP74I through HYP78I)
   c) 1.2 for "magasins de bricolage" (MBR75 through MBR79)
   d) 4.5 for "centres d'equipement de la maison" (CEM75 through CEM79)
   e) 53.5 for Carrefour hypermarkets (HYP74C through HYP78C)
   f) 40.6 for Euromarché hypermarkets (HYP74E through HYP78E).

We conclude that generally $\hat{\alpha}_0 > 0$: economies of scale can be achieved with respect to the use of labour.

We will now check whether α_0 can indeed be associated with threshold labour. Threshold labour is assumed to depend on weekly opening time and number of departments. We have no data on weekly opening time. It is assumed to be equal for all establishments. Then threshold labour depends only on number of departments. We have no data on number of departments. It is assumed to be equal for all establishments per shop type and to be correlated with average (sales) size per shop type. Ignoring the results for "magasins populaires", we see that the average value for the threshold coefficient per shop type can indeed be associated with the average sales size per shop type (see Table A.5.3) in the case of supermarkets, (mainly) independent hypermarkets, "magasins de bricolage", Carrefour hypermarkets and Euromarché hypermarkets. Only in the case of "centres d'équipement de la maison" does the value of α_0 appear to be somewhat low.

Table A.5.1. The test statistics of the tests for structural change and the estimates of α_0 and α_1 for the transformed relationship.

code	λ	F_a	$F_{.05}(2,I-4)$	F_c	$F_{.05}(\frac{I}{2},\frac{I}{2}-2)$	$\hat{\alpha}_0$	$\hat{\sigma}(\hat{\alpha}_0)$	$\hat{\alpha}_1$	$\hat{\sigma}(\hat{\alpha}_1)$
SUP75	1	.59	3.20	1.17	2.03	.1	(1.3)*	2.08	(.11)
SUP76	.5	2.20	3.18	1.43	1.92	5.9	(1.3)	1.52	(.08)
SUP77	.5	3.09	3.26	1.32	2.24	4.2	(1.5)	1.54	(.11)
SUP78	1	1.37	3.49	1.31	2.91	4.3	(2.5)*	1.50	(.17)
SUP79	1	.02	3.63	.51	3.34	8.8	(2.9)	1.15	(.15)
MP75	1	.72	3.74	1.81	3.68	-5.4	(3.9)*	3.12	(.23)
MP76	1	2.01	3.49	1.56	2.91	-7.5	(2.9)	3.18	(.16)
MP77	1	8.31*	3.32	2.26	2.38	1.2	(1.6)*	2.27	(.12)
MP78	1	2.11	3.32	1.01	2.38	1.6	(1.3)*	1.90	(.09)
MP79	1	1.31	3.26	1.53	2.24	2.8	(3.6)*	2.02	(.16)
HYP75	0	.46	3.55	.28	3.10	46.4	(16.2)	1.58	(.11)
HYP76	.5	2.72	3.30	1.41	2.31	11.7	(12.1)*	1.69	(.12)
HYP77	.5	.15	3.38	.94	2.53	62.3	(14.5)	1.19	(.10)
MBR75	.5	1.20	3.19	.91	1.98	1.5	(.7)	2.83	(.15)
MBR76	1	1.65	3.16	.99	1.87	.7	(.3)	2.46	(.15)
MBR77	.5	2.18	3.17	1.73	1.89	1.4	(.4)	2.17	(.10)
MBR78	1	.36	3.13	.77	1.77	.9	(.5)*	2.20	(.12)
MBR79	1	3.95*	3.13	1.18	1.75	1.6	(.5)	1.76	(.11)
CEM75	.5	.79	3.13	1.48	1.77	3.3	(1.2)	2.11	(.13)
CEM76	.5	2.17	3.20	1.02	2.03	4.3	(1.7)	1.49	(.17)
CEM77	.5	.27	3.26	.99	2.20	4.7	(1.3)	1.35	(.11)
CEM78	.5	1.78	3.15	1.36	1.85	4.9	(1.4)	1.30	(.09)
CEM79	.5	.43	3.23	1.47	2.10	5.4	(1.9)	1.16	(.11)
HYP74I	0	.44	3.20	1.24	2.03	62.5	(13.7)	1.41	(.11)
HYP76I	1	2.10	3.14	.94	1.79	31.5	(8.4)	1.41	(.09)
HYP78I	0	.81	3.12	1.71	1.73	23.6	(9.6)	1.27	(.06)
HYP74CE	1	.68	3.30	.77	2.31	103.6	(24.8)	1.13	(.18)
HYP76CE	0	.58	3.18	1.85	1.92	205.7	(18.3)	.76	(.07)
HYP78CE	0	.48	3.16	1.19	1.87	49.6	(13.5)	.95	(.04)
HYP74C	1	.21	3.74	1.03	3.68	68.3	(47.1)*	1.14	(.21)
HYP76C	1	2.58	3.38	2.11	2.53	63.3	(32.9)	.86	(.12)
HYP78C	0	.25	3.32	1.04	2.38	29.0	(23.1)*	.99	(.06)
HYP74E	1	.53	3.74	1.71	3.68	55.6	(43.7)*	1.67	(.39)
HYP76E	1	4.18*	3.44	1.76	2.77	13.9	(10.1)*	1.52	(.11)
HYP78E	0	2.58	3.44	2.44	2.77	52.2	(22.6)	1.01	(.11)

Note Table A.5.1: see next page.

Note Table A.5.1:

$F_\alpha(\phi_1, \phi_2) = X$ means $Pr(F > X) = \alpha$ where F has a central F-distribution with (ϕ_1, ϕ_2) degrees of freedom. An asterisk is printed next to F_a, respectively F_c if $F_a > F_{.05}(\phi_1, \phi_2)$, respectively $F_c > F_{.05}(\phi_1, \phi_2)$, i.e. if the hypothesis of no structural change cannot be rejected at a 5% level of significance. Estimated standard errors are denoted by $\hat{\sigma}$. An asterisk is printed next to $\hat{\sigma}(\hat{\alpha}_0)$, respectively $\hat{\sigma}(\hat{\alpha}_1)$ if $|\hat{\alpha}_0| < 2 \times \hat{\sigma}(\hat{\alpha}_0)$, respectively $|\hat{\alpha}_1| < 2 \times \hat{\sigma}(\hat{\alpha}_1)$, i.e. if the coefficients α_0, respectively α_1 are not significantly different from zero at a 5% level of significance. See section A.5.5 for an explanation of the codes used.

A.5.5. Data.

The source of data used is given in Table A.5.2. A further description of the variables is given in Table A.5.3. A definition of a supermarket, a "magasin populaire" and a hypermarket is given in the appendix of chapter six. The description of a "magasin de bricolage" is: establishment with primarily self service supplying an assortment of (electronic) tools, household, garden, sanitary and decorating articles. The description of a "centre d'équipement de la maison" is: establishment supplying an assortment of furniture and sometimes tapestry, furniture fabrics and (electronic) household articles.

Table A.5.2. Source of data used.

code	source
SUP75	"P.d.R. 1975, Supermarchés", L.S.A., no. 593 (16-9-1976)
SUP76	" 1976 " " " 629 (10-6-1977)
SUP77	" 1977 " " " 677 (07-7-1978)
SUP78	" 1978 " " " 720 (29-6-1979)
SUP79	" 1979 " " " 764 (27-6-1980)
MP75	"P.d.R. 1975, Magasins Populaires", L.S.A., no. 595 (30-9-1976)
MP76	" 1976 " " " " 631 (24-6-1977)
MP77	" 1977 " " " " 671 (26-5-1978)
MP78	" 1978 " " " " 722 (13-7-1979)
MP79	" 1979 " " " " 757 (09-5-1980)
HYP75	"P.d.R. 1975, Hypermarchés", L.S.A., no. 593 (16-9-1976)
HYP76	" 1976 " " " 629 (10-6-1977)
HYP77	" 1977 " " " 676 (30-6-1978)
MBR75	"P.d.R. 1975, Magasins de Bricolages", L.S.A., no. 596 (07-10-1976)
MBR76	" 1976 " " " " 644 (04-11-1977)
MBR77	" 1977 " " " " 691 (24-11-1978)
MBR78	" 1978 " " " " 734 (16-11-1979)
MBR79	" 1979 " " " " 780 (28-11-1980)
CEM75	"P.d.R. 1975, Centres d'équip. de la M.", L.S.A., no. 598 (21-10-1976)
CEM76	" 1976 " " " " " 641 (14-10-1977)
CEM77	" 1977 " " " " " 684 (06-10-1978)
CEM78	" 1978 " " " " " 729 (12-10-1979)
CEM79	" 1979 " " " " " 778 (14-11-1980)
HYP74I	
HYP74CE	"Atlas,les 292 Hypermarchés en France", L.S.A., no. 517/518(19-12-1974)
HYP74C	"Hyperama", L.S.A., no. 522 (30-1-1975)
HYP74E	

to be continued on next page

Table A.5.2. continued

code	source
HYP76I	
HYP76CE	"Atlas,les 337 Hypermarchés en France", L.S.A., no. 605/606(16-12-1976)
HYP76C	"Hyperama", L.S.A., no. 610 (28-1-1977)
HYP76E	
HYP78I	
HYP78CE	"Atlas,les 392 Hypermarchés en France", L.S.A., no 693/694(8/15-12-1978)
HYP78C	"Hyperama", L.S.A., no. 698 (26-1-1979)
HYP78E	

Note Table A.5.2:

P.d.R. = Points de Repère;

L.S.A. = Libre Service Actualités.

Note Table A.5.3.:

HYP74CE = HYP74C ∪ HYP74E;

HYP76CE = HYP76C ∪ HYP76E;

HYP78CE = HYP78C ∪ HYP78E.

Table A.5.3. Further description of the samples: Q_i is value of annual sales expressed in 10^6 French francs and L_i is volume of labour expressed in full-time equivalents.

code	number of observations	$minQ_i$	$\Sigma Q_i/I$	$maxQ_i$	$minL_i$	$\Sigma L_i/I$	$maxL_i$	type of organization
SUP75	48	5.7	16.9	57.5	12	34.9	94	mainly
SUP76	56	5.2	20.8	66.0	12	37.0	105	independent
SUP77	38	2.1	17.0	53.7	5	30.3	94	" "
SUP78	24	7.8	22.2	62.4	13	36.9	72	" "
SUP79	20	11.5	28.4	77.3	18	41.0	83	" "
MP75	18	8.4	25.0	82.8	20	70.6	185	mainly
MP76	24	9.8	23.1	71.6	23	65.7	207	independent
MP77	34	3.2	27.1	73.0	10	66.5	217	" "
MP78	34	3.6	28.6	83.5	9	57.4	178	" "
MP79	38	9.9	28.4	85.9	23	59.8	144	" "
HYP75	22	53.6	133.4	288.5	119	257.6	514	mainly
HYP76	36	36.2	120.0	243.9	65	214.2	500	independent
HYP77	30	51.0	172.0	343.0	90	268.0	517	" "
MBR75	52	.9	6.5	44.9	2.5	20.0	120	all types
MBR76	60	.8	4.2	15.0	3	11.0	39	" "
MBR77	58	.6	5.3	20.0	3	12.9	45	" "
MBR78	74	1.1	6.6	21.0	3	15.3	41	" "
MBR79	76	1.7	8.6	34.5	4	16.1	60	" "
CEM75	74	1.1	13.7	62.7	2	32.1	110	all types
CEM76	48	1.0	13.8	59.4	1	24.8	88	" "
CEM77	40	2.8	15.0	63.1	6	24.9	81	" "
CEM78	60	2.4	21.8	63.7	8	33.2	99	" "
CEM79	44	6.0	21.2	51.4	11	30.0	100	" "
HYP74I	48	48.0	108.2	277.0	100	213.0	428	independent
HYP76I	70	46.0	121.4	299.0	86	203.1	483	"
HYP78I	78	53.0	139.2	340.0	75	200.0	455	"
HYP74CE	36	60.0	210.0	514.0	132	337.3	756	chain
HYP76CE	56	34.0	236.3	593.0	58	286.3	600	"
HYP78CE	60	52.0	297.0	726.0	58	332.0	750	"
HYP74C	18	142.0	285.8	514.0	196	396.6	756	Carrefour
HYP76C	30	154.0	314.4	593.0	145	332.8	600	"
HYP78C	34	143.0	373.8	726.0	162	398.0	750	"
HYP74E	18	60.0	133.9	270.0	132	277.7	500	Euromarché
HYP76E	26	34.0	146.2	230.0	58	232.7	353	"
HYP78E	26	52.0	196.6	385.0	58	251.0	500	"

Note Table A.5.3: see preceding page.

CHAPTER SIX.

LABOUR PRODUCTIVITY IN FRENCH SUPERMARKETS.

6.1. Introduction.

The aim of this chapter is to investigate whether the relationship between volume of labour and value of annual sales, discussed in chapter five, also applies to French supermarket(-like) shop types. It is also our objective to investigate whether differences in labour productivity can be explained using a vector of specific characteristics of the individual establishments.

This study is conducted because

i) to the best of our knowledge, no detailed studies have been conducted on the explanation of differences in labour productivity of the shop types considered here. Furthermore, the shop types investigated play an important role in French retailing. See footnote [38] of chapter two;

ii) establishments investigated are sometimes very large (see Table A.6.2 of the appendix to this chapter), whereas Nooteboom's empirical studies refer primarily to small shops. Moreover, no French establishments have yet been studied using the relationship discussed in chapter five;

iii) weekly opening time varies among the establishments investigated. It is interesting to test whether indeed the volume of threshold labour of an establishment depends on the weekly opening time of its departments. See section 5.2;

iv) differences in labour productivity are investigated using variables which were not used in Nooteboom's empirical analyses: percentage counter service, mode of supply to the shop, presence of a petrol station and weekly opening time. In addition, we know of no other studies using all these variables;

v) it is interesting to study differences between the three shop types considered in this chapter ("magasins populaires", hypermarkets and supermarkets) and to study differences between the years of observation (1975 to 1979);

vi) a non-linear estimation procedure is introduced to estimate all the coefficients simultaneously, as well as their standard errors. This method is familiar to econometricians. However, it is hardly ever used in our type of analysis.

Three cross-section samples of supermarket-like establishments (299 in all) are studied: some of their properties are described in the appendix to this chapter.
In section 6.2 the consequences of the adaptation of relationship (5.3.8) to large retail establishments are discussed. Section 6.3 deals with further hypotheses as a consequence of the influence of specific properties of the establishments: mode of service, wage rate, mode of supply to the shop, weekly opening time, gross margin, presence of a petrol station and year of observation. The results of the tests are reported in section 6.4, whereas section 6.5 gives conclusions.

6.2. Large retail establishments.

In applying relationship (5.3.8), we have to bear in mind that we are dealing with establishments, which are sometimes very large. This leads to the following considerations:
firstly, no great homogeneity of the samples to be studied may be assumed regarding assortment composition (width and depth). For instance, the non-food sales share usually increases with increasing sales and also the composition of non-food sales alters: larger supermarkets and hypermarkets of our samples often have a cafeteria or a petrol station. Labour productivity depends considerably on the type of products [1]. Therefore, special attention will be paid to differences in assortment composition. The following assortment groups will be dealt with: fresh foods (meat, fruit,vegetables etc.), non-fresh foods (beverages, grocery products etc.), non-foods (covering a very wide range comprising magazines, clothes, electronic hardware etc.), cafeteria, petrol station. Our data material forces us to assume that the number of departments per assortment group is equal for all establishments of a shop type. We must admit that this assumption is not always realistic: e.g. in the case of the assortment group of non-foods;
secondly, in large retail establishments there are many tasks to be performed, apart from those vis-à-vis customers, which play a less important or even a minor role in small retail establishments: management, security, stockkeeping, administration, commercial activities etc. These tasks can be looked upon as diseconomies of scale [2]. It is assumed that the volume of these tasks does not disturb the relationship between volume of labour and value of sales [3]. This assumption is debatable because firstly, these tasks cannot be performed

anymore in the idle time between serving customers and secondly, the average time spent on these tasks per value unit of sales may depend on scale. Part of these tasks will have a threshold function: one general manager, one security employee, administrator etc. In small retail establishments threshold labour is associated with opening time. A complication for large retail establishments is that the threshold part of the above mentioned tasks is not necessarily a function of opening time, but sometimes of working time;
thirdly, there is less reason to assume no substitution possibility of capital for labour than in the case of small retail establishments. This is caused by the low degree of homogeneity of the establishments per shop type regarding assortment composition, mode of service and extent of own production (i.e. marketing strategy). Moreover, the large retail establishments studied in this chapter sometimes have a certain flexibility in modifying their total available floorspace. Of course, this is not always the case, but it is when they own the area surrounding the building of the establishment and if their building construction is simple. Then substitution possibilities are not entirely reduced after instalment of the establishment. In this chapter, however, the hypothesis of absence of a significant substitution possibility is maintained. This policy must be regarded as a first approximation;
fourthly, no great homogeneity of samples to be studied may be assumed regarding their type of organization. Of course, this is not necessarily a consequence of the size of the establishments. Different types of organization may have different modes of supply to the establishment, which result in different volumes of labour required in the establishment per value unit of sales. Therefore, special attention will be paid to differences in mode of supply to the establishment.

The above considerations lead to the following adaptation of (5.3.8):

$$(6.2.1) \qquad L_i = \alpha_{00} + \sum_{k=1}^{K_i} \alpha_{0k} + \sum_{k=1}^{K_i} \alpha_{1k} g_k(X_i) Q_{ki},$$

where L_i: volume of labour in establishment i;

K_i: number of assortment groups of establishment i: these groups are classified as follows: fresh foods, non-fresh foods, non-foods, cafeteria and petrol station;

Q_{ki}: value of annual sales of assortment group k;

X_i: vector of specific properties. Special attention will be paid to mode of service, extent of own production and mode of supply;

α_{00}: threshold labour of tasks other than those vis-à-vis customers. This threshold is not necessarily associated with opening time;

α_{0k}: threshold labour of assortment group k. Its value is associated with the number of departments and their annual opening time.

Equation (6.2.1) is equivalent to

(6.2.2) $$L_{ki} = \alpha_{0k} + \alpha_{1k} g_k(X_i) Q_{ki} \quad \text{for } k = 1, \ldots, K_i$$

and

(6.2.3) $$L_i = \alpha_{00} + \sum_{k=1}^{K_i} L_{ki},$$

where L_{ki}: volume of labour for assortment group k.

This equivalence implies that a large establishment is considered to be a system of several independent small shops as far as the use of labour is concerned. Assuming we wish to view this interpretation in the light of the application of queuing theory, it then depends on the assumption that the results of the application of queuing theory can simply be added together. There are some problems from a theoretical point of view: customers are in a position to minimize their total waiting time (as they have information about several queues) [4] and management is able to maximize the utilization factor of service capacity by a varying allocation of available labour over the departments of the assortment groups. Economies are likely to be achieved. As a first approximation, we suppose that these economies are cancelled out by the diseconomies mentioned earlier.

Equation (6.2.1) is our maintained hypothesis. The following hypotheses will be tested:

H25: economies of scale can be achieved with respect to the use of labour;

H26: the volume of threshold labour is associated with the number of departments which, in turn, depends on the number and nature of assortment groups;

H27: different assortment groups have different partial "average" sli's (scale adjusted labour intensity: α_{1k}).

H25 and H26 can be tested by the examination of the estimated value of

$\alpha_{00} + \sum_{k=1}^{K_i} \alpha_{0k}$ and H27 by the examination of the estimated values of α_{1k}.

6.3. Further hypotheses.

In this section the influence of the remaining specific properties X_i on equation (6.2.1) will be discussed. These properties are associated with type of labour, type of product, method of service, method of shop operation, mode of supply and characteristics of demand. Nooteboom [1980] [5] proposes a specification of $g(X_i)$ in view of the fact that he has to deal with small establishments. In our case, the choice of the specification of $g_k(X_i)$ is based on the consideration that large establishments are dealt with and on availability of data. Some of the elements of X_i are also discussed elsewhere in retailing literature [6]. Unfortunately, two important variables, share of part-time labour and average transaction are not available for the French samples studied here. Their influence on labour productivity is studied in chapters seven and eight, where different samples are used. One has to bear in mind that the results in this chapter are conditional on the omission of these variables.

Mode of service.

The mode of service depends on whether counter service or self-service is used to sell the products. It is obvious that there is a difference in labour productivity between shop types using counter service and those using self-service [7]. It is assumed that labour productivity is higher for self-service than for counter service [8].

H28: scale adjusted labour intensity increases if the percentage of the selling area used for counter service increases.

Wage rate.

Firstly, it is assumed that the wage rate per establishment is an indicator of the quality of labour. Secondly, it is assumed that the motivation to use available labour efficiently is induced by the height of the wage rate [9].

H29: scale adjusted labour intensity decreases if the wage rate of the establishment increases.

Mode of supply to the shop.

There are establishments which get their products prepacked, priced and delivered from a central depot. There are also establishments which have to buy their products at auctions and have to pack and price themselves. Therefore, the mode of supply influences productivity of labour of the establishments.

H30: scale adjusted labour intensity depends on the mode of supply to the establishment.

The "sign" of this hypothesis depends on the definition of mode of supply. See section 6.4.

Weekly opening time.

In France weekly opening time varies among establishments per shop type [10]. This enables us to test whether threshold labour is indeed influenced by the opening time of the departments. Unfortunately, however, there are two complications. Firstly, not all threshold labour is necessarily associated with opening time, there is also a part influenced by working time. See section 6.2. Secondly, there are reasons to assume that opening time also influences scale adjusted labour intensity.

Rewriting (6.2.1) in the light of the first complication we arrive at

$$L_i = \delta_0 DO_{0i} + \sum_{k=1}^{K_i} \delta_k DO_{ki} + \sum_{k=1}^{K_i} \alpha_{1k} g_k(X_i) Q_{ki}, \tag{6.3.1}$$

where DO_{ki}: weekly opening time of the department(s) of assortment group k in establishment i;

DO_{0i}: weekly working time in departments other than those belonging to a certain assortment group;

δ_k: coefficient, the value of which is associated with the number of departments of assortment group k [11];

δ_0: coefficient, the value of which is associated with the number of departments other than those belonging to a certain assortment group.

The influence of weekly opening time on scale adjusted labour intensity is of a somewhat complex nature. If weekly opening time increases

i) intensity of competition decreases, because an increasing number of competitive establishments is assumed to be closed. This may imply that custom has to accept longer waiting time. Then labour intensity decreases;

ii) fluctuations in the labour requirements increase, because an increasing number of opening hours comprises more "odd hours". The discrepancy between required and available labour increases and labour intensity increases. Fluctuations in the labour requirements may also decrease, because an increasing number of opening hours enlarges the possibility for customers to avoid "peak hours" [11].

We do not have an a priori hypothesis about the influence of weekly opening time on scale adjusted labour intensity. It is interesting, however, to study its influence.

H31: the volume of threshold labour increases if weekly opening time increases.

Gross margin.

The samples to be studied have no great homogeneity regarding assortment composition, mode of service and extent of own production. Variables are not always available to describe these phenomena. Therefore, average percentage gross margin will be used as a makeshift for the "service level" factors mentioned above. See section 2.2 for a definition of average percentage gross margin. We realize that it is unorthodox to use this variable, which can also be viewed as a resultant of retail activities. It is assumed, however, that a high average percentage gross margin stems from

- a high average selling price, which might indicate that the assortment composition is particularly deep or that a high service level is supplied. This implies that sales are labour intensive;
- a low average purchasing price, which might indicate that considerable labour (own production) has to be performed before the goods reach the selling area.

The influence of competition on the buying and selling market is neglected in the above assumptions. The influence of productivity on price setting is also ignored.

H32: scale adjusted labour intensity decreases if average percentage gross margin decreases.

Presence of a petrol station.

Thurik [1981a] shows that average transaction per customer increases if there is a petrol station adjacent to the establishment. He assumes that the presence of a petrol station is an indicator for the accessibility by car and that motorized customers make larger transactions. Labour intensity decreases if average transaction increases. See footnote 12 of this chapter. Furthermore, the favourable competitive position resulting from easy access by car, will make customers accept longer waiting times.

H33: scale adjusted labour intensity is lower if a petrol station is present.

Influence of year.

It is assumed that labour productivity increased in recent years due to rising wage rates stimulating management to apply labour saving techniques. Our samples cover the period between 1975 and 1979.

H34: scale adjusted labour intensity is higher in 1975 and 1976 than in 1978 and 1979.

6.4. Tests.

The above mentioned hypotheses are tested using the following specification:

$$(6.4.1) \qquad L_i = \alpha_{00} + (\alpha_{01} + \alpha_{02}DEC_i)\frac{DO_i}{\overline{\overline{DO}}_i} + [(\alpha_{11}QPF_i + \alpha_{12}QEL_i + \alpha_{13}QD_i)\exp(\alpha_{1e}DES_i) + \alpha_{14}QEC_i] \times \left(\frac{FL_i}{\overline{\overline{FL}}_i}\right)^{\alpha_2}\left(\frac{MAT_i}{\overline{\overline{MAT}}_i}\right)^{\alpha_3}\exp[\alpha_4(M_i - \overline{M}_i) + \alpha_5(CS_i - \overline{\overline{CS}}_i)] \times \left(\frac{DO_i}{\overline{\overline{DO}}_i}\right)^{\alpha_6}\exp(\alpha_7 DT_i) + v_i,$$

where L_i: volume of labour (in full-time equivalents) in establishment i;

$DEC_i = DES_i + DCA_i$;

DES_i = 1 if a petrol station is present and 0 otherwise;

DCA_i = 1 if a cafeteria is present and 0 otherwise;

DO_i: weekly opening time (in hours);

QPF_i: annual sales of fresh foods (in 10^6 French francs);

QEL_i: annual sales of non-fresh foods (in 10^6 FF);

QD_i: annual sales of non-foods (in 10^6 FF);

$QEC_i = QES_i + 4 \times QCA_i$;

QES_i: annual sales of the petrol station (in 10^6 FF);

QCA_i: annual sales of the cafeteria (in 10^6 FF);

Preliminary tests showed that it is reasonable to assume a proportion of 1 to 4 between the partial "average" sli of petrol sales and cafeteria sales;

FL_i: wage rate per man year (in 10^3 FF);

MAT_i: $(\sum_{k=1}^{K} MAT_{ki})/K$;

MAT_{ki} = 1 if deliveries through central depot;

= 2 if deliveries through wholesalers;

= 3 if deliveries through suppliers (other retailers, auctions, producers).

It is assumed that with increasing MAT, more labour has to be performed in the establishment. See H30;

M_i: average percentage gross margin divided by 100. See equation (2.2.9);

CS_i: share of counter service area in total selling area;

DT_i = 0 if the obervation refers to 1975, 1976 or 1977 and 1 if the observation refers to 1978 or 1979;

$\overline{DO}_i$: sample average weekly opening time of the observations of 1978 and 1979 if i is observed in 1978 or 1979 or sample average weekly opening time of 1975, 1976 and 1977 if i is observed in 1975, 1976 or 1977;

$\overline{FL}_i$, $\overline{MAT}_i$, $\overline{M}_i$ and $\overline{CS}_i$: sample averages defined in the same manner as $\overline{DO}_i$;

v_i: disturbance term.

Equation (6.4.1) needs some elucidation.

Comparing equations (6.3.1) and (6.4.1) we see that

i) α_{00} is introduced to test whether threshold labour depends entirely on weekly opening time. If this is the case, $\alpha_{00} \neq 0$ must be rejected;

ii) $DO_{ki} = DO_i$ for k = 1, ..., K. This is assumed because no data for separate assortment groups are available and because it is reasonable that opening time does not differ considerably between assortment groups;

iii) if $\alpha_{00} = 0$, then α_{01} can be interpreted as the volume of threshold labour (in full-time equivalents) for establishments having a weekly opening time which equals average weekly opening time ($DO_i = \overline{\overline{DO}}_i$) and not having a petrol station or cafeteria;

iv) α_{02} denotes additional threshold labour for a petrol station or a cafeteria. It is assumed that petrol station threshold labour equals cafeteria threshold labour;

v) $$g_k(X_i) = \left(\frac{FL_i}{\overline{\overline{FL}}_i}\right)^{\alpha_2} \left(\frac{MAT_i}{\overline{\overline{MAT}}_i}\right)^{\alpha_3} \exp[\alpha_4(M_i - \overline{M}_i) + \alpha_5(CS_i - \overline{\overline{CS}}_i)] \times$$

$$\times \left(\frac{DO_i}{\overline{\overline{DO}}_i}\right)^{\alpha_6} \exp(\alpha_7 DT_i) \qquad \text{for } k = 4$$

and

$$g_k(X_i) = g_4(X_i) \exp(\alpha_{1e} DES_i) \qquad \text{for } k = 1, 2, 3.$$

The asymmetry between $g_k(X_i)$ for k = 1, 2, 3 on the one hand and $g_4(X_i)$ on the other is justified by the fact that the presence of a petrol station (DES_i) is assumed to influence only the sli's of sales other than petrol sales. With respect to remaining influences $g_k(X_i)$ is independent of k. This is assumed for the sake of convenience. We restrict ourselves to a multiplicative specification of $g_k(X_i)$. This is done because it accounts for interaction between variables. An exponential specification is chosen for variables which can take zero value;

vii) a fixed proportion of 1 to 4 is assumed between the partial "average" sli of petrol sales and that of cafeteria sales. This proportion is a result of preliminary tests conducted on the same material. It is maintained for both supermarkets and hypermarkets; it seems reasonable that cafeteria sales are considerably more labour intensive than petrol sales. It is used to reduce the danger of multicollinearity between sales shares.

The interpretation of the remaining coefficients now becomes:

α_{1k} for k = 1, ..., K: partial scale adjusted labour intensity of assortment group k if $FL_i = \overline{\overline{FL}}_i$, $MAT_i = \overline{\overline{MAT}}_i$, $M_i = \overline{M}_i$, $CS_i = \overline{\overline{CS}}_i$, $DO_i = \overline{\overline{DO}}_i$ and $DES_i = DT_i = 0$ (partial "average" sli);

α_2, α_3 and α_6: elasticities of $g_k(X_i)$ for k = 1, ..., 4 with respect to $FL_i/\overline{FL}_i$, $MAT_i/\overline{MAT}_i$ and $DO_i/\overline{DO}_i$;

α_4, α_5 and α_7: influence of percentage gross margin, share of counter service area and year on $g_k(X_i)$ for k = 1, ..., 4;

α_{1e}: influence of petrol station on $g_k(X_i)$ for k = 1, 2, 3.

A definition of shop types "magasin populaire" (MP7579), hypermarket (HYP7577) and supermarket (SUP7579) is given in the appendix to this chapter. The sources of the data and a description of the vectors used are also given there.

Table 6.1. Estimates of α_{00}, α_{01} and α_6 with relationship (6.4.1).

shop type		MP7579	HYP7577	SUP7579	HYP7577
intercept	$\hat{\alpha}_{00}$	22.6 (18.1)*	-7.71 (61.54)*	-3.80 (8.24)*	-24.18 (34.81)*
weekly opening time	$\hat{\alpha}_{01}$	-18.6 (18.2)*	48.62 (64.38)*	6.67 (8.27)*	76.26 (36.12)
weekly opening time	$\hat{\alpha}_6$	.26 (.27)*	.18 (.34)*	-.23 (.18)*	0
number of observations	I	86	82	131	82
goodness of fit	r^2	.979	.954	.952	.954

Note Table 6.1: the estimation results are produced by a non-linear least squares fit using Marquardt's algorithm. See Marquardt [1963]. The algorithm conducts an interpolation between the Taylor series method and the gradient method. It has the advantage of the Taylor series method in that it converges rapidly to an optimal value of the coefficient vector if the initial value of the vector is in the vicinity of this optimum. It has the advantage of the gradient method in that it is able to converge if the initial value of the coefficient vector is not close to the optimum. Judge et al. [1980] report that indeed Marquardt's algorithm appears to perform very well in practice, even if the initial value of the coefficient vector is not close to the minimum of the least squares objective function. Procedures such as Marquardt's algorithm usually converge only to local minima. Therefore various (largely differing) initial values of the coefficient vector are always tried. No analytical expression is available for the standard error σ. The standard error is computed numerically within the algorithm. It is assumed that estimated coefficients are asymptotically normally distributed. Estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficient. An asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64 \times \hat{\sigma}(\hat{\eta})$, i.e. if η is not significantly different from zero at a 10% level of significance. The square of the correlation coefficient between the vectors of L_i and its estimation is taken as a measure of goodness of fit.

First, we want to test whether threshold labour depends entirely on weekly opening time. This will be done by examining the values of $\hat{\alpha}_{00}$ and $\hat{\alpha}_{01}$. In Table 6.1 these values are reported in addition to those of $\hat{\alpha}_6$ (consider only columns with $\hat{\alpha}_6 \neq 0$). The values of the remaining coefficients are not reported; they are practically identical to those reported in Table 6.2 (with $\alpha_{00} = 0$). We see that $\hat{\alpha}_{00}$ does not differ significantly from zero in any case where $\alpha_6 \neq 0$ and neither does $\hat{\alpha}_{01}$.
It should be noted that the estimated correlation coefficient $\hat{\rho}$ between the distributions of $\hat{\alpha}_{00}$ and $\hat{\alpha}_{01}$ is extremely high ($\hat{\rho} < -.95$). This may be due to an "overspecification" of our relationship in the light of the information contained in the data (especially in the vector of DO_i's). Therefore, using α_{00} we cannot test whether threshold labour depends entirely on weekly opening time, nor whether it depends on weekly opening time at all (H31). For further testing it is assumed that $\alpha_{00} = 0$, i.e. threshold labour depends entirely on weekly opening time. This seems realistic in case of "magasins populaires" and supermarkets, where the amount of threshold labour is small, and where it can very well be explained in terms of departments having a function vis-à-vis customers.

The following conclusions can be drawn from Table 6.2 regarding the hypotheses formulated above (consider only columns MP7579, HYP7577 and SUP7579):

H25: $\hat{\alpha}_{01} > 0$ and significantly in all three cases. Consequently, there is strong evidence in favour of the hypothesis that economies of scale can be achieved with respect to the use of labour. α_{01} can be interpreted as the volume of threshold labour for establishments with average weekly opening time. Threshold labour depends on number of departments and weekly opening time. Strictly, $\alpha_{01} = \overline{ND} \times \overline{DO} \div \overline{DT}$, where $\overline{ND}$ is sample average number of independently staffed departments and $\overline{DT}$ is sample average weekly working time per full-time employee. Average weekly opening hours of "magasins populaires", hypermarkets and supermarkets are 47.0, 70.4 and 49.2, respectively. If average weekly working time per full-time employee is 36 hours [13] then the calculated number of departments for "magasins populaires", hypermarkets and supermarkets are approximately 3 ($\approx 4.02 \times \frac{36}{47}$), 21 ($\approx 40.66 \times \frac{36}{70.4}$) and 2($\approx 2.88 \times \frac{36}{49.2}$), respectively. This calculated number seems reasonable for "magasins populaires" and supermarkets: a series of cash desks and two, respectively one, counters for specialized goods. It seems rather large for hypermarkets. There may be some threshold labour concerning activities other than those vis-à-vis customers.

H26: $\hat{\alpha}_{02} > 0$ and significantly. If a petrol station is present, threshold labour increases with 1.6 ($\approx$ 1.2 department [14]); if a cafeteria is present, threshold labour increases also with 1.6 ($\approx$ 1.2 department). See definition DEC_i. If the same values are assumed for hypermarkets, the high value of their intercept is partially explained by the fact that practically all hypermarkets have a petrol station and a cafeteria. It is reasonable to assume that a petrol station and a cafeteria both consist of one department. A value greater than one found for $\hat{\alpha}_{02}$ may be explained by the fact that the petrol station has sometimes a longer opening time than the shop to which it is attached.

H27: $\hat{\alpha}_{1k} > 0$ and significantly (except for HYP7577 where $\hat{\alpha}_{12} > 0$ but not significantly). For "magasins populaires" fresh foods are more labour intensive than non-fresh foods, whereas non-foods are more labour intensive than fresh-foods. For hypermarkets fresh foods, non-fresh foods and the petrol station are approximately equally labour intensive. Non-foods are more labour intensive than these groups. For supermarkets non-fresh foods, non-foods and the petrol station are approximately equally labour intensive, whereas these groups are less labour intensive than fresh foods. Cafeteria sales of hypermarkets and supermarkets are approximately four times more labour intensive than petrol station sales (result of preliminary test).

H28: $\hat{\alpha}_5 > 0$ and significantly. The hypothesis is supported that <u>sli</u> increases if the percentage of the selling area used for counter service increases.

H29: $\hat{\alpha}_2 < 0$ and significantly in all three cases. Strong support is found for the hypothesis that <u>sli</u> decreases if the wage rate increases.

H30: $\hat{\alpha}_3 > 0$ and significantly. Support is found for the hypothesis that <u>sli</u> depends on the mode of supply to the etablishment. The sign of $\hat{\alpha}_3$ is in accordance with the expectation. (See definition MAT_i).

H31: an attempt is made to test the hypothesis whether the volume of threshold labour increases if weekly opening time increases. This is done by examining the values of $\hat{\alpha}_{00}$ and $\hat{\alpha}_{01}$ in Table 6.1. No conclusion can be drawn in the light of their high standard errors and the high correlation coefficient between their distributions. Therefore, H31 is maintained for further testing for the time being.

A second attempt to test H31 is made by assuming $\alpha_{00} = 0$ and by replacing the vector $DO_i/\overline{DO}_i$ in the threshold part by a vector of ones. The explanation decreases (but not significantly) for hypermarkets and supermarkets.

The probability of encountering a considerable share of threshold labour independent of opening time is highest for hypermarkets. It is seen in Table 6.2 that $\hat{\alpha}_6$ does not differ significantly from zero for hypermarkets.

A third test is conducted for hypermarkets: assuming $\alpha_6 = 0$, the values of $\hat{\alpha}_{00}$ and $\hat{\alpha}_{01}$ are examined. See Table 6.1, last column: $\hat{\alpha}_{00}$ does not differ significantly from zero, whereas $\hat{\alpha}_{01}$ > and significantly. H31 is supported using this last specification. We admit that the tests are arbitrary or their results weak, but yet no reason to reject H31 can be traced.

H32: $\hat{\alpha}_4 > 0$ and significantly for hypermarkets and supermarkets, but $\hat{\alpha}_4 < 0$ and significantly for "magasins populaires": the hypotheses that <u>sli</u> decreases if average percentage gross margin decreases is rejected for "magasins populaires". Our interpretation of this result is that the influence of "service level" on <u>sli</u> is already accounted for by percentage counter service or that the association of percentage gross margin with "service level" is disturbed by price effects on the buying and selling market. The situation for "magasins populaires" has not been favourable in recent years [15]: their market share has been under severe pressure which might have forced them to develop a strategy in which price competition plays an important role.

Table 6.2. Estimates of α_{01} through α_7 with relationship (6.4.1) respectively (6.4.2) assuming that α_{00} = 0.

shop type relationship		MP7579 (6.4.1)	HYP7577 (6.4.1)	SUP7579 (6.4.1)	ALL (6.4.2)		
weekly opening time	$\hat{\alpha}_{01}$	4.02 (1.66)	40.66 (8.05)	2.88 (1.27)	5.46 (1.94)	$\hat{\alpha}_{0h}$ =	34.99 (4.62)
petrol station/ cafeteria	$\hat{\alpha}_{02}$			1.59 (.86)			
fresh foods	$\hat{\alpha}_{11}$	1.83 (.21)	1.00 (.60)	2.84 (.26)	1.27 (.21)	$\hat{\alpha}_{11s}$ =	.92 (.27)
non-fresh foods	$\hat{\alpha}_{12}$	1.20 (.21)	.83 (.53)*	.76 (.36)	.64 (.16)		
non-foods	$\hat{\alpha}_{13}$	3.98 (.24)	2.21 (.29)	1.46 (.29)	2.15 (.15)	$\hat{\alpha}_{13m}$ =	2.51 (.24)
petrol station	$\hat{\alpha}_{1e}$			-.14 (.04)			
petrol station/ cafeteria	$\hat{\alpha}_{14}$		.96 (.43)	1.21 (.29)	1.03 (.22)		
wage rate	$\hat{\alpha}_2$	-.89 (.08)	-.78 (.10)	-.65 (.06)	-.77 (.05)		
mode of supply	$\hat{\alpha}_3$		.26 (.10)	.11 (.05)	.26 (.05)		
% gross margin	$\hat{\alpha}_4$	-1.11 (.66)	5.96 (2.31)	1.16 (.70)	4.43 (.97)	$\hat{\alpha}_{4m}$ =	-.71 (.77)*
% counter service	$\hat{\alpha}_5$	.32 (.05)					
weekly opening time	$\hat{\alpha}_6$	.02 (.11)*	.21 (.19)*	-.15 (.07)	.16 (.08)	$\hat{\alpha}_{6s}$ =	-.25 (.20)*
year	$\hat{\alpha}_7$	-.06 (.02)		.01 (.03)*	-.03 (.04)*		
number of observations	I	86	82	131	299		
goodness of fit	r^2	.978	.954	.952	.985		

Note Table 6.2: see Note Table 6.1.

H33: $\hat{\alpha}_{1e} < 0$ and significantly. The hypothesis is supported that sli drops if a petrol station is present.

H34: $\hat{\alpha}_7 < 0$ and significantly for "magasins populaires". For supermarkets $\hat{\alpha}_7$ does not differ significantly from zero. Only for "magasins populaires" the hypothesis is supported that sli is higher in 1975 and 1976 than in 1978 and 1979.

Comparing the estimates of the columns MP7579, HYP7577 and SUP7579 in Table 6.2, it is seen that no large differences appear for several coefficients. Therefore, all 299 observations are pooled to obtain more general results (and sometimes smaller errors). This is done because

- we are not content with the results as regards the influence of weekly opening time and year of observation on sli;
- we would like to have a more sound basis for hypotheses as regards the partial "average" sli's for the different assortment groups.

Three dummy variables are incorporated in equation (6.4.1) to permit hypermarkets to have more threshold labour, supermarkets to have a higher partial labour intensity for fresh foods and "magasins populaires" to have a higher partial labour intensity for non-foods. Also the influence of weekly opening time and average percentage gross margin is permitted to depend on the shop type. Variables DEC_i, DES_i and CS_i are left out of consideration, because they appear only in one shop type. Equation (6.4.1) is now substituted by

$$(6.4.2)\quad L_i = (\alpha_{01} + \alpha_{0h}DHY_i)\frac{DO_i}{\overline{DO}_i} + (\alpha_{11}QPF_i + \alpha_{11s}DSU_iQPF_i + \alpha_{12}QEL_i + \alpha_{13}QD_i + \alpha_{13m}DMP_iQD_i + \alpha_{14}QEC_i) \times \left(\frac{FL_i}{\overline{FL}_i}\right)^{\alpha_2}\left(\frac{MAT_i}{\overline{MAT}_i}\right)^{\alpha_3} \exp[(\alpha_4(DHY_i + DSU_i) + \alpha_{4m}DMP_i)(M_i - \bar{M}_i) + \alpha_7 DT_i]\left(\frac{DO_i}{\overline{DO}_i}\right)^{\alpha_6(DMP_i + DHY_i) + \alpha_{6s}DSU_i} + v_i,$$

where DHY_i = 1 if the establishment is a hypermarket and 0 otherwise;
DSU_i = 1 if the establishment is a supermarket and 0 otherwise;
DMP_i = 1 if the establishment is a "magasin populaire" and 0 otherwise;

v_i: disturbance term;

for $\overline{DO}_i$, $\overline{FL}_i$, $\overline{MAT}_i$ and $\overline{M}_i$ the respective averages of the respective shop types have been maintained;

sales of all assortment groups are given in prices of 1976.

From column ALL in Table 6.2 it can be concluded that, when all observations are grouped together,

i) generally, non-fresh foods are less labour intensive than fresh foods;

ii) generally, fresh foods are less labour intensive than non-foods;

iii) fresh foods in supermarkets are more labour intensive than in "magasins populaires" and hypermarkets;

iv) non-foods in "magasins populaires" are more labour intensive than in supermarkets and hypermarkets;

v) $\hat{\alpha}_4 > 0$ and significantly for hypermarkets and supermarkets and $\hat{\alpha}_{4m} < 0$ and not significantly for "magasins populaires. The hypothesis is supported that sli decreases if average percentage gross margin decreases. It is not rejected anymore for "magasins populaires";

vi) $\hat{\alpha}_6 > 0$ and significantly for "magasins populaires" and hypermarkets and $\hat{\alpha}_{6s} < 0$ and not significantly for supermarkets. Sli appears to increase if weekly opening time increases for "magasins populaires" and hypermarkets; no significant effect is found for supermarkets;

vii) no support is found for the hypothesis that sli is higher in 1975 and 1976 than in 1978 and 1979

We surmise that the high labour intensity of fresh food sales in supermarkets is due to the fact that, on the whole, these products are sold using counter service. We do not have an explanation for the high labour intensity for non-food sales in "magasins populaires".

We propose the following hypothesis concerning the results on the influence of weekly opening time on sli: for all three shop types sli increases with increasing weekly opening time, because then fluctuations in the labour requirements increase (see section 6.2, weekly opening time, argument ii)). For supermarkets, however, this effect is offset by a decreasing intensity of competition (argument i)). This is not the case for "magasins populaires" and hypermarkets, because their competitive power is always high, irrespective of their weekly opening time: usually, "magasins populaires" occupy favourable locations in town centres and the attractiveness of hypermarkets is always great due to their wide and deep assortment composition, low prices and easy access by car. They are often said to have a "fonction locomotive" in shopping centres.

6.5. Conclusions.

The main conclusions of the exercises with large French supermarket(-like) establishments are:

i) the relationship between volume of labour and value of annual sales discussed in chapter five serves its purpose very well, because

   a) in spite of the low degree of homogeneity in the samples, the relationship appears to be a useful tool when explaining differences in labour productivity. These differences are explained using a vector of specific properties (assortment composition, mode of service, wage rate, mode of supply to the shop, weekly opening time, gross margin, petrol station, year). Practically all estimated coefficients show signs which support the hypotheses to be tested and standard errors are small in the light of the complicated specification;

   b) the explanation of the relationship is extremely high for a cross-section sample. See goodness of fit in Table 6.2. Also, the examination of the residuals does not reveal any structure. In Figures 6.1 through 6.3 the residuals are drawn for all three shop types. They are computed with relationship (6.4.1);

   c) threshold labour varies according to what is expected theoretically. The concept of threshold labour plays a dominant role in the theoretical justification of Nooteboom's relationship: it is associated with weekly opening time and number of departments. From our exercises we conclude that

      - it cannot be rejected that the volume of threshold labour within a shop type increases if weekly opening time increases. We should be careful when stating this conclusion, because no satisfactory test could be devised [16];
      - the volume of threshold labour within a shop type increases if the number of departments increases;
      - differences between the volume of threshold labour among the shop types can very well be explained in the light of the expected number of departments.

The theoretical drawbacks of the use of this relationship for large retail establishments given in section 6.2 do not seem to be decisive;

ii) the partial "average" scale adjusted labour intensities (partial sli) per assortment group do sometimes differ between the assortment groups and between the three shop types. It is interesting to note that
   a) generally, non-fresh foods are less labour intensive than fresh foods which themselves are less labour intensive than non-foods;
   b) fresh foods are more labour intensive in supermarkets than in "magasins populaires" and hypermarkets;
   c) non-foods are more labour intensive in "magasins populaires" than in hypermarkets and supermarkets;

iii) there is a very strong influence of the wage rate on labour intensity. A value of approximately -.75 is found for the elasticity of sli with respect to relative wage rate [17];

iv) interesting results are achieved with respect to the influence of mode of service, mode of supply to the shop and presence of a petrol station on sli;

v) sli is reported to increase if weekly opening time increases for "magasins populaires" and hypermarkets. It is interesting to note that we concluded in chapter two that the efficiency of total available floorspace (with respect to the value of total annual sales) does not depend on weekly opening time for the same shop types;

vi) for hypermarkets and supermarkets only the hypothesis is supported that sli increases if average percentage gross margin increases. In chapter two it is seen that for "magasins populaires" and supermarkets only, the hypothesis is supported that efficiency of total available floorspace decreases if average percentage gross margin increases. In short, we are not content with the use of average percentage gross margin as an indication for "service level", under the assumption that, if the "service level" increases, more labour and floorspace is needed per value unit of sales;

vii) for "magasins populaires" sli is found to be lower in 1978 and 1979 than in 1975 and 1976. In chapter two it is seen that for "magasins populaires" efficiency of total floorspace is higher in 1978 and 1979 than in 1975 and 1976.

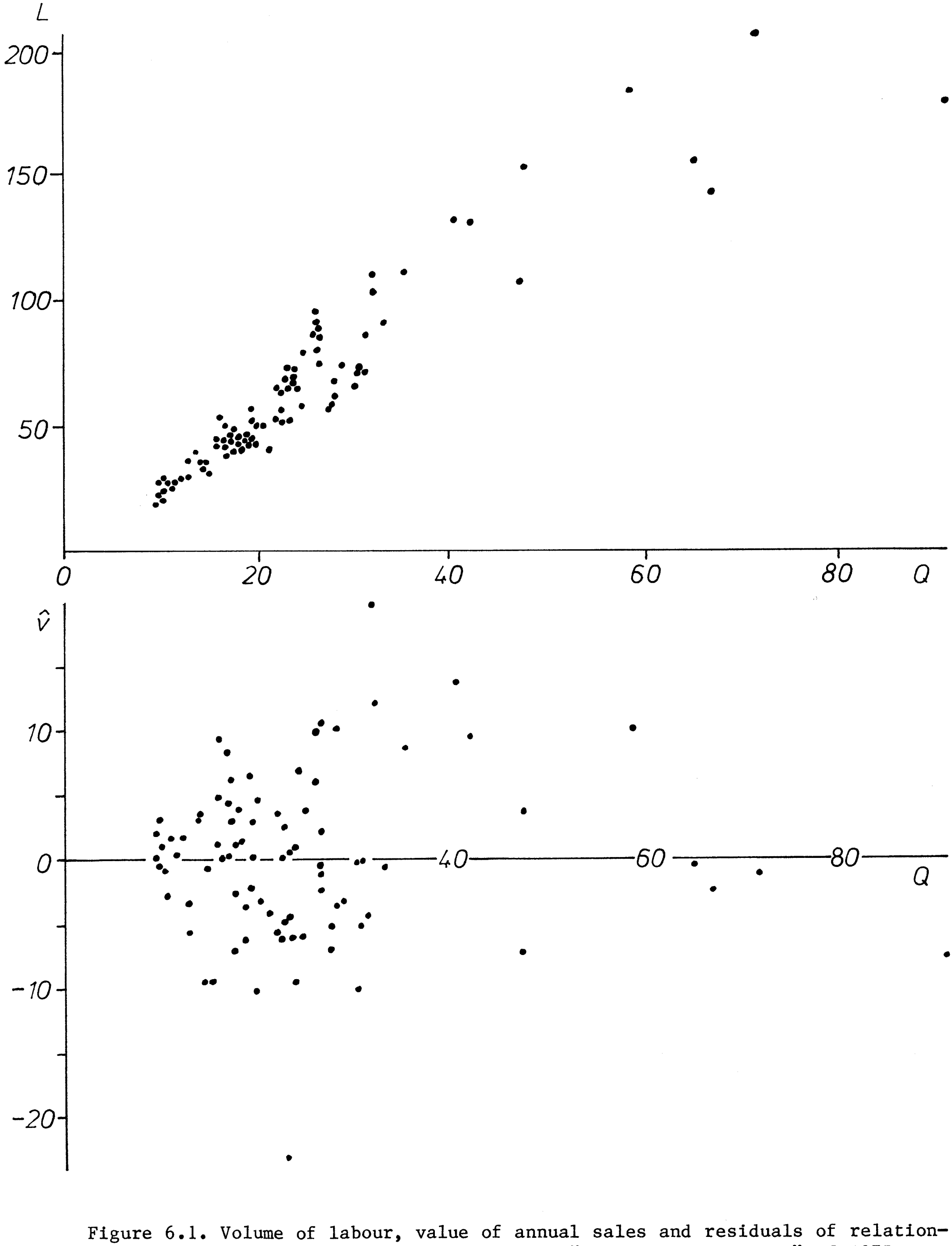

Figure 6.1. Volume of labour, value of annual sales and residuals of relationship (6.4.1) for MP7579 (French "magasins populaires" of 1975 through 1979). L: volume of labour (in full-time equivalents); Q: value of annual sales (in 10^6 French francs); $\hat{v}$: residual of equation (6.4.1).

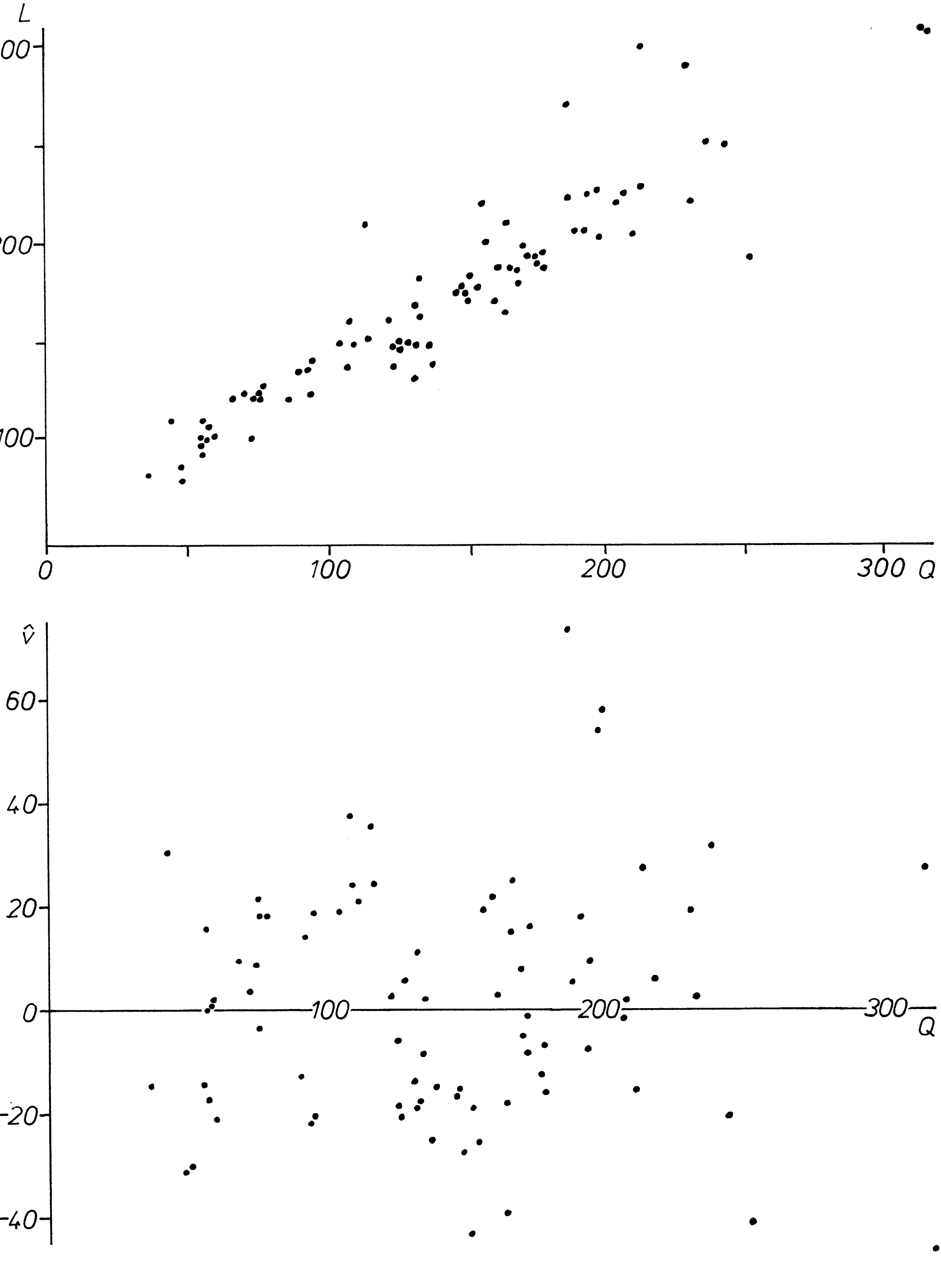

Figure 6.2. Volume of labour, value of annual sales and residuals of relationship (6.4.1) for HYP7577 (French hypermarkets of 1975 through 1977). L: volume of labour (in full-time equivalents); Q: value of annual sales (in 10^6 French francs); $\hat{v}$: residual of equation (6.4.1).

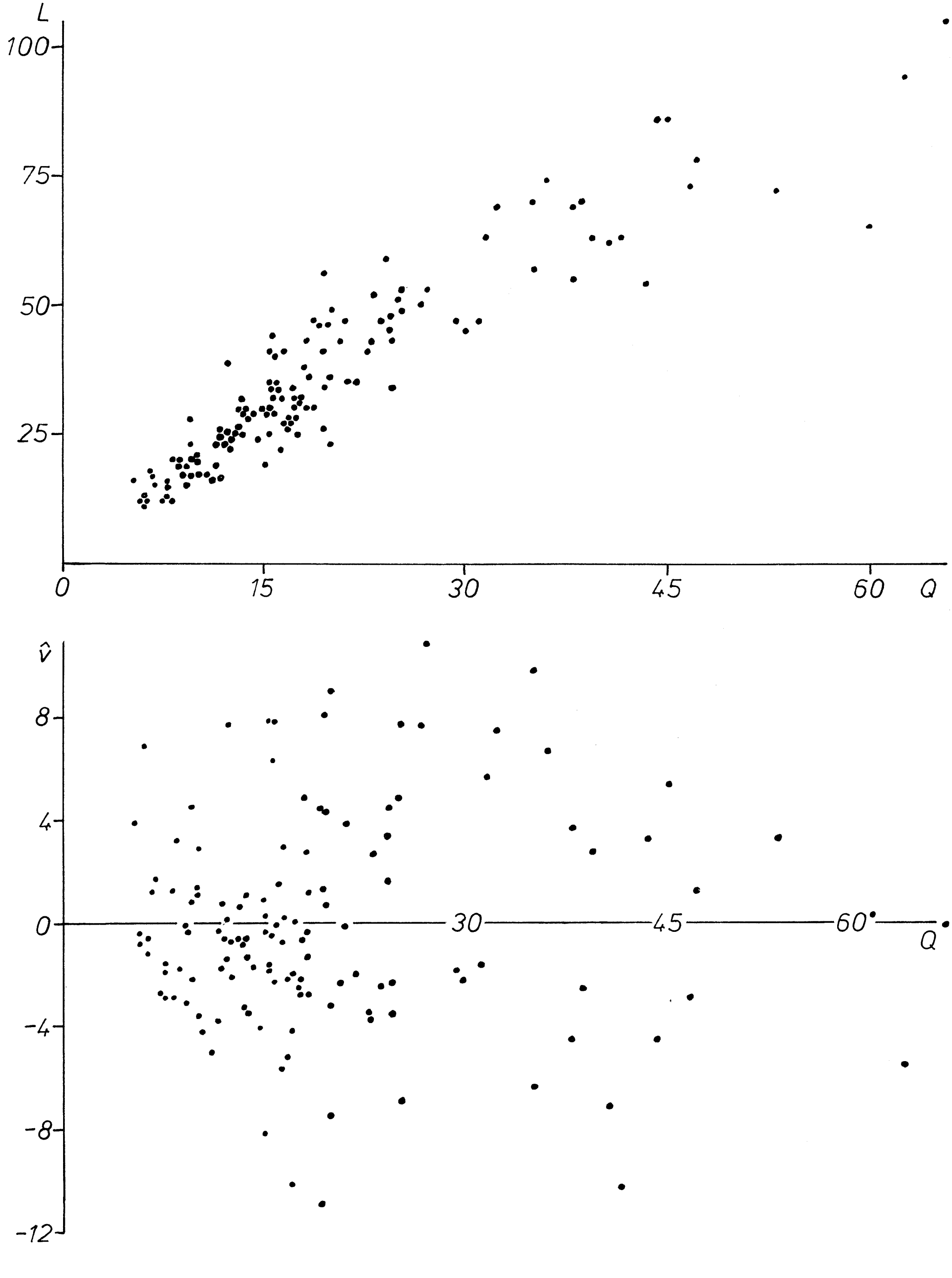

Figure 6.3. Volume of labour, value of annual sales and residuals of relationship (6.4.1) for SUP7579 (French supermarkets of 1975 through 1979). L: volume of labour (in full-time equivalents); Q: value of annual sales (in 10^6 French francs); $\hat{v}$: residual of equation (6.4.1).

Footnotes to chapter six.

[1] See for instance Ward [1973] p. 37, Bucklin [1972] p. 83 or McClelland [1966] p. 84.

[2] See Leunis and Brams [1978] p. 3 and Pickering [1972] p. 261.

[3] Thurik [1981b] shows that there is a linear non-homogeneous relationship with a positive intercept between the volume of managerial tasks and value of annual sales for subsamples of the samples studied in this chapter.

[4] Purchases in large supermarkets are often a combined effort, so that a "customer" can wait in more than one queue at the same time.

[5] See p. 126 ff.

[6] See Algera [1979], Bucklin [1972], Dean [1973], George [1966], George and Ward [1973], Hall, Knapp and Winsten [1961], Ingene [1982], Leunis and Brams [1978], McClelland [1966], Thorpe and Shepherd [1977] and Ward [1973].

[7] See Dawson and Kirby [1979] p. 98, Ward [1973] p. 49 and Henksmeier [1960] p. 83 ff.

[8] See McClelland [1966] p. 80 and Bates [1976] p. 55.

[9] See Hall, Knapp and Winsten [1961] p. 135, Bucklin [1972], Ward [1973], Nooteboom [1980] and Ingene [1982]. See footnote 17 for a comparison of some empirical results.

[10] See footnote 44 of chapter two.

[11] Suppose $L_{ki} = \delta_k DO_{ki} + \alpha_{1k} g_k(X_i)\, Q_{ki}$, where L_{ki}: volume of labour for assortment group k (cf. equation (6.2.2)). The elasticity of L_{ki} with respect to DO_{ki} (weekly opening time) reads $\delta_k DO_{ki}/L_{ki}$ for each assortment group k. This elasticity increases with weekly opening time and decreases with volume of labour, if $\delta_k > 0$. If weekly opening time also influences scale adjusted labour intensity (for instance $g_k(X_i) = DO_{ki}^{\alpha_6}\; g_k'(X_i'))$, then this elasticity becomes more complicated: $\alpha_6 + (1 - \alpha_6)\, \delta_k DO_{ki}/L_{ki}$.

[12] A third influence of weekly opening time on scale adjusted labour intensity is that of average transaction per customer. Chapter eight deals with the influence of average transaction on labour intensity. Theoretically, average transaction should have a negative influence on labour intensity; no conclusive empirical support is found for this hypothesis in the Dutch samples, whereas this hypothesis is supported for the French sample. The influence of weekly opening time on average transaction is

complicated. We differentiate between three ways of manipulating opening time: opening time can be increased by

a) early opening hours and lunch time hours;

b) late opening hours and evening hours;

c) weekend opening hours.

Type a) is intended for a quick purchase before or during the working day. It will tend to increase the number of customers and to decrease average transaction. Of course this way of increasing opening hours is only effective in business districts or residential areas (= urban locations). Types b) and c) are intended both for a quick purchase and for the large weekly transaction if the distance from residential areas is small. They are primarily for the large weekly transaction if the distance from residential areas is long. (Laresse [1980] observes that the average transaction is larger for a chain of urban supermarkets on Sundays than on week days and Mathis [1973] reports that the further a customer travels, the larger her transaction becomes). In short, it is assumed that the influence of weekly opening time on average transaction depends on the distance from residential areas. This distance is not available in our data.

[13] Average weekly working time per full-time employee is assumed to be 36 hours. This number is calculated as follows: weekly working time per full-time employee is 40 hours, yearly opening time of an establishment is 50 weeks and yearly working time per full-time employee is 45 weeks.

[14] Average weekly opening time for supermarkets is approximately 50 hours. Average weekly working time for supermarkets is approximately 36 hours. So 1.3 full-time equivalent is needed for the threshold labour per department.

[15] See Marenco and Quin [1981] p. 35.

[16] Differences in estimated threshold values for food and clothes shops on basis of regional averages in the V.S., Canada and U.K. can be explained using some estimation of average opening time. See Nooteboom [1980] p. 223.

[17] Ward [1973] p. 85 reports a positive influence between average wage rate and labour productivity for U.K. town averages of 1966. Ingene [1982] reports the same result for Standard Metropolitan Statistical Areas in the U.S.A. of approximately 1972, and he refers also to Schwartzman [1971] who reports the same result for the U.S.A. (96 states of 1963 and

Japan (84 prefectures of 1964 and 1968).
Nooteboom [1980] uses the same elasticity as reported in our study (though a different specification and estimation procedure is applied). He reports (p. 196) values ranging from -.43 to -.73 for some Dutch samples of independent butchers and independent and chain supermarkets and superettes. He also reports a value of -.8 for shop type averages in the Dutch food trade and one of -.5 for the Dutch non-food trade (p. 164). These data refer to the period of 1957 to 1974. In the present study we find values ranging from -.65 to -.89 for large French retail establishments (chapter six), values ranging from -.20 to -.63 for small Dutch independents (chapters seven and eight), and values ranging from -.48 to -.78 for Dutch chain supermarkets and superettes (chapter eight). Thurik and Van Schaik [1984] estimate a value of -1.2 for 85 Dutch shop type averages of 1981 and Thurik and Vollebregt [1984] estimate a value of -1.6 for 39 French shop type averages of 1978.
The differing values found for the estimate of the elasticity of sli with respect to the wage rate could be further analysed if it would be possible to make an empirical decomposition of the two reasons for its presence: indicator of the quality of labour and indicator of the urge to use labour efficiently.

APPENDIX TO CHAPTER SIX.

DATA.

The source of the data and the partitioning of our samples over the years of observation are given in Table A.6.1. A further description of the variables used is given in Table A.6.2.

The definitions of the shop types are:

"Supermarché": magasin d'alimentation (autonome) atteignant 400 m^2 de surface de vente (ne dépassant pas 2500 m^2) en libre service ou réalisant au moins 7.5 millions de francs de chiffre d'affaires annual, grâce à un assortiment de 2.500 à 5.000 références, comprenant 500 à 1.500 références non alimentaires.

"Hypermarché": libre-service de 2.500 m^2 de surface de vente minimale, présentant un assortiment complet (20.000 à 35.000 références), avec des rayons alimentaires (3.500 à 5.000 références) et non alimentaires (16.000 à 30.000 références) et offrant un parking à sa clientèle.

"Magasin populaire": point de vente limitant son assortiment (7.000 à 10.000 références) aux articles de grande vente et offrant généralement, en plus des secteurs nouveauté et bazar, des rayons alimentaires (1.500 à 4.000 références). Le plus souvent exploités en libre-service, ces derniers peuvent constituer, selon la surface qui leur est consacrée et leur propre chiffre d'affaires, un supermarché intégré au magasin populaire.

Table A.6.1. Source of data and partitioning over the years of observation.

code	year of observation	number of establishments	average sales (in 10^6 French francs of the current year)	average volume of labour (in full-time equivalents)	source of the data
MP7579	1975	18	25.1	70.6	P.d.R. 1975, Magasins Populaires, L.S.A., no. 595 (07-10-1976)
	1976	24	23.1	65.7	P.d.R. 1976, Magasins Populaires, L.S.A., no. 631 (24-06-1977)
	1978	19	30.2	70.1	P.d.R. 1978, Magasins Populaires, L.S.A., no. 722 (13-07-1979)
	1979	25	30.5	60.1	P.d.R. 1979, Magasins Populaires, L.S.A., no. 757 (09-05-1980)
		86			
HYP7577	1975	22	132.7	257.6	P.d.R. 1975, Hypermarchés, L.S.A., no. 593 (16-09-1976)
	1976	36	120.8	214.2	P.d.R. 1976, Hypermarchés, L.S.A., no. 629 (10-06-1977)
	1977	24	180.8	276.7	P.d.R. 1977, Hypermarchés, L.S.A., no. 676 (30-06-1978)
		82			
SUP7579	1975	42	17.8	36.8	P.d.R. 1975, Supermarchés, L.S.A., no. 593 (16-09-1976)
	1976	56	20.8	37.7	P.d.R. 1976, Supermarchés, L.S.A., no. 629 (10-06-1977)
	1978	23	22.0	36.4	P.d.R. 1978, Supermarchés, L.S.A., no. 720 (29-06-1979)
	1979	10	26.3	34.0	P.d.R. 1979, Supermarchés, L.S.A., no. 764 (27-06-1980)
		131			

Note Table A.6.1: P.d.R. = "Points de Repère"; L.S.A. = "Libre Service Actualités".

Table A.6.2. Further description of the data: L_i is volume of labour (full-time equivalents), QPF_i, QEL_i and QD_i are value of annual sales of fresh foods, non-fresh foods and non-foods (in 10^6 French francs of 1976), DO_i is weekly opening time (in hours), FL_i is wage rate per man year (in 10^3 French francs of 1976), M_i is gross profits divided by total annual sales and MAT_i is an indicator of supply (no dimension).

code	$\min L_i$ $\overline{L}$ $\max L_i$	$\min QPF_i$ $\overline{QPF}$ $\max QPF_i$	$\min QEL_i$ $\overline{QEL}$ $\max QEL_i$	$\min QD_i$ $\overline{QD}$ $\max QD_i$	$\min DO_i$ $\overline{DO}$ $\max DO_i$	$\min FL_i$ $\overline{FL}$ $\max FL_i$	$\min M_i$ $\overline{M}$ $\max M_i$	$\min MAT_i$ $\overline{MAT}$ $\max MAT_i$
MP7579	20.0	0	2.77	2.41	40.0	23.0	.149	
	66.1	6.72	7.86	10.12	47.0	40.4	.206	
	207.1	26.47	69.06	38.67	65.0	53.4	.271	
HYP7577	65.0	10.94	12.57	9.74	52.0	28.3	.125	1.44
	244.1	37.89	40.58	50.91	70.4	40.2	.145	2.41
	517.0	78.36	85.18	118.73	79.0	56.9	.178	3.00
SUP7579	12.0	2.02	2.29	.16	40.0	20.0	.111	1.00
	36.8	7.90	7.50	3.62	49.2	38.6	.165	1.97
	105.0	28.02	23.15	16.03	78.0	70.0	.216	3.00

Note Table A.6.2: non-food sales of hypermarkets also include hobby centre, garden centre sales etc.

CHAPTER SEVEN.

PART-TIME LABOUR AND LABOUR PRODUCTIVITY.

7.1. Introduction.

The aim of this chapter is to investigate the influence of the share of part-time labour in total labour on labour productivity in retailing. This chapter intends to make the following contributions to the explanation of differences in labour productivity:

i) various aspects of the role of part-time labour in retailing are discussed in detail;

ii) the influence of its role is estimated for several different shop types;

iii) all coefficients of the labour cost curve for small Dutch retail establishments are also estimated simultaneously. In chapter six this is done for large French establishments.

In both the Netherlands and in France, the share of part-time labour is high and it increased in recent years [1]. In this chapter shopkeepers' motives for using part-time labour are discussed as are the motives of employees to work on a part-time basis. The effects of the use of part-time labour on labour productivity are also studied.
The central hypothesis of this study is that a shopkeeper has to deal with a strongly fluctuating demand for labour over time and that part-time labour is one of the main instruments to cope with this fluctuation. The basic model used in this study is the linear relationship between volume of labour and value of annual sales discussed in chaper five. Using this relationship the influence of assortment composition, wage rate, share of part-time labour, share of counter service sales and shop type is studied.
Eight samples of small Dutch retail establishments and large French "magasins populaires" are studied. The total number of observations is 683: some of the sample properties are given in the appendix to this chapter.

In section 7.2 hypotheses are formulated concerning the influence of the share of part-time labour, the wage rate and the share of counter service sales on labour productivity. These hypotheses are formulated on the basis of a discussion of fluctuations in time of the number of customers' arrivals, shopkeepers' instruments to cope with these fluctuations, the importance of part-time labour as an instrument and other reasons for the occurrence of part-time labour. In section 7.3 tests are performed and their results are discussed. In section 7.4 some conclusions and recommendations are given.

7.2. The use of part-time labour.

It is simply assumed in chapter five that available labour equals required labour up to a disturbance term [2] (cf. equation (5.3.2)). Part-time labour is assumed to be one of the main instruments for the adaptation of available to required labour. Consequently, it is one of the principle elements of the theoretical justification of Nooteboom's labour cost curve. In this section we shall deal with the use of part-time labour in more detail.

The distribution of the number of customers' arrivals may fluctuate strongly over time. On a yearly basis the number of customers' arrivals may concentrate in December and in the week before a bank holiday. On a monthly basis it may concentrate at the beginning of the month. On a weekly basis it may concentrate on shopping evenings and on Saturdays. On a daily basis it may concentrate around noon and towards closing time. Of course, the intensity of these fluctuations depends on the shop type: for food shops monthly fluctuations will not be intense, for non-food shops in general yearly fluctuations will not be intense. However, for specific non-food shops there may be heavy seasonal fluctuations: e.g. toys, sailing equipment, garden utensils, sportswear, etc.

In retailing it is not usual to sell forward (as in manufacturing industry, handicraft, mail order), to control customers' arrivals (as with hairdressers, in restaurants) or to manipulate their arrivals by price differentiating (as with the tariffs of car washes, telephone and electricity boards, travel companies). Furthermore, the product of service industries in general cannot be stored, as opposed to that of manufacturing industries.

The demand for labour per unit of time fluctuates with the number of customers' arrivals per unit of time. The demand for labour depends also on the average transaction per customer. The latter dependence will not be treated explicitly in this chapter [3], because average transaction per customer is not always available for the samples investigated in this study. Hence, it is implicitly assumed that average transaction per customer is constant and independent of time. It seems reasonable that for a certain shop type fluctuations of the number of customers' arrivals over time depend on

i) location [4]. If an establishment is located in a residential area customers' arrivals are more evenly distributed than if an establishment is located in a business quarter, an industrial area or a rural area;

ii) population [4]. If people have more available time to shop during non-peak hours, customers' arrivals are more evenly distributed. Possible indicators for available time during non-peak hours are
   - percentage of elderly people, who do not work (retired);
   - percentage of families with young children;
   - percentage of unemployed;
   - number of persons per household: the larger this number is, the more time may be assumed to be available;

iii) assortment composition. Fresh foods necessitate shorter shopping intervals than other products. Therefore customers' arrivals are more evenly distributed on a weekly or monthly basis, but not necessarily on a daily basis;

iv) weekly opening time. The more the weekly opening time of an individual shop is stretched beyond normal opening hours (evening or Sunday opening hours), the less evenly distributed customers' arrivals may become, because an increasing number of opening hours may comprise more "odd hours". However, an increasing number of opening hours enlarges the possibility for customers to avoid "peak hours", so that their arrivals become more evenly distributed.

It is assumed that the distribution of customers' arrivals is exogenous on a short term basis [5]. Consequently, the labour requirements are also exogenous, if the operating and marketing strategy of the establishment are fixed. How the labour requirements depend upon this strategy and how available labour can be adapted to required labour will now be dealt with.

The influence of fluctuations of the number of customers' arrivals over time on fluctuations of the demand for labour over time depends on the mode of service. In a self-service establishment this influence is likely to be weaker than in a counter service establishment, because less work has to be done vis-à-vis customers. This is the first advantage of self-service.

It is the shopkeeper's (or the management's) task to adapt available labour to the demand for labour. This adaptation will result in a fluctuating volume of available labour over time. It is one of the short term instruments available to the shopkeeper [6]. It is important that shopkeepers attempt to reduce the divergence between available and required labour, because

- if available labour exceeds required labour, labour productivity decreases. In retailing (as in other service industries) total costs consist primarily of labour costs. Therefore labour productivity is to be guarded closely;
- if required labour exceeds available labour, service offered to customers drops and sales are likely to decrease. This will not be the shopkeeper's intention.

In the tuning of availability and requirement of labour a shopkeeper has the following instruments to reduce their divergence

i) varying availabity of labour by using part-time labour;

ii) varying working pace combined with a varying level of organizational efficiency or a varying use of technical devices;

iii) varying service level (= to make custom accept longer waiting time on Saturdays, nocturnal opening hours etc.). A varying service level can also be associated with the fact that during peak hours no repairs are done, claims dealt with or returns accepted;

iv) shifting utilization of available labour over various tasks (e.g. during odd hours administrative, stockkeeping tasks etc. are performed);

v) forethought and preparation.

In counter service shop types the use of part-time labour plays a dominant role: working pace will never be very low when management is faced with high wage rates; technical devices are practically absent; a varying service level may endanger the sales level; tasks apart from those vis-à-vis customers are limited; the possibilities of forethought and preparation are very limited.
In self-service establishments also other instruments are useful: shifting utilization of available labour and forethought and preparation, because here the share of tasks vis-à-vis customers is limited. This is the second advantage of self-service [7].

Considering these arguments we could state that for a sample of establishments of a certain shop type, which all have the same fluctuations of the demand for labour and the same low share of self-service, those with the highest share of part-time labour in total labour are likely to have higher labour productivity. We could also state that for shop types where counter service is predominant the influence of the share of part-time labour on labour productivity is stronger than for shop types with a considerable degree of self-service. These statements are conditional upon the following:

a) the quality of a part-time employee is equivalent to the quality of a full-time employee;
b) part-time labour is merely used to fill the gap between required and available labour.

These conditions are not fulfilled. As regards to condition a), the quality of part-time labour probably differs from full-time labour because:

i) a part-time employee may have other motives to work than a full-time employee;
ii) not all tasks in a retail establishment are suitable to be performed by part-time employees;
iii) from Table 7.1 we see that part-time labour is cheaper [8].

As regards condition b), part-time labour is used for many reasons [9]:

i) fluctuations in the demand for labour over time (cf. condition b));
ii) job sharing: part-time employees fill in a full-time vacancy [10];
iii) labour market conditions: full-time employees are not available [11]. Generally, retail work is monotonous, not very well paid and it lacks career possibilities. Part-time employees are more and more available in the seventies [12], because
   - married woman, schoolchildren and students, willing to work on a part-time basis, enter the labour market;
   - social significance of work changes: more often a deliberate choice is made for part-time work instead of full-time work;
iv) entrepreneurial flexibility: numerous juridical and fiscal regulations serving employees' interests discourage employment of full-timers. The possibility to keep part-time employees out of these regulations is greater. There are lower emotional barriers to be overcome to fire part-time employees than to fire full-time employees;
v) price of labour: full-time labour is more expensive than part-time labour (see Table 7.1). Secundary and tertiary labour conditions are also less favourable for part-time employees;

vi) compartmentation: increasing size of the establishment facilitates a compartmentation of labour tasks, so that part-time employees can be supervised efficiently by full-time employees;

vii) weekly opening time: the more the weekly opening time exceeds normal weekly working time (40 hours), the more part-time labour will be used. In the Netherlands where weekly opening time is strictly regulated and almost unified for the retailing industry, variations in the share of part-time labour cannot be attributed to variations in weekly opening time [13].

Table 7.1. Sample average wage per hour (in Dutch guilders of the current year) excl. social securities and other personnel costs.

shop type	full-time employee	part-time employee
ZB75	6.11	4.35
SUP75	7.36	5.04
ZB79	9.19	7.03
SUP79	10.69	7.21
ELE80	15.46	11.95

In our opinion reasons ii) through v) are primarily valid in a time series explanation of the share of part-time labour. However, there may be important geographical differences in labour market conditions and the price of labour. We conclude that there are many reasons for the use of part-time labour and also many consequences of its use on labour productivity, the resulting balance of which is not unambiguous. Two effects seem of essential concern:

- the share of part-time labour depends on the fluctuations of the demand for labour, for which no information is available;
- the influence of the share of part-time labour on labour productivity depends on the share of counter service sales.

What remains is to investigate the resulting balance effect of the share of part-time labour on labour productivity from an empirical point of view.
Using equation (5.3.8) as a maintained hypothesis, the following hypotheses will be tested on the level of individual establishments:

H35: scale adjusted labour intensity decreases if the share of part-time labour in total labour increases.
H36: the influence mentioned in H35 is stronger for shop types where counter service is predominant (cf. clothes shops, dry cleaning shops etc.) than for shop types where counter service is not predominant (i.e. with a considerable share of self-service, e.g. supermarkets).

Hypotheses H28 and H29 are discussed in chapter six. In this chapter they are tested for small Dutch establishments. They read:

H28: scale adjusted labour intensity increases if the share of counter service in total sales increases [14].
H29: scale adjusted labour intensity decreases if the average hourly wage rate increases [15].

The following reports are found in literature as regards the influence of part-time labour on labour productivity in retailing:
- George [1966] p. 57 reports a significant positive effect of the share of part-time labour on labour productivity for total retail trade for 160 British towns for different town sizes (Census of distribution 1961);
- Ward [1973] p. 88 reports no significant positive effect of the share of part-time labour on labour productivity for total retail trade for 50 British towns (Census of distribution 1966);
- Nooteboom [1980] p. 193 reports a significant negative effect of the share of part-time labour on scale adjusted labour intensity for Dutch independent butcher's shops of 1974;
- Nooteboom [1980] p. 232 reports a significant negative effect of the share of part-time labour on scale adjusted labour intensity for the total retail trade for 160 British towns (Census of distribution 1961);
- Nooteboom [1980] p. 264 reports a significant negative effect of the share of part-time labour on scale adjusted labour intensity for the Dutch self-service grocery trade using time series data of 1953 till 1973. He also re-

ports a (not significant) negative effect for Dutch food trade (excluding self-service grocery) and for Dutch non-food trade. See also Nooteboom [1983] for tests with more recent data;

- Thurik and Vollebregt [1984] report a significant negative effect of the share of part-time labour on scale adjusted labour intensity using averages of 39 French shop types of 1978.

7.3. Tests.

The above mentioned hypotheses are tested using the following specification:

$$(7.3.1) \qquad L_i = \alpha_{01} + \alpha_{02}DSL_i + (\alpha_{11}Q_{1i} + \alpha_{12}Q_{2i}) \left(\frac{FL_i}{\overline{FL}}\right)^{\alpha_2} \exp(\alpha_3 PT_i + \alpha_4 CS_i + \alpha_5 DCH_i) + v_i,$$

where L_i: volume of labour (in hours per year) of establishment i;

DSL_i = 1 if a butcher's shop is present and 0 otherwise;

Q_{ki} for k = 1,2: value of annual sales in assortment group k (in 10^3 Dutch guilders or French francs of the current year). See Table 7.3 for a description of the assortment groups;

FL_i: wage rate per hour including social securities and other personnel costs (in Dutch guilders or French francs of the current year);

$\overline{FL}$: sample average hourly wage rate;

PT_i: share of part-time labour in total labour: hours worked by employees and members of the shopkeeper's family working less than 30 hours per week, divided by total hours worked (by part-timers as well as full-timers);

CS_i: share of counter service sales [16]: value of annual sales through counter service divided by value of total annual sales;

DCH_i = 1 if the establishment belongs to a chain and 0 otherwise (if the establishment is independent);

v_i: disturbance term [2].

Confronting equations (5.3.8) and (7.3.1) we see that

$$(7.3.2) \qquad \sum_{k=1}^{K} \alpha_{0k} = \alpha_{01} + \alpha_{02}DSL_i$$

and

(7.3.3) $g_k(X_i) = g(X_i)$ for $k = 1, 2$

with

$$g(X_i) = \left(\frac{FL_i}{\overline{\overline{FL}}}\right)^{\alpha_2} \exp(\alpha_3 PT_i + \alpha_4 CS_i + \alpha_5 DCH_i).$$

Opening time is not available for the samples considered in this chapter. Besides, opening time hardly varies among Dutch establishments. Therefore, we can only test whether threshold labour depends on number of departments. This number varies according to whether a butcher's shop is present or not. Assumption (7.3.3) is made for the sake of convenience.

A multiplicative specification is chosen for $g(X_i)$, because such a specification accounts for interaction between variables. An exponential specification is chosen for variables which can take zero value.

The interpretation of coefficients of (7.3.1) now becomes:

α_{01}: threshold labour if no butcher's shop is present;

$\alpha_{01} + \alpha_{02}$: threshold labour if a butcher's shop is present;

α_2: elasticity of $g(X_i)$ with respect to the relative wage rate $FL_i/\overline{\overline{FL}}$;

α_3: influence of part-time labour on $g(X_i)$;

α_4: influence of share of counter service sales on $g(X_i)$;

α_5: influence of type of organization on $g(X_i)$;

α_{1k}: partial scale adjusted labour intensity for assortment group k if $FL_i = \overline{\overline{FL}}_i$ and $PT_i = CS_i = DCH_i = 0$ (partial "average" sli).

Equation (7.3.1) is estimated for Dutch independent superettes of 1975 and 1979 (ZB75 and ZB79), Dutch independent supermarkets of 1975 and 1979 (SUP75 and SUP79), Dutch independent and chain clothes shops of 1979 (CLI79 and CLC79), Dutch electro-technical retailers of 1980 (ELE80) and French "magasins populaires" of 1978 and 1979 (MP7879). A concise description of the samples used is given in the appendix to this chapter. For the non-food shop types (CLI75, CLC79 and ELE80) the share of self-service sales is always zero, so that α_4 cannot be estimated for these shop types.

Table 7.2. Estimates of coefficients of equation (7.3.1).

shop type		ZB75	SUP75	ZB75 ∪ SUP75	ZB79	SUP79	ZB79 ∪ SUP79	CLI79	CLC79	CLI75 ∪ CLC79	ELE80	MP7879
threshold	$\hat{\alpha}_{01}$	4192 (505)	4395 (1349)	4214 (534)	3315 (342)	2841 (906)	2991 (335)	552 (474)*	2088 (365)	1335 (291)	2100 (439)	-10999 (4512)
butcher's shop	$\hat{\alpha}_{02}$		2417 (1248)	2440 (878)		1242 (884)*	883 (582)*					
ass. group 1	$\hat{\alpha}_{11}$		11.63 (5.67)	13.11 (3.34)	9.19 (2.83)	5.97 (1.68)	7.58 (1.27)	8.63 (.64)	7.63 (.46)	8.60 (.44)	5.09 (.33)	3.23 (.32)
ass. group 2	$\hat{\alpha}_{12}$	8.92 (.96)	8.07 (.99)	8.34 (.67)	5.41 (.34)	4.85 (.42)	5.00 (.27)	11.67 (.68)	8.62 (.54)	10.96 (.44)	24.87 (1.22)	5.69 .56)
wage rate	$\hat{\alpha}_{2}$	-.30 (.13)	-.27 (.16)	-.23 (.10)	-.44 (.11)	-.43 (.12)	-.46 (.08)	-.20 (.10)	-.40 (.13)	-.24 (.08)	-.45 (.15)	-.99 (.10)
% part-time	$\hat{\alpha}_{3}$	-.14 (.20)*	-.13 (.21)*	-.14 (.14)*	.17 (.18)*	.63 (.16)	.52 (.11)	-.19 (.15)*	-.54 (.19)	-.31 (.12)	-.48 (.33)*	-.55 (.11)
% counter service	$\hat{\alpha}_{4}$	-.31 (.28)*	-.05 (.39)*	-.13 (.23)*	.29 (.20)*	.45 (.16)	.40 (.12)					.13 (.06)
chain	$\hat{\alpha}_{5}$									-.17 (.03)		
number of observations	I	73	60	113	111	104	215	100	100	200	103	32
goodness of fit	r^2	.742	.876	.954	.858	.919	.957	.884	.904	.887	.894	.982

Note Table 7.2: see Note Table 6.1. N.B. an asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$, i.e. if η is not significantly different from zero at a 10% level of significance.

Table 7.3. Description of the assortment groups used in equation (7.3.1).

code	Q_{1i}	Q_{2i}
ZB75	---	all products
SUP75, ZB79, SUP79	fresh meat	other products (dairy products, dry grocery products, non-foods etc.)
CLI75, CLC79	men's wear	ladies' and children's wear
ELE80	retail sales	repairs and installation
MP7879	foods	non-foods

The following conclusions can be drawn from Table 7.2 regarding the hypotheses formulated above:

H35: $\hat{\alpha}_3 < 0$ for all four samples [17] where counter service is predominant (clothes shops and electro-technical retailers) and significantly [18] in two cases. However, in the other two cases (CLI79 and ELE80) $|\hat{\alpha}_3| > 1.25\ \hat{\sigma}(\hat{\alpha}_3)$. Support is found for the hypothesis that scale adjusted labour intensity decreases if the share of part-time labour in total labour increases for shop types where counter service is predominant. For those Dutch shop types where counter service is not predominant (ZB75, SUP75, ZB79, SUP79) we see that $\hat{\alpha}_3 < 0$ and not significantly for the three samples of 1975 and $\hat{\alpha}_3 > 0$ and significantly in two out of three cases in 1979. For French "magasins populaires", where counter service is not predominant, we see that $\hat{\alpha} < 0$ and significantly. Support is found for the hypothesis that scale adjusted labour intensity decreases if the share of part-time labour increases for French "magasins populaires"; this hypothesis cannot be rejected for Dutch independent superettes and supermarkets of 1975, but must be rejected for Dutch independent superettes and supermarkets of 1979.

H36: We conclude from the discussion of the results of $\hat{\alpha}_3$ that the influence mentioned in H35 is indeed stronger for counter service shop types than for self-service shop types. French "magasins populaires" is the only shop type where counter service is not predominant and where scale adjusted labour decreases significantly if the share of part-time labour increases.

H29: $\hat{\alpha}_2 < 0$ in all eleven cases and significantly in ten. Strong support is provided for the hypothesis that scale adjusted labour intensity decreases if the average hourly wage rate increases.

H28: $\hat{\alpha}_4 > 0$ in four out of seven cases and significantly in three. The hypothesis is not rejected that scale adjusted labour intensity increases if the share of counter service in total sales increases; this hypothesis is supported by the most recent data: ZB79, SUP79 and MP7879.

From Table 7.2. it can also be seen that:

i) $\hat{\alpha}_{01} > 0$ in ten out of eleven cases and significantly in nine: $\hat{\alpha}_{01} < 0$ and significantly for MP7879. For the Dutch shop types strong support is found for the hypothesis of a positive intercept (= threshold coefficient). If the threshold coefficient is associated with the sum of opening times of all independently staffed departments in the shop and if it is assumed that yearly opening time for all departments in Dutch shops is approximately 2500 hours, then the average number of departments appears to be somewhat higher than one for ZB75 and SUP75 and approximately one for ZB79, SUP79, CLC79 and ELE80;

ii) $\hat{\alpha}_{02} > 0$ in all four cases and significantly in two: additional threshold labour resulting from the presence of a butcher's shop is approximately 2400 hours in 1975 and approximately 1000 hours in 1979;

iii) examining $\hat{\alpha}_{11}$ and $\hat{\alpha}_{12}$
   - for Dutch grocery stores fresh meat sales are more labour intensive than remaining sales;
   - for clothes shops sales of men's wear sales are less labour intensive than remaining sales (i.e. ladies' and children's wear);
   - for electro-technical retailing sales are considerably less labour intensive than own production (repairs and installation);
   - for "magasins populaires" food sales are less labour intensive than non-food sales;

iv) the elasticity of $g(X_i)$ with respect to the relative wage rate, α_2, is significantly < 0 in all cases. It appears to be higher (in absolute value) for Dutch grocery shops of 1979 than for those of 1975. Presumably wage differences are better reflections of variations of quality of labour in 1979 than in 1975. This might be due to a greater availability of labour in 1979 than in 1975;

v) the elasticity of $g(X_i)$ with respect to the relative wage rate, α_2, appears to be higher (in absolute value) for French "magasins populaires" then for any Dutch shop type. Presumably, wage differences are better reflections of variations of quality of labour in France than in the Netherlands. This might be due to a higher degree of wage equalization in the Netherlands [19];

vi) chain clothes shops appear to be less labour intensive than independent clothes shops (cf $\hat{\alpha}_5$). This might be due to economies of scale on the enterprise level (management, administration, stockkeeping etc.). Also differences in service level or assortment composition may occur;

vii) goodness of fit is high for a cross-section analysis. Groen, Thurik and Van der Wijst [1983] confronted the residuals of equation (7.3.1) with a vector of environmental variables for Dutch grocery shops and clothes shops. They found no correlations, from which they concluded that there is hardly anything left to explain using environmental variables.

The results discussed in i), ii) and iii) provide support for hypotheses H25, H26 and H27, respectively. See section 6.2.

The final remarks of this section are devoted to our findings as regards the influence of the share of part-time labour on scale adjusted labour intensity. We mentioned above that no support is found for H35 in 1975 and that H35 is even rejected in 1979 for Dutch grocery shops. We still have some belief in H35 for shop types where counter service is not predominant. The lack of support for H35 may be due to the following:

i) no data on fluctuations of demand for labour are available. This is a serious shortcoming. Experiments were performed with two variables: share of sales made by customers from the immediately surrounding area (if this share is high customers probably tend to make smaller transactions per trip and the distribution of the number of customers' arrivals might fluctuate less than if customers cover large distances to buy in the shop) and the share of families with young children in the surrounding area (if this share is high, the share of working women is probably low, so that women have more time available to shop and are in a better position to distribute their shopping trips over time than is the case with working women). These variables have no significant influence on scale adjusted labour intensity nor do they change the influence of the share of part-time labour;

ii) the high share of self-service, which facilitates the use of other instruments than part-time labour to reduce the divergence between available and required labour. No data on the use of these instruments are available;

iii) other motives than the tuning of available and required labour to use part-time labour. Considerable simple labour has to be performed in grocery shops in contradistinction to more specialized non-food establishments. Shopkeepers are inclined to use part-timers for these tasks, because
- the availability of full-timers is limited for simple labour;
- a high entrepreneurial flexibility is maintained using part-time labour;
- part-time labour is cheaper.

This inclination appears to be greater in 1979 than in 1975. Support for the hypothesis that in 1979 part-time labour is chosen for its "cheapness" rather than for tuning available and required labour, is provided by the following experiment: if in equation (7.3.1) it is assumed that $\alpha_3 = 0$, then in 1979 the absolute value of the elasticity of $g(X_i)$ with respect to the relative wage rate, α_2, increases (though not significantly) compared to the analysis in which $\alpha_3 \neq 0$. In 1975 this elasticity does not change;

iv) all employees or members of the shopkeeper's family working less than thirty hours a week are defined to be part-timers. Such a definition has disadvantages:
- it may be too crude. Probably, there is a difference in the contribution to labour productivity between a part-time employee who works four hours per week and one who works twenty-five hours per week. Furthermore, employees working only several full-time weeks per year cannot be traced in the data;
- probably, there is a difference between the contribution of family members and that of employees to labour productivity. Experiments were performed excluding part-time family labour. The results did not differ significantly from those using total part-time labour;

v) for grocery shops of 1979 there is a small scale effect in the share of part-time labour, i.e. the share of part-time labour increases with the value of total annual sales [20]. The variable "share of part-time labour" might act as an indicator for an omitted variable to which this scale influence should be attributed. Experiments were performed using a scale corrected measure of the share of part-time labour. The results did not differ significantly from those using the uncorrected share of part-time labour.

The share of part-time labour has a significant positive influence on labour productivity for French "magasins populaires", where counter service is not predominant. We assume that this result is also due to the large size of "magasins populaires", which facilitates compartmentation of labour tasks, so that part-time employees can be efficiently supervised by full-time employees.

7.4. Conclusions and recommendations.

The main conclusions of this study are that

i) support is found for hypothesis H35, that labour productivity increases if the share of part-time labour in total labour increases for shop types where counter service is predominant. These shop types are: independent clothes shops, chain clothes shops and electro-technical retailers. These shop types do not use self-service, at best they use self-selection by the customers;

ii) for Dutch grocery shops of 1975 no support is found for hypothesis H35. This hypothesis is even rejected for Dutch grocery shops of 1979. For these shops the share of part-time labour appears to have a negative influence on labour productivity;

iii) the conclusions i) and ii) support the hypothesis (H36) that the influence of the share of part-time labour on labour productivity is weaker for self-service shop types than for counter service shop types;

iv) for "magasins populaires" the share of part-time labour appears to have a positive influence on labour productivity;

v) the results discussed in this chapter provide support for hypotheses H25, H26, H27 and H29. H28 cannot be rejected. See sections 6.2 and 6.3.

Conclusions ii) and iv) are commented on in the last part of section 7.3.

We conclude this chapter with five recommendations for further study:

i) adaptation of Nooteboom's theoretical justification of the use of retail labour in a way which deals with the increasing compartmentation of tasks and the decreasing share of labour involved in direct contact with customers, as a result of the growing size of an establishment, and which also deals with the role of part-time labour in such cases;

ii) the use of interviews to improve our knowledge of the entrepreneurial attitude towards part-time labour;

iii) detailed measurement of the fluctuation of customers' arrivals over time;

iv) consideration of the share of the labour of the owner and his family in total labour as well as the average weekly working time of full-time employees;

v) the use of aggregate (regional) data rather than individual establishments. Proceeding this way, fluctuations in demand for labour may cancel out [21].

Footnotes to chapter seven.

[1] The percentage of employees in retailing working on a part-time basis in the Netherlands increased from almost 26% in 1973 to more than 34% in 1978. The increase is particularly strong in small retailing business (see Werk in de Winkel [1979], Table 5).
From the Enquêtes Annuelles d'Entreprise dans le Commerce [1976a], [1976b], [1977] and [1981], it is seen that in France the share of part-time labour in total labour increased for most shop types from 1972 to 1977 (See Table "repartition du personnel salarié â temps partiel").

[2] A disturbance term is defined here as an independently distributed stochastic variable with zero expectation and constant variance.

[3] See chapter eight for a discussion on the influence of average transaction per customer on the demand for labour.

[4] See Nooteboom [1980] p. 164.

[5] On a long term basis the distribution of customers' arrivals may be influenced by varying the type of product or weekly opening time and the requirement of labour by altering the percentage of self-service sales.

[6] Other short term decision instruments are: pricing and promotion etc.

[7] McClelland [1966] p. 90 says: "The cost-cutting raison d'être of self-service is not just that it reduces work, but that it substitutes work that can be done at an even pace in advance of the customers' arrival for work that had to wait upon her".

[8] See Hall, Knapp and Winsten [1961] p. 53, who assume from the fact that part-time labour is cheaper that it is less qualified than full-time labour. Nooteboom [1980] p. 141 argues that the use of part-time labour has operating as well as commerial consequences, because particularly in the field of durables and luxuries part-timers may lack adequate knowledge.

[9] See Schoemaker et al. [1981].

[10] This is quite common in France if the establishment closes during lunch time and full-time employees have the disadvantage of idle hours.

[11] See Hall, Knapp and Winsten [1961] p. 57, George [1966] p. 54 and Ward [1973] p. 86. A cross-section as well as a time series study of the influence of the state of the labour market on labour productivity is reported on by George and Ward [1973]. See also Nooteboom [1980] p. 252 ff.

[12] See Werk in de Winkel [1979], p 13.

[13] This motive seems to be more important for the hospitality industry.

[14] See section 6.2 and also Henksmeier [1960] p. 104, McClelland [1966] p. 30, Ward [1973] p. 49, Bates [1976] p. 55 and Dawson and Kirby [1975] p. 98.

[15] See section 6.2 and footnote 17 of chapter six.

[16] For the French sample consisting of 32 "magasins populaires" this variable is not available and replaced by share of counter service area in total selling area.

[17] We realize that there are only three independent samples: colomn CLI $\cup$ LC of Table 7.2 refers to a sample comprising the grouped data from samples CLI and CLC.

[18] A level of significance of 10% is maintained: a coefficient η is called significantly different from zero if $|\hat{\eta}| > 1.64\ \hat{\sigma}(\hat{\eta})$.

[19] See footnote 17 of chapter six for a comparison with further results.

[20] In an attempt to explain the share of part-time labour in total labour, the following results are obtained. The share of part-time labour

- increases significantly with value of total annual sales only for SUP79 and MP7879. This increase is also found by Holdren [1960] p. 56 for averages out of 1100 American supermarkets. Gerlach [1976] p. 90 does not observe this result for German Verbraucher-Märkte;
- does not depend on the share of meat sales nor on the share of counter service sales for Dutch grocery shops;
- does not depend on the share of food sales nor on the share of counter service area for MP7879;
- decreases significantly if the share of men's wear sales increases for both independent and chain clothes shop.

[21] See George [1966], Nooteboom [1980] and Thurik and Vollebregt [1984].

APPENDIX TO CHAPTER SEVEN.

DATA.

Table A.7.1. Description of the samples used.

code	number of observations	country	year of collection	shop type	type of organization
ZB75	73	Netherlands	1975	superette	independent
SUP75	60	Netherlands	1975	supermarket	independent
ZB79	111	Netherlands	1979	superette	independent
SUP79	104	Netherlands	1979	supermarket	independent
CLI79	100	Netherlands	1979	clothes shop	independent
CLC79	100	Netherlands	1979	clothes shop	small chain
ELE80	100	Netherlands	1980	electro-technical retailer	independent
MP7879	32	France	1978,1979	"magasin populaire"	mainly independent

The difference between superettes and supermarkets in the Netherlands is defined by the sales share of fresh products, particularly meat. A precise definition of a "magasin populaire" is given in the appendix to chapter six. It can be associated with a variety store or Dutch "Hema", but it often has an integrated supermarket.
The Dutch data were gathered by the field force of E.I.M. The French data were composed on the basis of studies of the French weekly, Libre Service Actualités ("Points de Repère, 1978, Magasins Populaires", L.S.A. 722 (13-7-1979) and "Points de Repère, 1979, Magasins Populaires", L.S.A. 757 (9-5-1980)). The type of organization of an establishment is called independent if the enterprise to which the establishment belongs consists of one establishment. For ZB75, SUP75, ZB79, SUP79 and ELE80 some establishments belong to small chains.

Table A.7.2. Further description of the samples: L_i is volume of labour, Q_i is value of annual sales, Q_{2i} is value of annual sales of assortment group 2, FL_i is hourly wage rate, PT_i is share of part-time labour and CS_i is share of counter service. L_i is expressed in hours, sales in 10^3 Dutch guilders or French francs and FL_i in Dutch guilders or French francs.

code	$minL_i$ $\overline{L}$ $maxL_i$	$minQ_i$ $\overline{Q}$ $maxQ_i$	$min(Q_{2i}/Q_i)$ $\overline{Q_{2i}}/Q_i$ $max(Q_{2i}/Q_i)$	$minFL_i$ $\overline{FL}$ $maxFL_i$	$minPT_i$ $\overline{PT}$ $maxPT_i$	$minCS_i$ CS $maxCS_i$
ZB75	5865	349	1.000	3.77	.000	.090
	10574	795	1.000	7.43	.160	.278
	17470	1776	1.000	12.51	.524	.490
SUP75	13445	1083	.630	6.56	.020	.190
	28268	2597	.780	8.79	.171	.381
	48965	4586	.920	13.09	.395	.580
ZB79	5080	475	.800	5.66	.000	.010
	10452	1136	.930	10.87	.176	.268
	23540	3930	1.000	16.35	.551	.550
SUP79	10380	1327	.670	9.17	.000	.010
	26152	3271	.800	12.75	.187	.369
	56250	7496	1.000	16.91	.442	.610
CLI79	3193	331	.150	6.65	.000	
	11282	1035	.659	15.31	.142	
	31180	2884	1.000	28.69	.670	
CLC79	2435	278	.110	9.25	.000	
	10205	1096	.652	16.26	.214	
	38925	4952	1.000	26.66	.870	
ELE80	2695	289	.000	8.68	.000	
	11034	1239	.121	19.00	.099	
	37526	4682	.568	26.03	.491	
MP7879	44160	12077	.224	20.62	.010	.000
	123381	32566	.428	28.94	.196	.505
	276480	85943	.648	36.84	.550	.865

Note Table A.7.2: see Table 7.3 for a description of the assortment groups.

CHAPTER EIGHT.

TRANSACTION PER CUSTOMER AND LABOUR PRODUCTIVITY IN SUPERMARKETS.

8.1. Introduction.

The aim of this chapter is to investigate whether average transaction per customer affects the relationship between volume of labour and value of annual sales in supermarkets.

We define

$$(8.1.1) \qquad Q_i = \sum_{n_i=1}^{N_i} TR_{n_i},$$

where: Q_i : value of annual sales in establishment i;

N_i : annual number of customers (arrivals) in establishment i;

TR_{n_i} : transaction, viz. value of the contents in the basket of customer n in establishment i.

Of course

$$(8.1.2) \qquad Q_i \triangleq N_i \, TR_i,$$

where TR_i: average transaction per customer in establishment i.

This chapter attempts to make the following contributions to the explanation of differences in labour productivity per establishment:

i) discussion of the role of transaction per customer;
ii) estimation of its influence for several samples of supermarkets;
iii) extension of our empirical labour costs analysis to Dutch chain supermarkets and superettes; French supermarkets are analysed in chapter six and Dutch independent establishments in chapter seven.

This study is conducted because a shopkeeper may try to influence average transaction to obtain economies, if indeed average transaction affects labour productivity. Moreover, average transaction is assumed to depend on assortment composition, whereas assortment composition also affects labour productivity. Hence, both average transaction and assortment composition will be taken into account to establish their individual influences on labour productivity. The labour cost curve discussed in chapter five is used to study the influence of assortment composition, wage rate, share of part-time labour, share of counter service sales and average transaction per customer. Use will also be made of the theoretical specification for the influence of average transaction given by Nooteboom.

Eight samples of supermarket establishments are studied. The total number of observations is 888: some of the sample properties are given in the appendix to this chapter.
In section 8.2 the influence of transaction per customer on labour productivity is discussed as well as the specification with which this influence will be tested. Section 8.3 deals with the tests and discusses their results. Some conclusions are given in section 8.4.

8.2. Transaction per customer and labour productivity.

Two types of labour can be distinguished in retailing: labour to serve customers and labour for activities other than serving customers. Labour to serve customers can be divided into counter service activities and cash registration activities. In small counter service shops these two types of activities are often done by one attendant whose counter is also a pay desk. In larger shops (supermarkets etc.) several assortment groups are often presented using counter service (fresh meat, fruits and vegetables etc.), whereas settlement of payment takes place centrally at the check-out points. Articles of these assortment groups and self-selected articles are paid for here. Labour for activities other than serving customers consists of packing, price marking and displaying (in anticipation of self-selection on the part of customers), stockkeeping, administration, management, promotional activities etc. This labour is important in supermarkets with a considerable share of self-service [1]. Average transaction per customer will be important for the amount of labour to serve customers. It will be important for both counter service activities and cash registration activities, because these activities consist of two parts: labour independent of the amount of the transaction and labour which depends on it [2]. Consequently, we shall not assume that the shops of a certain shop type are identical with respect to average service time per value unit of sales (see section 5.2). The amount of labour independent of the transaction consists of greeting the customer, packing, counting, advising, waiting (for the customer to choose or to produce her wallet or check book), settling accounts etc. This labour increases if the number of customers increases given constant total sales (implying decreasing average transaction). Average transaction will practically be of no influence for activities other than serving customers, because here primarily total sales matter and not how they come about. However, transaction can also be defined as package size, viz. value of a package of identical goods (carton, tin, pack of tins, crate etc.) [3]. Clearly, also then average transaction will be important for counter service activities and cash registration activities, but now economies can also be achieved through activities other than serving customers (packing, price marking, displaying, stockkeeping etc.).

The influence of package size is ignored because

- data are never available;
- it will certainly be correlated with transaction as defined in section 8.1.

However, the fact that shopkeepers hardly ever discount according to transaction per purchase, but according to transaction per good, suggests that an important variable is neglected.

In short, the following hypothesis will be tested for establishments belonging to a certain shop type:

H37: labour productivity increases if average transaction per customer increases.

First, we present a test specification for establishments having one group of products (, one department and equal opening time). This is done to facilitate our succeeding presentation of a specification for establishments with more than one assortment group. Equations (5.3.4) and (5.2.3) give

(8.2.1) $$L_i = \alpha_0 + (\tau_1+\tau_2)\ g(X_i)Q_i \quad \text{with } \alpha_0 > 0,\ \tau_1 > 0 \text{ and } \tau_2 > 0,$$

where α_0: threshold coefficient;

τ_1: average service time per value unit of sales;

τ_2: average labour time per value unit of sales for activities other than serving customers;

$g(X_i)$: a function of specific properties X_i of establishment i and again

L_i: volume of labour in establishment i;

Q_i: value of annual sales in establishment i.

Disturbance terms are deleted in this section to simplify notation.
Now

(8.2.2) $\tau_1 \triangleq \tau_3 \,/\, TR_i$,

where τ_3: average service time per customer.

Referring to our discussion in the beginning of this section, we assume that service time per customer consists of labour independent of the transaction as well as labour depending on the value of the transaction [2]. We obtain

(8.2.3) $\tau_3 = \tau_4 + \tau_5 \, TR_i$ with $\tau_4 > 0$ and $\tau_5 > 0$,

where τ_4: average service time per customer irrespective of her purchases;
τ_5: average service time per customer per value unit of her purchases.

Substitution of (8.2.2) and (8.2.3) into (8.2.1) gives

(8.2.4) $L_i = \alpha_0 + \left(\frac{\tau_4}{TR_i} + \tau_6\right) g(X_i) Q_i$,

where $\tau_6 \triangleq \tau_5 + \tau_2$,

or using (8.1.2)

(8.2.5) $L_i = \alpha_0 + (\tau_4 N_i + \tau_6 Q_i)\, g(X_i)$ [4].

We will now present our test specification for establishments all having $K > 1$ assortment groups with an equal number of departments and equal opening time. Equation (5.3.8) and assumptions $\alpha_{1k} = \tau_{1k} + \tau_{2k}$ and $g_k(X_i) = g(X_i)$ for all k, $k = 1, \ldots, K$ give

(8.2.6) $L_i = \alpha_0 + \sum_{k=1}^{K} (\tau_{1k} + \tau_{2k})\, g(X_i) Q_{ki}$ with $\tau_{1k} > 0$ and $\tau_{2k} > 0$ for all k, $k = 1, \ldots, K$, where τ_{1k}: average service time per value unit of sales in assortment group k;

τ_{2k}: average labour time per value unit of sales for activities other than serving customers in assorment group k

and again

Q_{ki}: value of annual sales in assortment group k.

We define

$$(8.2.7) \qquad \tau_{1k} \triangleq \tau_{3k}/TR_{ki}.$$

We assume

$$(8.2.8) \qquad \tau_{3k} = \tau_{4k} + \tau_{5k}\, TR_{ki} \text{ with } \tau_{4k} > 0 \text{ and } \tau_{5k} > 0 \text{ for all } k,\ k = 1, \ldots, K,$$

where τ_{3k}: average service time per customer in assortment group k;

τ_{4k}: average service time per customer in assortment group k irrespective of her purchases;

τ_{5k}: average service time per customer in assortment group k per value unit of her purchases;

TR_{ki}: average transaction per customer in assortment group k.

We also define again

$$(8.2.9) \qquad \tau_{6k} \triangleq \tau_{5k} + \tau_{2k}$$

and

$$(8.2.10) \qquad Q_{ki} \triangleq N_{ki}\, TR_{ki},$$

where N_{ki}: annual number of customers of assortment group k.

Substitution of (8.2.7) through (8.2.10) into (8.2.6) gives

$$(8.2.11) \qquad L_i = \alpha_0 + \sum_{k=1}^{K} (\tau_{4k} N_{ki} + \tau_{6k} Q_{ki})\, g(X_i).$$

Variable N_{ki} is not available in our samples. Thus, we are forced to introduce the following simplification:

$$(8.2.12) \qquad N_{ki} = N_i \quad \text{for all } k,\ k = 1, \ldots, K$$

or expressed in words: visiting customers always buy in all K assortment groups. This is no unrealistic simplification for shops with a small number of assortment groups.

Then

$$(8.2.13) \qquad L_i = \alpha_0 + (\tau_4 N_i + \sum_{k=1}^{K} \tau_{6k} Q_{ki})\ g(X_i),$$

where $\tau_4 = \sum_{k=1}^{K} \tau_{4k}$: average service time per customer in all assortment groups irrespective of her purchases.

Hypothesis H37 can now be tested examining the value of τ_4: support is provided by a positive value of τ_4, average service time per customer irrespective of her purchases. The only empirical report found in literature as regards the influence of average transaction per customer is written by Nooteboom [1980] p. 195, who fails to find an influence in samples of Dutch chain supermarkets and superettes. These samples are also investigated in this chapter. However, a different test specification and a different estimation procedure are applied. Moreover, samples of Dutch independent supermarkets and superettes are also studied here, as well as a sample of French supermarkets.

8.3. Tests.

Hypothesis H37 is tested using the following specifications:

$$(8.3.1) \qquad L_i = \alpha_{00} DX_i + (\tau_4 N_i + \tau_{61} Q_{1i} + \tau_{62} Q_{2i}) \left(\frac{FL_i}{\overline{\overline{FL}}}\right)^{\alpha_2} \times$$

$$\times \exp(\alpha_3 PT_i + \alpha_5 CS_i) + v_i$$

and

$$(8.3.2) \qquad L_i = \alpha_{01} + \alpha_{02}\ DSL_i + (\tau_4 N_i + \tau_{61} Q_{1i} + \tau_{62} Q_{2i} +$$

$$+ \tau_{63} Q_{3i} \exp(\tau_{63e} DNF_i)) \left(\frac{FL_i}{\overline{\overline{FL}}}\right)^{\alpha_2} \exp(\alpha_7 DPR_i) + v_i,$$

where L_i: volume of labour (in hours per year) of establishment i;

DX_i = 1 + DSL_i for Dutch independent supermarkets (SUP75, SUP79);

DSL_i = 1 if a butcher's shop is present and 0 otherwise;

DX_i = 1 for Dutch independent superettes (ZB79), because they have no butcher's shop;

DX_i = 2 + DEC_i for French supermarkets (SUP7879);

DEC_i = DES_i + DCA_i;

DES_i = 1 if a petrol station is present and 0 otherwise;

DCA_i = 1 if a cafeteria is present and 0 otherwise;

N_i: annual number of customers;

Q_{ki} for k = 1, 2, 3: value of annual sales in assortment group k (in 10^3 Dutch guilders or French francs of the currunt year). See Table 8.3 for a description of the assortment groups;

FL_i: wage rate per hour including social securities and other personnel costs (in Dutch guilders or French francs of the current year);

$\overline{FL}$: sample average hourly wage rate;

PT_i: share of part-time labour in total labour. See section 7.3;

CS_i: share of counter service sales. See section 7.3;

DNF_i = 1 if the establishment has an orientation towards non-food products and 0 if not;

DPR_i = 1 if the establishment has a particularly deep assortment composition and 0 if not;

v_i: disturbance term.

These last specifications need no further explanation in the light of the explanation already given of the test specifications in chapters six and seven and considering our discussion in section 8.2. Differences in the value of threshold labour are not explicitly estimated for the relatively small samples of Dutch independent supermarkets and French supermarkets. Therefore, variable DX_i is used. We refer to chapters seven and six respectively for an explicit estimation using larger samples. The specification chosen for DX_i is consistent with our conclusions drawn in these chapters:

- there is one independently staffed department in Dutch independent supermarkets and superettes. There is an additional department if there is a butcher's shop;
- there are two independently staffed departments in French supermarkets and an additional one if there is a cafeteria or a petrol station.

Table 8.1. Estimates of coefficients of equation (8.3.1): Dutch independent supermarkets and superettes and French supermarkets.

shop type		SUP75	ZB79	SUP79	SUP7879
threshold	$\hat{\alpha}_{00}$	1747 (921)	3377 (789)	2193 (596)	3612 (1431)
transaction	$\hat{\tau}_4$	16.78 (11.96)*	12.88 (8.66)*	-11.87 (6.84)	19.85 (7.51)
ass. group 1	$\hat{\tau}_{61}$	13.48 (6.18)	8.28 (4.13)	7.05 (2.13)	4.26 (.44)
ass. group 2	$\hat{\tau}_{62}$	7.04 (1.66)	4.37 (.77)	5.75 (.56)	.76 (.33)
wage rate	$\hat{\alpha}_2$	-.41 (.15)	-.63 (.19)	-.54 (.15)	-.50 (.11)
% part-time	$\hat{\alpha}_3$	-.12 (.26)*	.34 (.30)*	.54 (.19)	
% counter service	$\hat{\alpha}_5$	-.06 (.34)*	.34 (.37)*	.36 (.20)	
number of observations	I	36	37	79	48
goodness of fit	r^2	.920	.885	.914	.954

Note Table 8.1: see Note Table 6.1. N.B. an asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$, i.e. if η is not significantly different from zero at a 10% level of significance.

Table 8.2. Estimates of coefficients of equation (8.3.2): Dutch chain supermarkets and superettes.

shop type		ZB73	SUP73	ZB74	SUP74
threshold	$\hat{\alpha}_{01}$	2869 (422)	8852 (2872)	2478 (452)	9254 (1549)
butcher's shop	$\hat{\alpha}_{02}$		8060 (1375)		5728 (893)
transaction	$\hat{\tau}_{4}$	-4.03 (3.81)*	-11.93 (11.55)*	-2.31 (4.03)*	3.02 (6.93)*
ass. group 1	$\hat{\tau}_{61}$	6.99 (1.14)	10.93 (3.21)	6.17 (1.20)	10.06 (2.20)
ass. group 2	$\hat{\tau}_{62}$	16.81 (2.57)	3.29 (5.30)*	13.73 (2.77)	12.37 (3.40)
ass. group 3	$\hat{\tau}_{63}$	7.95 (.43)	9.67 (.99)	7.36 (.44)	6.16 (.68)
non-foods	$\hat{\tau}_{63e}$		.13 (.04)		.21 (.04)
wage rate	$\hat{\alpha}_{2}$	-.69 (.10)	-.48 (.15)	-.78 (.13)	-.60 (.13)
deep assortment	$\hat{\alpha}_{7}$		.01 (.02)*		.01 (.02)*
number of observations	I	185	140	182	179
goodness of fit	r^2	.947	.928	.943	.942

Note Table 8.2: see Note Table 8.1.

Table 8.3. Description of the assortment groups used in equations (8.3.1) and (8.3.2).

code	Q_{1i}	Q_{2i}	Q_{3i}
SUP75, ZB79,SUP79	fresh meat	other products (dairy products, dry grocery products, non-foods etc.)	---
SUP7879	fresh foods	other products (non-fresh foods and non-foods)	---
ZB73,SUP73, ZB74,SUP74	meat and meat products	fruits and vegetables	other products (dairy products, dry grocery products, non-foods etc.)

Equation (8.3.1) is estimated for Dutch independent supermarkets of 1975 and 1979 (SUP75 and SUP79), Dutch independent superettes of 1979 (ZB79) and French supermarkets of 1978 and 1979 (SUP7879). The samples used are considerably smaller than those used in previous chapters, because average transaction per customer is not always available in the original samples. The estimation results are given in Table 8.1. Equation (8.3.2) is estimated for Dutch chain supermarkets and superettes of 1973 and 1974 (SUP73, SUP74, ZB73 and ZB74). The estimation results are given in Table 8.2.

Examining the values found for $\hat{\tau}_4$ in Tables 8.1. and 8.2, we see that $\hat{\tau}_4$ is positive in four out of eight cases and significantly positive in one case (SUP7879). We also see that $\hat{\tau}_4$ is negative in the remaining four cases and significantly negative in one case (SUP79). We conclude that the hypothesis (H37), that labour productivity increases if average transaction per customer increases, is not supported by our data.

We shall now add some conclusions with respect to the remaining coefficients in Table 8.1:

i) generally, the results with respect to SUP75, ZB79 and SUP79 are in conformity with those reported in chapter seven; we mentioned above that

the samples used in the present chapter were considerably smaller than those of chapter seven. However, $\hat{\alpha}_{00}$ for SUP75 seems to be somewhat small in the light of $\hat{\alpha}_{01}$ and $\hat{\alpha}_{02}$ in Table 7.2.
In addition, $\hat{\alpha}_2$ are consistently, but not significantly, larger than that of Table 7.2. for all three samples;

ii) we saw in chapter seven that α_2 appeared to be higher (in absolute value) for French "magasins populaires" than for any Dutch shop type considered. It was assumed that wage differences are better reflections of variations of quality of labour in France than in the Netherlands. This hypothesis is not supported by the results shown in Table 8.1: $\hat{\alpha}_2$ is approximately equal for all Dutch and French (SUP7879) shop types;

iii) fresh meat is more labour intensive than other products (cf. $\hat{\tau}_{61}$ and $\hat{\tau}_{62}$) for SUP75, ZB79 and SUP79;

iv) fresh products are considerably more labour intensive than other products (cf. $\hat{\tau}_{61}$ and $\hat{\tau}_{62}$) for SUP7879.

The conclusions with respect to the remaining coefficients in Table 8.2 (Dutch chain supermarkets and superettes) are [5]:

i) $\hat{\alpha}_{01} > 0$ and significantly in all four cases. Also, $\hat{\alpha}_{02} > 0$ and significantly in both cases. For Dutch chain shop types strong support is found for the hypothesis of a positive intercept (= threshold coefficient): the hypothesis (H25, see section 6.2) that economies can be achieved with respect to the use of labour is supported. There is additional threshold labour resulting from the presence of a butcher's shop (H26). If the threshold coefficient is associated with the sum of opening times of all independently staffed departments in the shop and if it is assumed that yearly opening time is approximately 2500 hours, then the average number of departments is one for superettes and three to four for supermarkets. The average additional number of departments due to the presence of a butcher's shop is two to three. Comparing these results with those of independent supermarkets reported in chaper seven, we observe that there are more departments in chain establishments than in independent;

ii) examining $\hat{\tau}_{61}$, $\hat{\tau}_{62}$ and $\hat{\tau}_{63}$, we see that
   - for chain superettes there is no significant difference between the labour intensity of meat and meat products ($\hat{\tau}_{61}$) and other products excluding fruits and vegetables ($\hat{\tau}_{63}$);

- for chain superettes fruits and vegetables are significantly more labour intensive ($\hat{\tau}_{62}$) than other product groups;
- $\hat{\tau}_{62}$ does not differ significantly from zero for SUP73. We surmise that mistakes were made in assembling the data for SUP73 [6]. SUP73 will be left out of discussion as far as τ_{6k} are concerned;
- other products ($\hat{\tau}_{63}$) are less labour intensive than meat (products) and fruits and vegetables for SUP74;

iii) $\hat{\alpha}_2 < 0$ and significantly in all cases. It is higher (in absolute value) for superettes than for supermarkets. Probably, wage differences are better reflections of variations of quality of labour in superettes than in supermarkets. This economy may be due to better management of small labour volumes;

iv) the share of non-food products appears to have a positive influence on labour intensity for chain supermarkets ($\hat{\tau}_{63e} > 0$ and significantly);

v) the depth of the assortment composition does not appear to affect labour intensity for chain supermarkets ($\hat{\alpha}_7$ does not differ significantly from zero).

In our view it is quite surprising that the hypothesis (H37), that labour productivity increases if average transaction per customer increases, is not supported by the data. To conclude this section we will mention some possible causes of this lack of support:

i) the share of counter service is so small in our samples of supermarkets that differences in average transaction primarily affect labour productivity at cash registration, which itself constitutes only a small part of total labour. Furthermore, average transaction is assumed to be strongly correlated with average package size. If economies by increasing package size are primarily obtained outside the establishment, a significant influence of average transaction on labour productivity (within the establishment) is lacking;

ii) there are four samples of establishments belonging to a chain (ZB73, ZB74, SUP73 and SUP74). Labour might be allotted centrally, according to assortment composition and sales size (or other crude rules) whereas further individual differences between establishments are neglected. Especially in the case of chain establishments, a large part of labour required may be performed outside the establishment, so that the relation between labour productivity and average transaction is disturbed, because economies are mainly obtained outside the establishment (package size);

iii) if a customer expects her transaction to become large, she alters her attitude towards shopping in the sense that she will use more of her own time and the time of available personnel, compared to a situation where she just "pops in" for a quick purchase;

iv) three out of the four most recent samples do not reject the hypothesis that increasing average transaction increases labour productivity ($\hat{\tau}_4$ is significantly positive for SUP7879 and $\hat{\tau}_4 > 1.4 \times \hat{\sigma}(\hat{\tau}_4)$ and positive for SUP75 and ZB79). Competition has become so severe in recent years, that only recently have entrepreneurs taken average transaction into account to cut volume of labour;

v) average transaction is assumed to depend on assortment composition. Labour intensive assortment groups (e.g. fresh foods) are assumed to yield large transactions. The effect of these large transactions on labour productivity is already incorporated to a large extent in the τ_{6k} of the assortment groups;

vi) clearly, average transaction is only one characteristic of the distribution function of transactions per individual customer. The influence of average transaction on labour productivity depends on whether different average transactions over establishments result from differences at the lower end of the scale of individual transactions or at the higher end. For instance, it is assumed that large transactions are primarily made during busy periods in the week (on Fridays and Saturdays), when labour productivity is already high. It is plausible that entrepreneurs alter their target concerning relative waiting time during busy periods. This affects the specification of the relationship between volume of labour and value of sales. So, if differences in average transaction result from differences in individual, mainly large, transactions, the influence of average transaction on labour productivity may be deceived, because entrepreneurs alter their target concerning relative waiting time;

vii) a measure for average transaction and a measure for assortment composition must both be taken into account to establish their individual influences on labour productivity. The available description of width and especially depth of assortment composition is inadequate;

viii) there is not enough variation in the value of average transaction per establishment. See Table A.8.2. The only sample with a large variation is SUP7879 and here H37 is supported;

ix) a high correlation may be assumed between annual number of customers and value of annual sales per establishment [7]. Multicollinearity may then disturb our estimation results [8]. Thurik [1982] uses a slightly different test specification for practically the same analyses as in the present chapter: scale corrected average transaction is used instead of number of customers, so that the danger of multicollinearity is eliminated [9]. Generally, the same estimation results are obtained. We conclude from this that multicollinearity is not likely to disturb our present results.

8.4. Conclusions.

The main conclusion of this study is that an entrepreneur can obtain economies regarding labour productivity by increasing the value of annual sales, but no support is found for the hypothesis that additional economies are obtained, if this increase is obtained by increasing average transaction per customer [10]. The first finding is also met in chapters six and seven and results from the positive value found for the intercept (threshold coefficient) in the labour cost curve [11]. In a way which has become traditional in economic analysis we try to reconcile ourselves to the surprise with respect to the second finding by conceiving causes which have to make plausible the lack of conclusive support for the initial hypothesis. Nine such causes are mentioned in section 8.3.

The most interesting of these causes, which deserve further consideration, are that

- it is transaction per good rather than transaction per purchase which influences economies, whereas economies with respect to transaction per good can be obtained, to a considerate degree, outside the establishment;
- central allotment of labour using crude rules of thumb neglects possible variations of required labour;
- a customer alters her attitude towards shopping when she envisages buying a large quantity of goods;
- only recently have entrepreneurs taken factors such as average transaction into account to cut volume of labour;
- the relation between average transaction and assortment composition disturbs empirical findings.

The interesting results obtained with the relationship between volume of labour and value of sales in chapter six (French supermarkets) and chapter seven (Dutch independent establishments) are now achieved with Dutch chain supermarkets and superettes: support is provided for hypotheses H25, H26, H27 and H28. See sections 6.2 and 6.3.

Footnotes to chapter eight.

[1] Self-service is an arrangement where the customer collects the goods required having access to them and being able to inspect them without mediation of shop attendants and where, consecutively, she takes them to a central check-out point to settle accounts, having assembled her requirement from anywhere in the shop. See McClelland [1963] p. 17.

[2] See McClelland [1966] p.88 and Nooteboom [1980] p. 128.

[3] Hall, Knapp and Winsten [1961] p. 65 state that it is a large transaction per good rather than a transaction per purchase which influences economies of scale.

[4] The elasticity of L_i (volume of labour) with respect to N_i (annual number of customers) reads: $\tau_4 N_i g(X_i)/L_i$; the elasticity of L_i with respect to Q_i (value of annual sales) reads: $\tau_6 Q_i g(X_i)/L_i$.

[5] Nooteboom [1980] also analyses differences in labour productivity using these samples. However, a different test specification and a different estimation procedure are applied.

[6] Tests and comparison between SUP73 and SUP74 pointed out that it is reasonable to surmise that the annual sales of fruits and vegetables and those of other products are not well divided in the composition of the data. Tests point out that this possible mistake affects the establishment of $\hat{\tau}_{62}$ and $\hat{\tau}_{63}$ only; the estimation of other coefficients does not seem to be affected.

[7] See Thurik [1982].

[8] However, generally, the correlation coefficient between number of customers and value of sales per assortment group is less than .9.

[9] Thurik [1982] discovers a functional relationship between average transaction and annual sales. Deviations from this relationship are called scale corrected average transaction. Some attention is paid in literature to the relation between average transaction and scale: Tilley and Hicks [1970] p. 4, Holdren [1960] p. 56, Hall, Knapp and Winsten [1961] p. 44, Ihde [1976] p. 41 and in Libre Service Actualités [1980d] and [1982b].

[10] Some tentative results concerning the explanation of average transaction in French supermarkets are reported by Thurik [1981a] and in Dutch chain supermarkets by Nooteboom [1980] p. 212.

[11] Economies of scale regarding labour productivity in retailing are often found. See Nooteboom [1980] and Ingene [1983] for literature references.

APPENDIX TO CHAPTER EIGHT.

DATA.

Table A.8.1. Description of the samples used.

code	number of observations	country	years of collection	shop type	type of organization
ZB73	185	Netherlands	1973	superette	chain
SUP73	140	Netherlands	1973	supermarket	chain
ZB74	182	Netherlands	1974	superette	chain
SUP74	179	Netherlands	1974	supermarket	chain
SUP75	36	Netherlands	1975	supermarket	independent
ZB79	37	Netherlands	1979	superette	independent
SUP79	79	Netherlands	1979	supermarket	independent
SUP7879	50	France	1978,1979	supermarket	mainly independent

The difference between superettes and supermarkets in the Netherlands is defined by the sales share of fresh products, particularly meat. The Dutch data on independents were gathered by the field force of E.I.M. The data of the Dutch chain establishments were provided by a large Dutch enterpise on a confidential basis. The type of organization of an establishment is called independent if the enterprise to which the establishment belongs consists of one (or sometimes a few) establishments. The French data were composed on the basis of studies of the French weekly Libre Service Actualités ("Points de Repère 1978: Supermarchés", L.S.A., 720 (29-6-1979) and "Points de Repère 1979: Supermarchés", L.S.A., 764 (27-6-1980)).

Table A.8.2. Further description of the samples: L_i is volume of labour (hours), Q_i is value of annual sales (10^3 Dutch guilders or French francs), $s_{ki} \triangleq Q_{ki}/Q_i$, where Q_{ki} is value of annual sales of assortment group k, FL_i is hourly wage rate and TR_i is average transaction per customer (both in Dutch guilders or French francs).

code	$\min L_i$ $\bar{L}$ $\max L_i$	$\min Q_i$ $\bar{Q}$ $\max Q_i$	$\min s_{1i}$ $\bar{s}_1$ $\max s_{1i}$	$\min s_{2i}$ $\bar{s}_2$ $\max s_{2i}$	$\min s_{3i}$ $\bar{s}_3$ $\max s_{3i}$	$\min FL_i$ $\overline{FL}$ $\max FL_i$	$\min TR_i$ $\overline{TR}$ $\max TR_i$
ZB73	6469	404	0	0	.727	5.69	5.02
	14951	1519	.017	.040	.943	7.33	8.69
	43165	3943	.183	.142	1.	9.90	14.99
SUP73	38234	2847	.069	.048	.705	5.74	10.02
	75755	7105	.133	.090	.777	6.98	15.88
	179107	17070	.210	.126	.832	8.28	25.34
ZB74	6301	499	0	0	.728	6.71	4.80
	15054	1681	.023	.047	.930	9.05	9.23
	38955	4263	.196	.138	1.	12.54	16.90
SUP74	26476	2767	.070	.051	.710	7.52	9.93
	64064	6871	.118	.091	.790	8.83	16.34
	143496	16614	.196	.137	.845	10.04	26.27
SUP75	16315	1127	.11	.65		6.56	6.49
	28937	2687	.22	.78		8.74	10.86
	48965	4586	.35	.89		10.79	16.17
ZB79	5250	486	0	.83		7.59	7.00
	12227	1370	.067	.93		10.75	12.79
	23050	3930	.170	1.		14.50	21.95
SUP79	12570	1326	.020	.670		9.17	9.73
	27414	3431	.209	.791		12.92	16.74
	56250	7496	.330	.980		16.91	30.00
SUP7879	24960	8578	.276	.420		13.47	27.53
	76847	26200	.465	.535		25.84	63.05
	163296	77290	.581	.724		46.82	180.00

Note Table A.8.2: see Table 8.3 for a description of the assortment groups.

CHAPTER NINE.

A STUDY ON ENTREPRENEURIAL BEHAVIOUR.

9.1. Introduction.

In this chapter we shall study whether retail entrepreneurs try to maximize the value of annual sales per establishment or that of annual net profit. The former hypothesis is maintained in chapters two and three and it is argued that this maximization is achieved by manipulating the partitioning of total available floorspace into selling area and remaining space. Different partitioning is associated with different marketing or operational strategies. See section 2.2. It is explained in chapter two that maximization of the value of annual sales is equivalent to that of annual net profit, if this partitioning does not affect cost factors nor average percentage gross margin. However, there are reasons to assume that it does. In that case, maximization of the value of annual sales and that of annual net profit are no longer equivalent. We shall discuss, in this chapter, to what extent the partitioning of total available floorspace influences cost factors and average percentage gross margin. Consecutively, we shall present a model which will be used to test whether shopkeepers maximize the value of annual sales or that of annual net profit. This model primarily consists of relationships already discussed in chapters two and six. For our tests we use data from large French supermarket(-like) establishments, which are also used in section 2.7 and chapter six. This is done, because we assume that these establishments are large enough from a financial point of view, to vary the partitioning of total floorspace easily. Moreover, the construction of their building is often flexible enough to permit easy variation.

9.2. Model.

In this section a model will be developed which studies entrepreneurial behaviour: whether retail entrepreneurs try to maximize the value of annual sales per establishment or that of annual net profit. This model consists primarily of relationships already discussed in chapters two and six. Therefore, the present treatment will sometimes be brief. Our considerations are based on the fact that total available floorspace of a retail establishment i, W_i, consists of selling area C_i and remaining space R_i:

$$(9.2.1) \qquad W_i \stackrel{\Delta}{=} C_i + R_i.$$

It is the shopkeeper's task to establish the partitioning of W_i into C_i and R_i. This partitioning is determined by the marketing or operational stategy of an establishment. See section 2.2. For example, a high share of remaining space is associated with
- a low share of self-service sales and a high share of counter service sales;
- a high share of own production.

It is assumed that this partitioning influences

i) value of annual sales. See chapter two;

ii) scale adjusted labour intensiy. See chapter five;

iii) occupancy costs per unit of floorspace. These costs consist of two components: (estimated) rent and remaining occupancy costs (energy, insurance, maintainance of inventory etc.). Average occupancy costs per unit of floorspace decrease if the share of remaining space increases, because selling area is more expensive than remaining space in terms of occupancy costs;

iv) wage rate. A high share of remaining space (i.e. high share of counter service sales and/or a high share of own production) requires a high quality of labour. Consequently, the wage rate will be high;

v) average percentage gross margin. Cf. equation (2.2.9) for a definition. A high share of remaining space (i.e. high share of counter service sales and/or a high share of own production) is associated with a high added value in the distribution process of goods.

There are distinct types of behaviour in establishing the partitioning of W_i into C_i and R_i. Our analysis should follow the lines set out in chapters two and three, if an entrepreneur tries to maximize the value of annual sales: only assumption i) must be taken into account. If, on the contrary, an entrepreneur tries to maximize the value of annual net profit, cost factors (assumptions ii) to iv)) and gross margin (assumption v)) must also be taken into account.

It is the aim of this chapter to study which is the entrepreneurial behaviour. To this end, we propose the following entrepreneurial goal function:

(9.2.2) $$LF_i = \xi P_i + (1-\xi)Q_i + \lambda_i(W_i - C_i - R_i) \text{ with } 0 \leq \xi \leq 1,$$

where LF_i: value of the Lagrangean function per establishment i;
P_i: value of annual net profit;
Q_i: value of annual sales;
λ_i: Lagrangean multiplier;
ξ: coefficient which determines entrepreneurial behaviour: sales is maximized if $\xi = 0$, and net profit if $\xi = 1$. It is difficult to draw conclusions if $\xi \neq 0$ and $\xi \neq 1$.

Now

(9.2.3) $$P_i \triangleq M_i Q_i - K_i$$

with

(9.2.4) $$K_i \triangleq FL_i L_i + HV_i W_i + O_i,$$

where M_i: average percentage gross margin divided by 100 for establishment i;
K_i: total annual costs;
FL_i: wage rate;
L_i: volume of labour;
HV_i: occupancy costs per unit of floorspace;
O_i: annual remaining costs.

N.B. $FL_i L_i$ are total labour costs and $HV_i W_i$ are total occupancy costs.

The five assumptions mentioned above describe various ways in which the partitioning of total floorspace influences variables defined in the goal function:

i) value of annual sales, Q_i:

(9.2.5) $$Q_i = \beta_i(C_i - \gamma_1)^{\pi\varepsilon}(R_i - \gamma_2)^{(1-\pi)\varepsilon}$$

with $\beta_i > 0$, $0 \leq \gamma_1 < C_i$, $0 \leq \gamma_2 < R_i$, $0 < \pi < 1$ and $\varepsilon > 0$.
See chapter two for an explanation of (9.2.5);

ii) scale adjusted labour intensity:

$$(9.2.6) \quad L_i = \alpha_0 + \alpha_{1i}\left(\frac{R_i}{W_i}\right)^{\alpha_3} Q_i \text{ with } \alpha_0 > 0 \text{ and } \alpha_{1i} > 0,$$

where L_i: volume of labour.
See chapter five for an explanation of (9.2.6). A high share of remaining space (i.e. low share of self-service sales and/or high share of own production) results in a high labour intensity [1]. Therefore, it is assumed that $\alpha_3 > 0$;

iii) through v) occupancy costs per unit of floorspace, HV_i, wage rate FL_i and average percentage gross margin, M_i are functions of the partitioning of total floorspace. We have no experience concerning the specification of the above functions.It should also be clear that HV_i, FL_i and M_i cannot be functions of the partitioning only. For instance, HV_i will also be influenced by the attractiveness of the location, or M_i by the assortment composition.

The model to estimate ξ becomes quite complicated, if all theoretical influences of the share of remaining space are honored in the test specifications. Moreover, we are not in a position to use knowledge already acquired for the explanation of HV_i, FL_i and M_i. Some preliminary explorative exercises were performed. It appears that

- no correlation can be found between wage rate and share of remaining space;
- a small and insignificant correlation is found between occupancy costs per unit of floorspace and share of remaining space [2];
- average percentage gross margin can by no means be explained using the share of remaining space.

Additionally, remaining costs do not appear to be influenced by the share of remaining space [3] and the share of remaining space appears to influence scale adjusted labour intensity, although not always significantly. The above results are obtained using not only samples of large French supermarket(-like) establishments, but also those of small Dutch supermarkets. These results are obtained using single equation regressions. This is a clear disadvantage.

We exempt the influences on the share of remaining space through occupancy costs per unit of floorspace, wage rate and average percentage gross margin (assumptions iii) through v)) from our further exercises. We leave them out of consideration rather than use them badly. Ideally, their influences should be taken into account. However, we have no sound theory concerning the nature of their influences. Explorative exercises do not show significant influences and moreover, we believe that, if there are any such influences, they are probably weak in the case of occupancy costs per unit of floorspace and wage rate. However, we believe that, certainly, there is an influence in the case of average percentage gross margin, but that we failed to establish it, because we do not have a sound theory for the explanation of average percentage gross margin per establishment. The omission of the influence of share of remaining space on average percentage gross margin may influence the results obtained in this chapter. Therefore, the exercises in this chapter must be viewed as a preliminary orientation. The omission of occupancy costs per unit of floorspace as an endogenous variable has the advantage that it permits its use as an exogenous variable explaining differences in floorspace efficiency.

Substitution of (9.2.3), (9.2.4) and (9.2.6) into (9.2.2) gives

$$(9.2.7) \qquad LF_i = \xi(M_i - \alpha_{1i}(\frac{R_i}{W_i})^{\alpha_3} FL_i)Q_i + (1-\xi)Q_i + \\ + \lambda_i(W_i - C_i - R_i) + \text{constant.}$$

After substitution of (9.2.5) into (9.2.7), the first order conditions

$$\frac{\partial LF_i}{\partial C_i} = \frac{\partial LF_i}{\partial R_i} = \frac{\partial LF_i}{\partial \lambda_i} = 0 \text{ give}$$

$$(9.2.8) \qquad \xi\ A_i\ \pi\varepsilon\ Q_i + (1-\xi)\pi\varepsilon\ Q_i = \lambda_i(C_i - \gamma_1);$$

$$(9.2.9) \qquad \xi A_i(1-\pi)\varepsilon\ Q_i + (1-\xi)(1-\pi)\varepsilon\ Q_i - B_i Q_i = \lambda_i(R_i - \gamma_2);$$

$$(9.2.10) \qquad W_i = C_i + R_i,$$

where

$$(9.2.11) \qquad A_i = M_i - \alpha_{1i}(\frac{R_i}{W_i})^{\alpha_3} FL_i$$

and

$$(9.2.12) \qquad B_i = \alpha_{1i}\left(\frac{R_i}{W_i}\right)^{\alpha_3} FL_i \; \xi \; \alpha_3 \; \left(\frac{R_i - \gamma_2}{R_i}\right).$$

Summation of (9.2.8) and (9.2.9) and application of (9.2.10) give

$$(9.2.13) \qquad \lambda_i = D_i Q_i/(W_i - \gamma_1 - \gamma_2)$$

with

$$(9.2.14) \qquad D_i = \xi A_i \varepsilon + (1-\xi)\varepsilon - B_i.$$

Now, equation (9.2.13) is used to eliminate λ_i from (9.2.8) and (9.2.9):

$$(9.2.15) \qquad C_i = \gamma_1 + (W_i - \gamma_1 - \gamma_2)[\xi A_i \; \pi\varepsilon + (1-\xi)\pi\varepsilon]/D_i;$$

$$(9.2.16) \qquad R_i = \gamma_2 + (W_i - \gamma_1 - \gamma_2)[\xi A_i(1-\pi)\varepsilon + (1-\xi)(1-\pi)\varepsilon - B_i]/D_i.$$

We are not able to show whether equations (9.2.15) and (9.2.16) have a solution, nor whether there is one or more than one solution. Hence, we are not able to show in a manner similar to that in chapter two [4], whether a possible stationary point defined by (9.2.15) and (9.2.16) refers to a maximum. However, on the basis of the estimation exercises we believe that equations (9.2.15) and (9.2.16) have one solution which refers to a maximum, because

- our maximization routine always finds an optimum value of the coefficient vector;
- using different but realistic initial values of the coefficient vector, either the same optimum value is found or the routine diverges into an irrelevant area.

We now consider the model consisting of equations (9.2.5), (9.2.6), (9.2.15) and (9.2.16). Endogenous variables are Q_i, L_i, C_i and R_i, whereas W_i is exogenous. The vector of coefficients occurring in these equations is called θ with $\theta' = (\beta_i \; \gamma_1 \; \gamma_2 \; \pi \; \varepsilon \; \alpha_0 \; \alpha_{1i} \; \alpha_3 \; \xi)$.
The restrictions on these coefficients are given above.
Coefficients β_i and α_{1i} are assumed to depend on specific properties of the establishment. This will be explained below.

The following hypotheses will be tested using this model:

H38: retail entrepreneurs try to maximize the value of annual sales per establishment rather than that of annual net profit, i.e. $\xi = 0$.

H39: scale adjusted labour intensity increases if the share of remaining space in total available floorspace increases, i.e. $\alpha_3 > 0$.

We propose H38 as our hypothesis to be tested and not maximization of the value of annual net profit (i.e. $\xi = 1$), because it seems realistic. It is questionable whether the implications of profit maximization can be coped with by shopkeepers (see section 2.2 for a more detailed motivation) and the results obtained with this hypothesis in chapters two and three, are encouraging.

The last part of this section is devoted to the estimation of the coefficient vector θ. Taking logarithms in (9.2.5) and specifying an additive disturbance structure we obtain

$$(9.2.17) \quad \log Q_i = \log\beta_i + \pi\varepsilon\log(C_i - \gamma_1) + (1-\pi)\varepsilon\log(R_i - \gamma_2) + v_{1i};$$

$$(9.2.18) \quad L_i = \alpha_0 + \alpha_{1i}\left(\frac{R_i}{W_i}\right)^{\alpha_3} Q_i + v_{2i};$$

$$(9.2.19) \quad C_i = \gamma_1 + (W_i - \gamma_1 - \gamma_2)\{[\xi A_i \pi\varepsilon + (1-\xi)\pi\varepsilon]/D_i\} + v_{3i};$$

$$(9.2.20) \quad R_i = \gamma_2 + (W_i - \gamma_1 - \gamma_2)\{[\xi A_i(1-\pi)\varepsilon + (1-\xi)(1-\pi)\varepsilon - B_i]/D_i\} + v_{4i}.$$

It should be noted that $v_{3i} + v_{4i} = 0$ in equations (9.2.19) and (9.2.20). Therefore, one of these equations can be deleted in our estimation procedure. We choose to leave out (9.2.20) [5].

We now define V_i with $V_i' = (v_{1i}\ v_{2i}\ v_{3i})$. We assume that $V_i \sim N(0,\Omega)$ for $i = 1, \ldots, I$: trivariate normal distribution with zero means and constant, positive definite and symmetric covariance matrix

$$\Omega = \begin{bmatrix} \omega_{11} & \omega_{12} & \omega_{13} \\ \omega_{21} & \omega_{22} & \omega_{23} \\ \omega_{31} & \omega_{32} & \omega_{33} \end{bmatrix}.$$

In addition, it is assumed that $E(V_i\ V_{i'}') = 0$ for $i \neq i'$.

Full information maximum likelihood estimates are found by locating a maximum of the likelihood function with respect to θ after concentrating this function with respect to Ω [6].

9.3. Tests.

Hypotheses H38 and H39 are tested for large French supermarkets using a model consisting of equations (9.2.17), (9.2.18) and (9.2.19), where

$$\beta_i = \beta_0 \left(\frac{HV_i}{\overline{\overline{HV}}}\right)^{\beta_1} \qquad (9.3.1)$$

and

$$\alpha_{1i} = \alpha_{11}\left(\frac{Q_{1i}}{Q_i} + \alpha_{1r}\frac{Q_{2i}}{Q_i}\right)\left(\frac{FL_i}{\overline{\overline{FL}}}\right)^{\alpha_2} \qquad (9.3.2)$$

and where W_i: total available floorspace for foods and non-foods [7] of establishment i (in 10^3 m^2);

C_i: selling area of foods and non-foods [7] (in 10^3 m^2);

R_i: remaining space (in 10^3 m^2);

Q_{1i}: value of annual sales of foods (in 10^6 French francs of 1979);

Q_{2i}: value of annual sales of non-foods [8] (in 10^6 FF of 1979);

$Q_i \triangleq Q_{1i} + Q_{2i}$;

L_i: volume of labour [9] (in full-time equivalents);

HV_i: total non-labour costs per m^2 (in 10^6 FF of 1979); occupancy costs are not available;

FL_i: wage rate per man year (in 10^6 FF of 1979);

$\overline{\overline{HV}}$ and $\overline{\overline{FL}}$: sample averages.

Some comments with respect to equations (9.3.1) and (9.3.2) are necessary, because they are simplified versions, when compared with the analyses in chapters two and six. These simplifications are pursued to reduce computations:
- β_0 is a measure of the "average" efficiency of floorspace;
- β_1 is the elasticity of β_i with respect to $HV_i/\overline{\overline{HV}}$;
- for simplicity, other influences on β_i are deleted. Cf. equation (2.7.1);
- α_{11} is the partial "average" scale adjusted labour intensity (sli) for food sales;
- $\alpha_{1r} = \alpha_{12}/\alpha_{11}$ where α_{12} is the partial "average" scale adjusted labour

intensity of non-food sales. For simplicity an a priori value of α_{1r} is used, which is based on the estimations of chapter six;

- α_2 is the elasticity of α_{1i} with respect to $FL_i/\overline{FL}$;
- for simplicity, other influences on α_{1i} are deleted. Cf. equation (6.4.1).

Also, as in chapter two, the remaining space threshold is assumed to be zero: $\gamma_2 = 0$.

Our model is estimated for "magasins populaires" (MP7579), hypermarkets (HYP7577) and supermarkets (SUP7579). A definition of these shop types is given in the appendix to chapter six, as well as the sources of the data and a description of some of the vectors used. A description of the remaining vectors can be found in the appendix to chapter two.

The following conclusions can be drawn from Table 9.1 regarding H38 and H39 (per shop type two estimations are reported: one with $0 \leq \xi \leq 1$ and one with $\xi = 1$):

H38: ξ does not differ significantly from zero in all three cases. It tends to be zero for "magasins populaires" and supermarkets. The likelihood ratio test statistic $2[L(\xi = 1) - L]$ can be computed from Table 9.1. This test statistic has asymptotically a χ^2-distribution with one degree of freedom. The hypothesis that shopkeepers try to maximize the value of annual net profit is rejected at a 5 percent level of significance for "magasins populaires" and supermarkets. This hypothesis cannot be rejected for hypermarkets. In short, the hypothesis that entrepreneurs try to maximize the value of annual sales is supported for "magasins populaires" and supermarkets. No such conclusion can be drawn ragarding hypermarkets.

H39: $\hat{\alpha}_3 > 0$ in all three cases if ξ is not restricted and significantly for "magasins populaires" and supermarkets. For these shop types the hypothesis is supported that labour intensity increases if the share of remaining space increases. Now, it is understandable that H38 cannot be tested for hypermarkets, because labour intensity is not influenced by the share of remaining space. Then, maximization of value of annual sales is equivalent to maximization of value of annual net profit.

In the light of the result that it cannot be rejected that $\xi = 0$, it is obvious that the estimated coefficients in Table 9.1 show values and signs which are in accordance with those obtained in chapters two and six. It is seen that

- average floorspace efficiency ($\hat{\beta}_0$) is higher for hypermarkets than for "magasins populaires" and supermarkets;
- the hypothesis (H3) is supported that floorspace efficiency increases if occupancy costs per unit of floorspace increase ($\hat{\beta}_1$);
- positive floorspace threshold coefficients ($\hat{\gamma}_1$) are found. Cf. H1;
- supermarkets have the highest selling space intensity ($\hat{\pi}$);
- the hypotheses (H2) is supported that the asymptotic sales elasticity with respect to total available floorspace is less than one ($\hat{\varepsilon}$);
- positive labour threshold coefficients ($\hat{\alpha}_0$) are found. Cf. H25;
- the hypothesis (H29) is supported that labour intensity decreases if the wage rate of the establishment increases ($\hat{\alpha}_2$);
- in the light of the simple model used, the explanation is fairly high for a cross-section model.

Table 9.1. Estimates of coefficients of the model consisting of equations (9.2.17), (9.2.18) and (9.2.19) with (9.3.1) and (9.3.2).

shop type		MP7579		HYP7577		SUP7579	
average efficiency	$\hat{\beta}_0$	3.11 (.03)	3.08 (.03)	3.90 (.13)	3.90 (.13)	3.23 (.04)	3.22 (.04)
occupancy costs	$\hat{\beta}_1$	.496 (.061)	.495 (.069)	.581 (.080)	.581 (.080)	.480 (.067)	.480 (.066)
threshold	$\hat{\gamma}_1$	.560 (.029)	.579 (.020)	2.16 (.95)	2.16 (.90)	.236 (.053)	.212 (.056)
distribution	$\hat{\pi}$	.336 (.026)	.261 (.044)	.360 (.030)	.358 (.028)	.534 (.028)	.549 (.025)
sales elasticity	$\hat{\varepsilon}$	.547 (.053)	.527 (.048)	.608 (.068)	.608 (.069)	.711 (.062)	.741 (.063)
threshold	$\hat{\alpha}_0$	8.30 (4.07)	-1.94 (3.36)*	31.52 (10.86)	29.99 (10.80)	3.67 (1.06)	2.59 (1.03)
foods <u>sli</u>	$\hat{\alpha}_{11}$	2.85 (.40)	2.09 (.09)	.714 (.053)	.703 (.049)	2.10 (.12)	1.86 (.07)
<u>sli</u> proportion	α_{1r}	2.	2.	4.	4.	.5	.5
wage rate	$\hat{\alpha}_2$	-.777 (.112)	-.568 (.079)	-.929 (.136)	-.919 (.144)	-.652 (.064)	-.570 (0.59)
remaining space	$\hat{\alpha}_3$	.815 (.295)	.091 (.056)*	.040 (.139)*	.007 (.123)*	.141 (.069)	-.013 (.028)*
goal	$\hat{\xi}$	.0 (.313)*	1	.230	1 (22.801)*	.0	1 (1.249)*
number of observations	I	71	71	68	68	121	121
neg.conc. loglikelihood	L	597.79	606.73	888.09	888.13	1012.58	1015.16
goodness of fit 1	r^2	.67	.63	.75	.75	.72	.72
goodness of fit 2	r^2	.75	.92	.92	.92	.94	.92
goodness of fit 3	r^2	.56	.54	.68	.68	.88	.88
goodness of fit 4	r^2	.85	.84	.87	.87	.86	.85
correlation of residuals	R	.55 .41 .85	.18 .49 .25	.02 .22 -.05	-.01 .22 -.11	-.30 .39 .04	-.49 .40 -.28

Note Table 9.1: see next page

Note Table 9.1: the asymptotic distribution of the maximum likelihood estimates is assumed to be multivariate normal. Estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficients. An asterisk (*) is printed next to the standard error of coefficient $\hat{\eta}$ if $|\hat{\eta}| < 1.64\ \hat{\sigma}(\hat{\eta})$, i.e. if η is not significantly different from zero at a 10% level of significance.
The square of the correlation coefficient between the vectors of the dependent variable and its estimation is taken as measure of goodness of fit: 1 refers to the antilog form of (9.2.17), 2 to (9.2.18), 3 to (9.2.19) and 4 to (9.2.20).
R is the matrix of correlation coefficients between the vectors of residuals of equations (9.2.17) through (9.2.19):

$$R = \begin{bmatrix} r_{12} & r_{13} \\ - & r_{23} \end{bmatrix}$$: 1 refers to (9.2.17), 2 to (9.2.18) and 3 to (9.2.19).

9.4. Conclusions.

In this chapter a model is built to study the question whether retail entrepreneurs try to maximize the value of annual sales per establishment or that of annual net profit. This model comprises relationships already discussed in chapters two and six. Its essence is that the partitioning of total floorspace into selling area and remaining space can be associated with the marketing or operational strategy and that this partitioning influences the value of annual sales, cost factors and average percentage gross margin. It is tested using samples of large French supermarket(-like) establishments. It appears that the hypothesis (H38) of maximization of the value of annual sales cannot be rejected. This was a maintained hypothesis in chapters two and three. It also appears that labour intensity increases if the share of remaining space in total floorspace increases (H39). It should be noted that the influence of the partitioning of total floorspace on average percentage gross margin is not established. Further research on the explanation of average percentage gross margin is needed to provide more evidence to support H38.

Footnotes to chapter nine.

[1] See Thurik and Van Schaik [1984], who study differences in average labour productivity per shop type in the retail trade in the Netherlands and who report that average labour intensity increases if the average share of remaining space increases.

[2] However, it appears that occupancy costs per unit of floorspace decrease with increasing total floorspace.

[3] See Thurik [1984b] for results concerning the influence of the average share of remaining space on average remaining costs for 85 Dutch shop types of 1981.

[4] Cf. footnote 12 of chapter two.

[5] Cf. footnote 28 of chapter two.

[6] See secton 2.5. for further details. It should be noted that the model consisting of equations (9.2.5), (9.2.6), (9.2.15) and (9.2.16) is not written in reduced form. Consequently, establishing the joint density function of the vector of endogenous variables, the absolute value of the Jacobian determinant of the transformation involved is not constant for each observation. These determinants do not disappear from the concentrated loglikelihood function. The numerical maximization is performed by the variable metric algorithm of Broyden, Fletcher, Goldfarb and Shanno.

[7] See footnote 35 of chapter two.

[8] See footnote 36 of chapter two.

[9] Where necessary, labour needed for the cafeteria, petrol station and other activities is deleted. This labour is estimated using the results of chapter six.

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N.B. additional references:
see Table A.5.2 in section A.5.5 for the source references of French data and section A.4.1 for the source references of the Dutch environmental data.

LIST OF HYPOTHESES TO BE TESTED.

H1: the elasticity of the value of annual sales with respect to total available floorspace, E, decreases with size (i.e. $\gamma_1 + \gamma_2 > 0$);

H2: the asymptotic elasticity of the value of annual sales with respect to total floorspace, ε, is less than or equal to one.

H3: efficiency of total available floorspace increases if occupancy costs per unit of floorspace increase.

H4: selling area intensity increases if depth of assortment composition increases.

H5A: efficiency of total available floorspace increases if share of fresh food sales increases.

H5B: selling area intensity increases if the share of fresh food sales increases.

H6A: efficiency of total available floorspace increases if the share of meat (products) sales increases.

H6B: the presence of a butcher's shop leads to additional threshold space and therefore to a higher elasticity of the value of total annual sales with respect to total available floorspace.

H7: efficiency of total available floorspace (with respect to value of total annual sales per hour weekly opening time) decreases, if the number of weekly opening hours increases.

H8: efficiency of total available floorspace (excluding the petrol station) is higher if there is a petrol station adjacent to the establishment.

H9: efficiency of total available floorspace (excluding the cafeteria) is higher if there is a cafeteria adjacent to the establishment.

H10: efficiency of total available floorspace (excluding these departments) is higher if departments such as a hobby centre or a garden centre are present on the premises of the establishment.

H11: efficiency of total available floorspace decreases if average percentage gross margin increases.

H12: efficiency of total available floorspace increased in recent years.

H13A: efficiency of total available floorspace decreases if selling area of a florist consists for a large part of a greenhouse.

H13B: selling area intensity increases if selling area of a florist's shop consists for a large part of a greenhouse.

H14: selling area intensity decreases if an electro-technical retailer is also involved in installations and repairs.

H15A: efficiency of total available floorspace increases if the retail sales share of photographer's shops increases.

H15B: selling area intensity increases if the retail sales share of photographer's shops increases.

H16: efficiency of total available floorspace increases if the retail sales per caput in the surrounding area of the product groups sold increases.

H17: efficiency of total available floorspace increases if the population density of the surrounding area increases.

H18: efficiency of total available floorspace increases if the number of competitive establishments per caput in the surrounding area decreases.

H19: efficiency of total available floorspace increases if the total number of establishments of the shopping centre increases.

H20: efficiency of total available floorspace increases if the average size of the total number of establishments of the shopping centre increases.

H21: efficiency of total available floorspace increases if the number of parking places of the shopping centre increases.

H22: efficiency of total available floorspace is higher if the shopping centre is not intersected by roads (than if it is intersected).

H23: efficiency of total available floorspace increases if the impression of the exterior of an establishment becomes more favourable (i.e. modern versus obsolete).

H24: efficiency of total available floorspace increases if the impression of the interior of an establishment becomes more favourable (i.e. modern versus obsolete).

H25: economies of scale can be achieved with respect to the use of labour;

H26: the volume of threshold labour is associated with the number of departments which, in turn, depends on the number and nature of assortment groups;

H27: different assortment groups have different partial "average" sli's (scale adjusted labour intensity: α_{1k}).

H28: scale adjusted labour intensity increases if the percentage of the selling area used for counter service increases.

H29: scale adjusted labour intensity decreases if the wage rate of the establishment increases.

H30: scale adjusted labour intensity depends on the mode of supply to the establishment.

H31: the volume of threshold labour increases if weekly opening time increases.

H32: scale adjusted labour intensity decreases if average percentage gross margin decreases.

H33: scale adjusted labour intensity is lower if a petrol station is present.

H34: scale adjusted labour intensity is higher in 1975 and 1976 than in 1978 and 1979.

H35: scale adjusted labour intensity decreases if the share of part-time labour in total labour increases.

H36: the influence mentioned in H35 is stronger for shop types where counter service is predominant (cf. clothes shops, dry cleaning shops etc.) than for shop types where counter service is not predominant (i.e. with a considerable share of self-service, e.g. supermarkets).

H37: labour productivity increases if average transaction per customer increases.

H38: retail entrepreneurs try to maximize the value of annual sales per establishment rather than that of annual net profit (i.e. $\xi = 0$).

H39: scale adjusted labour intensity increases if the share of remaining space in total available floorspace increases (i.e. $\alpha_3 > 0$).

Index of hypotheses to be tested

hypothesis	general discussion on page	hypothesis on page	estimation results in Table	discussion of results on page
H1	20	26	2.2,2.3,A.2.4,3.1,3.2,3.3,3.5,9.1	44,50,72,86-87,101,230
H2	24-25	26	2.2,2.3,A.2.4,3.1,3.2,3.3,3.5,9.1	44-45,50,87,101,230
H3	31	31	2.2,2.3,A.2.4,3.1,3.2,3.3,3.5,9.1	45,53,87,106,230
H4	31-32	32	2.2	45
H5A	32	32	2.2,A.2.4	47
H5B	32	32	2.2,A 2.4	47
H6A	33	33	2.2,A.2.4	47
H6B	33	33	2.2,A.2.4	45
H7	34	34	2.3	53
H8	34	34	2.3	53
H9	34	34	2.3	53
H10	34	35	2.3	53
H11	35	35	2.3,3.1,3.2,3.3,3.5	53,55,87-88
H12	36	36	2.2,2.3	47,54,55
H13A	82	82	3.3	92
H13B	82	82	3.3	92
H14	82	82	3.3	92
H15A	82-83	83	3.3	92
H15B	82-83	83	3.3	92
H16 through H24	116-118	119	A.4.2	131-132
H25	135-137	158	A.5.1,6.2,7.2,8.1,8.2,9.1	148-149,166-167,194-195,213,230
H26	135-140,156-158	158	A.5.1,6.2,7.2,8.1,8.2	149,167,194-195,213
H27	139-140,156,158	159	6.2,7.2,8.1,8.2	167,171,194-195,213-214
H28	159	159	6.2,7.2,8.1	167,194
H29	159	159	6.2,7.2,8.1,8.2,9.1	168,194,213-214,230
H30	160	160	6.2	168
H31	160-161	161	6.1,6.2	166,168
H32	161	161	6.2	168,171
H33	162	162	6.2	170
H34	162	162	6.2	170,171
H35	138,186-189	189	7.2,8.1	193,195-197
H36	185-189	189	7.2	193
H37	204-205	205	8.1,8.2	212,214-216
H38	22-23,221-222,127	227	9.1	229
H39	222-224	227	9.1	229

INDEX OF SHOP TYPES INVESTIGATED.

The following Dutch shop types are considered throughout this study:

BAK77: independent baker's shop
CL79: clothes shop (independent and small chain)
CLC79: clothes shop belonging to a small chain
CLI79: independent clothes shop
CON77: independent confectioner's shop
ELE80: independent electrotechnical retailer
FLO80: independent florist's shop
GRE78: independent greengrocer
IMO77: independent ironmonger's shop
PHO80: independent photographer's shop
SHO76: independent shoe shop
SUP73: chain self-service grocery store (supermarket)
SUP74: chain self-service grocery store (supermarket)
SUP75: independent self-service grocery store (supermarket)
SUP79: independent self-service grocery store (supermarket)
WUN77: independent women's underwear shop
ZB73: small chain self-service grocery store (superette)
ZB74: small chain self-service grocery store (superette)
ZB7374: small chain self-service grocery store (superette)
ZB75: small chain self-service grocery store (superette)
ZB79: small chain self-service grocery store (superette)
ZS75: small chain self-service grocery store (superette and supermarket)
ZS79: small chain self-service grocery store (superette and supermarket)

Index of Dutch shop types.

code	estimation results in Table	sample descriptions in Table
BAK77	3.1,3.4,3.5	A.3.1,A.3.2,A.3.3
CL79	A.4.2	A.4.1
CLC79	3.2,3.4,7.2	A.3.1,A.3.2,A.7.1,A.7.2
CLI79	3.2,3.4,7.2	A.3.1,A.3.2,A.7.1,A.7.2
CON77	3.1,3.4,3.5	A.3.1,A.3.2,A.3.3
ELE80	3.3,3.4,7.2	A.3.1,A.3.2,7.1,A.7.1,A.7.2
FLO80	3.3,3.4	A.3.1,A.3.2
GRE78	3.1,3,4	A.3.1,A.3.2
IMO77	3.3,3.4	A.3.1,A.3.2
PHO80	3.3,3.4,3.5	A.3.1,A.3.2,A.3.3
SHO76	3.3,3.4	A.3.1,A.3.2
SUP73	2.2,A.4.2,8.2	A.2.1,A.2.2,A.4.1,A.8.1,A.8.2
SUP74	2.1,2.2,A.4.2,8.2	A.2.1,A.2.2,A.4.1,A.8.1,A.8.2
SUP75	2.2,A.2.4,7.2,8.1	A.2.1,A.2.2,A.4.1,7.1,A.7.1,A.7.2,A.8.1,A.8.2
SUP79	2.1,2.2,7.2,8.1	A.2.1,A.2.2,7.1,A.7.1,A.7.2,A.8.1,A.8.2
WUN77	3.2,3.4	A.3.1,A.3.2
ZB73	8.2	A.8.1,A.8.2
ZB74	8.2	A.8.1,A.8.2
ZB7374	2.2,A.4.2	A.2.1,A.2.2,A.4.1
ZB75	2.2,A.2.4,7.2	A.2.1,A.2.2,A.4.1,7.1,A.7.1,A.7.2
ZB79	2.2,7.2,8.5	A.2.1,A.2.2,7.1,A.7.1,A.7.2,A.8.1,A.8.2
ZS75	A.4.2	A.4.1
ZS79	A.4.2	A.4.1

The following French shop types are considered throughout this study:

CEM75 through CEM79:	furniture store	centre d'équipement de la maison
HYP74C, HYP76C, HYP78C:	chain hypermarket	"Carrefour"
HYP74E, HYP76E, HYP78E:	chain hypermarket	"Euromarché"
HYP74I, HYP76I, HYP78I:	independent hypermarket	hypermarché
HYP75, HYP76, HYP77:	mainly independent hypermarket	hypermarché
HYP7577:	mainly independent hypermarket	hypermarché
MBR75 through MBR79:	self-service hobby store	magasin de bricolage
MP75 through MP79:	mainly independent variety store	magasin populaire
MP7579:	mainly independent variety store	magasin populaire
MP7879:	mainly independent variety store	magasin populaire
SUP75 through SUP79:	mainly independent supermarket	supermarché
SUP7579:	mainly independent supermarket	supermarché
SUP7879:	mainly independent supermarket	supermarché

Index of French shop types.

code	estimation results in Table	sample descriptions in Table
CEM75 through CEM79	A.5.1	A.5.2,A.5.3
HYP74C, HYP76C, HYP78C	A.5.1	A.5.2,A.5.3
HYP74E, HYP76E, HYP78E	A.5.1	A.5.2,A.5.3
HYP74I, HYP76I, HYP78I	A.5.1	
HYP75, HYP76, HYP77	A.5.1	
HYP7577	2.3,6.1,6.2,9.1	A.2.1,A.2.3,A.6.1,A.6.2
MBR75 through MBR79	A.5.1	A.5.2,A.5.3
MP75 through MP79	A.5.1	A.5.2,A.5.3
MP7579	2.3,6.1,6.2,9.1	A.2.1,A.2.3,A.6.1,A.6.2
MP7879	7.2	A.7.1,A.7.2
SUP75 through SUP79	A.5.1	A.5.2,A.5.3
SUP7579	2.1,2.3,6.1,6.2,9.1	A.2.1,A.2.3,A.6.1,A.6.2
SUP7879	8.1	A.8.1,A.8.2

SAMENVATTING.

Deze studie poogt een verklaring te geven voor verschillen in de produktiviteit van vloeroppervlakte per vestiging en voor verschillen in de arbeidsproduktiviteit per vestiging voor winkeltypen in de detailhandel. Onder verklaring wordt verstaan: het kwantitatief aannemelijk maken van verbanden tussen variabelen, waarbij een causale interpretatie wordt gegeven. Een winkeltype wordt gedefinieerd als een groep vestigingen die een zekere homogeniteit bezitten met betrekking tot assortiment, service-niveau, mate van eigen produktie en mate van zelfstandigheid. Voorbeelden van winkeltypen zijn: supermarkten hetzij behorend tot het midden- en kleinbedrijf (MKB), hetzij tot het grootwinkelbedrijf (GWB), groentewinkels, confectiezaken behorend tot het midden- en kleinbedrijf, schoenwinkels, bloemisterijen etc.
De produktiviteit van vloeroppervlakte wordt bestudeerd met behulp van het verband tussen de waarde van de jaarlijkse omzet (in guldens) en de grootte van de totale bedrijfsoppervlakte (in vierkante meters) per vestiging. Arbeidsproduktiviteit wordt bestudeerd met behulp van het verband tussen het arbeidsvolume (in aantal werkzame personen of aantal gewerkte uren) en de waarde van de jaarlijkse omzet (in guldens) per vestiging. Verschillen in de produktiviteit van vloeroppervlakte en arbeid worden verklaard met behulp van eigenschappen van de vestiging (type en kwaliteit van arbeid en service verlening, assortimentstypering etc.) en haar omgeving (typering van het winkelcentrum etc.).
De belangrijkste variabelen in deze studie zijn: waarde van de jaarlijkse omzet, grootte van de totale bedrijfsoppervlakte en arbeidsvolume per vestiging. De totale bedrijfsoppervlakte per vestiging is exogeen (d.w.z. dat er geen poging wordt gedaan deze variabele te verklaren) en winkeliers proberen de waarde van de jaarlijkse omzet te maximaliseren door een marketing- of operationele strategie te kiezen, welke samenhangt met de verdeling van de totale bedrijfsoppervlakte in winkeloppervlakte en overige bedrijfsruimte. Deze twee veronderstellingen vormen de basis voor een model, dat de waarde van de jaarlijkse omzet en het aandeel van de winkeloppervlakte in de totale bedrijfsoppervlakte verklaart, gegeven de totale bedrijfsoppervlakte voor vestigingen in een zeker winkeltype. Exercities met dit model zijn te vinden in hoofdstukken twee, drie en vier. In hoofdstuk twee worden kleine Nederlandse (zowel MKB als GWB) en grote Franse supermarkten onderzocht. In hoofdstuk drie worden andere Nederlandse winkeltypen onderzocht in de sfeer van zowel voedings- en genot-

middelen als duurzame en overige goederen. Waar in hoofdstukken twee en drie de nadruk ligt op de invloed van eigenschappen van de vestiging (huisvestingskosten per vierkante meter, verschillen in assortiment etc.), wordt in hoofdstuk vier de invloed van omgevingsvariabelen (eigenschappen van het winkelcentrum, bevolkingsdichtheid etc.) onderzocht. Onze conclusie is dat het voorgestelde model een goede statistische verklaring geeft, dat de invloed van eigenschappen van de vestiging een begrijpelijke en vaak significante bijdrage levert tot deze verklaring en dat omgevingseigenschappen nauwelijks bijdragen tot deze verklaring, indien deze eigenschappen naast die van de vestiging worden beschouwd.

Exercities met de relatie tussen arbeidsvolume en waarde van de jaarlijkse omzet per vestiging worden behandeld in hoofdstukken zes, zeven en acht. Deze relatie is gebaseerd op de analyses van Nooteboom, waarvan de essentie uiteengezet wordt in hoofdstuk vijf. Deze relatie verklaart arbeidsvolume met behulp van waarde van de jaarlijkse omzet, marketing of operationele strategie en overige vestigingseigenschappen (type en kwaliteit van arbeid etc.).

In hoofdstuk zes wordt onderzocht of deze relatie van toepassing is op grote Franse supermarkten (bijv. "hypermarchés") en of verschillen in arbeidsproduktiviteit verklaard kunnen worden met behulp van eigenschappen van de vestiging zoals assortiment, wijze van bediening, toeleveringswijze, wekelijkse openingstijd e.d. De resultaten blijken bevredigend in de zin dat er geen empirische reden is, de relatie niet ook toe te passen op grote detailhandelsvestigingen en dat vestigingseigenschappen de produktiviteitsverschillen uitstekend verklaren.

In hoofdstuk zeven worden verschillende aspecten van de rol van part-time arbeid in de detailhandel besproken. De invloed van de hoogte van het aandeel part-time arbeid in het totale arbeidsvolume op de arbeidsproduktiviteit per vestiging wordt empirisch onderzocht voor verscheidene Nederlandse en Franse winkeltypen. De hypothese dat arbeidsproduktiviteit stijgt wanneer dit aandeel stijgt wordt gesteund in het geval van winkeltypen zonder zelfbediening en van Franse "magasins populaires".

In hoofdstuk acht wordt de hypothese onderzocht of, naast het schaalvoordeel in de arbeidsproduktiviteit dat verkregen kan worden door de waarde van de jaarlijkse omzet te vergroten, er ook een extra schaalvoordeel ontstaat, wanneer de gemiddelde transactiegrootte per klant toeneemt. Er wordt geen empirische bevestiging van deze hypothese gerapporteerd, waarbij voornamelijk Nederlandse supermarkten worden beschouwd.

De in hoofdstukken twee, drie en vier gebruikte veronderstelling dat ondernemers de waarde van de jaarlijkse omzet trachten te maximaliseren wordt expliciet getoetst in hoofdstuk negen. Deze toetsing geschiedt binnen een model waarbij de relaties, die gebruikt zijn voor de analyse van vloerproduktiviteit en arbeidsproduktiviteit, geintegreerd worden. De hypothese kan niet verworpen worden tegenover de alternatieve hypothese dat ondernemers trachten de waarde van de jaarlijkse winst te maximaliseren.
Nuances wat betreft bovengenoemde uitspraken en bevindingen kunnen in het korte bestek van deze samenvatting niet besproken worden. Daartoe wordt verwezen naar de respectievelijk hoofdstukken. Deze kunnen vrijwel onafhankelijk gelezen worden en bevatten alle een sectie met conclusies. Achterin dit boek is een lijst opgenomen van alle hypothesen die getoetst worden.

RESUME.

Cette étude se propose d'expliquer les différences de la productivité de la surface et celles de la main d'oeuvre pour des établissements (= magasins) d'un certain type de commerce de détail. "Expliquer" est utilisé ici dans le sens de rendre quantitativement plausible des relations entre variables en donnant une interprétation causale. Le type de commerce est défini comme un groupe d'établissements ayant une certaine homogénéité au niveau de la composition de l'assortiment, du service rendu, du degré de la production propre et de la forme d'organisation. Exemples de type de commerce: supermarchés faisant partie soit des entreprises petites et moyennes (PME) soit du grand commerce (GC), des établissements vendant des fruits et légumes ou des vêtements (et faisant partie des PME), des magasins de chaussures, des établissements de floriculture etc.
La productivité de la surface est étudiée au moyen de la relation entre la valeur du chiffre d'affaires annuelles (en francs français) et la taille de la surface totale (en mètres carrés) par établissement. Quant à la productivité de la main d'oeuvre, elle est étudiée au moyen de la relation entre le volume de travail (en nombre de personnes employées ou en nombre d'heures travaillées) et la valeur du chiffre d'affaires annuelles (en francs français). Les différences de la productivité de la surface et celles de la main d'oeuvre sont expliquées par les caractéristiques de l'établissement (type et qualité de la main d'oeuvre, du service rendu, composition de l'assortiment, etc.) et celles de son environnement (description du centre commercial etc.).
Les variables les plus importantes de cette étude sont donc: la valeur du chiffre d'affaires annuelles, la taille de la surface totale et le volume de travail par établissement. On considère deux choses: que la surface totale par établissement est exogène et que les entrepreneurs essaient de maximaliser la valeur du chiffre d'affaires annuelles en choisissant une stratégie marketing ou opérationelle. Cette stratégie est liée à la façon de répartir la surface totale en surface magasin et en surface restante (qui sert à tenir le stock, à accomplir la propre production, etc.). Ces deux suppositions fournissent la base d'un modèle qui explique la valeur du chiffre d'affaires annuelles et la part de la surface magasin dans la surface totale donnée pour des établissements d'un certain type de commerce de détail. On peut trouver des applications de ce modèle dans les chapitres deux, trois et quatre. Le deuxième chapitre présente une étude de petits supermarchés hollandais (tant PME que GC)

et de grands supermarchés français (comprenant magasins populaires et hypermarchés). Le troixième chapitre présente une étude d'autres types de commerce hollandais dans les domaines tant alimentaires que non-alimentaires. L'analyse développée dans le quatrième chapitre s'attache à l'influence des caractéristiques de l'environnement (description du centre commercial, densité de la population, etc.), tandis que celle des deuxième et troisième chapitres s'attache surtout à l'influence des caractéristiques de l'établissement même (coûts de logement par mètre carré, différentes compositions d'assortiment, etc.). Nos conclusions sont: 1) que le modèle proposé fournit une bonne explication statistique, 2) que l'influence des caractéristiques de l'établissement contribue à cette explication d'une façon compréhensible et souvent signifiante, 3) que les caractéristiques de l'environnement ne contribuent que fort peu à cette explication quand elles sont considérées de pair avec celles de l'établissement lui-même.

Les chapitres six, sept et huit présentent des applications de la relation entre le volume de travail et la valeur du chiffre d'affaires annuelles. Cette relation est basée sur les analyses de Nooteboom, dont l'essentiel est présente dans le cinquième chapitre. Cette relation explique le volume de travail par la valeur du chiffre d'affaires annuelles, la stratégie marketing ou opérationelle et d'autres attributs de l'établissement individuel (type et qualité de la main d'oeuvre, etc.). Le sixième chapitre recherche si cette relation peut être appliquée également à des grands supermarchés français (en comprenant magasins populaires et hypermarchés) et si des productivités différentes de la main d'oeuvre peuvent être expliquées par des attributs de l'établissement individuel tels qu'ils ressortent de la composition de l'assortiment, du caractère du service rendu, du mode d'approvisionnement, de la durée d'ouverture hebdomadaire, etc. Les résultats apparaissent satisfaisants en ce sens que, d'un côté, il ne s'élève aucune opposition empirique à appliquer aussi la relation au domaine des grandes surfaces et que, d'un autre côté, les attributs des établissements individuels fournissent une excellente explication des différentes productivités. Le septième chapitre discute les divers aspects du rôle du travail à temps partiel dans le commerce de détail. L'influence de la part de ce travail dans le volume de travail total sur la productivité de la main d'oeuvre est étudiée empiriquement pour divers types de commerce hollandais. L'hypothèse que la productivité croît si cette part croît est verifiée seulement dans le cas des types de commerce sans libre service. Dans le huitième chapitre on étudie l'hypothèse dans le cas où il y a, à côté des économies de l'échelle obtenues par l'augmentation de la valeur du chiffre d'affaires annuelles, des économies supplémentaires dues à une augmentation de la valeur moyenne des produits achetés par client. On n'obtient cependant aucune confirmation de cette hypothèse quand on considère des supermarchés hollandais. Dans les septième et huitième chapitres on trouve une étude succincte de quelques types de commerce français.

L'hypothèse posée dans les chapitres deux, trois et quatre affirmant que les entrepreneurs essaient de maximaliser la valeur de leur chiffre d'affaires annuelles est testée dans le neuvième chapitre. Ce test est réalisé à l'aide d'un modèle dans lequel les relations utilisées dans l'analyse de la productivité de la surface et de la main d'oeuvre ont été intégrées. Cette hypothèse ne peut pas être réjetée en faveur de l'hypothèse alternative que les entrepreneurs essaient de maximaliser la valeur des profits annuels. (Pour obtenir ce résultat on a utilisé les données des grands supermarchés français).

Les nuances concernant les constatations citées ci-dessus ne peuvent pas être discutées suffisamment dans le court espace de ce résumé. Pour les détail des recherches et surtout des restrictions des constatations nous nous référons aux chapitres respectifs. Ceux-ci peuvent être lus indépendamment. A la fin de ce livre se trouve une liste de toutes les hypotheses que nous avons testées, ainsi qu'un index de tous les types de commerce considérés.

Stellingen behorende bij het proefschrift <u>Quantitative analysis of retail productivity</u>, A.R. Thurik. Erasmus Universiteit Rotterdam, 5 april 1984.

-1-

Het Bedrijfssignaleringssysteem (B.S.S.) is een door het Economisch Instituut voor het Midden- en Kleinbedrijf ontwikkeld systeem van informatie-uitwisseling voor ondernemers en accountants in het midden- en kleinbedrijf van de detailhandel. Het jaarwerk van het B.S.S., dat een overzicht geeft van financiële en operationele kenmerken van detailhandelsondernemingen, is van groot belang voor longitudinaal onderzoek. Dit onderzoek zal meer vruchten kunnen afwerpen indien het B.S.S. zich concentreert op verdieping van de dataverzameling (meer gegevens bij meer ondernemingen voor een beperkt aantal branches) dan indien het zich concentreert op uitbreiding ervan naar meer branches.

-2-

De mening dat schaalvergroting in de detailhandel noodzakelijkerwijs leidt tot daling van de werkgelegenheid, houdt geen rekening met het feit dat ondernemersarbeid (inclusief arbeid van gezinsleden) produktiever is dan werknemersarbeid.

-3-

Het onderwijs in Nederland besteedt terecht grote aandacht aan zwakbegaafde leerlingen, hetgeen blijkt uit een breed pakket van voorzieningen in het kader van het buitengewoon onderwijs. Het is onjuist dat aan hoogbegaafde leerlingen niet in dezelfde mate aandacht wordt geschonken.

-4-

De Nederlandse diplomatieke dienst is erbij gebaat, indien voor de te vervullen posten in ruimere mate dan tot op heden het geval is recrutering gaat plaatsvinden buiten het ambtenarencorps van Buitenlandse Zaken.

-5-

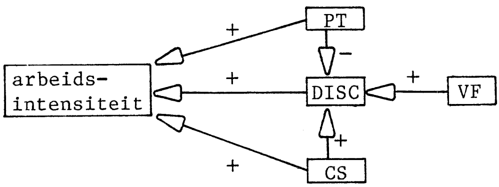
In de periode van 1976 tot 1982 zijn de procentuele totale kosten (totale kosten als percentage van de omzet) in het midden- en kleinbedrijf van de detailhandel sterk gestegen. Deze stijging is veroorzaakt door een toeneming van de procentuele niet-loonkosten, terwijl de procentuele loonkosten vrijwel constant zijn gebleven. Wanneer in de komende jaren de onderbezetting vermindert - bijvoorbeeld als gevolg van het verdwijnen van onrendabele vestigingen - en de loonmatiging doorzet, zullen de procentuele totale kosten dalen. Het zal van de mate van prijsconcurrentie afhangen of dit kostenvoordeel aan de consument zal worden doorgegeven.

-6-

Het doen van fundamenteel economisch onderzoek aan niet-universitaire instellingen voor toegepast onderzoek brengt een tweetal risico's met zich voor diegenen die dit onderzoek doen. In de eerste plaats is de kans groot dat zij na verloop van tijd toch voornamelijk worden ingeschakeld bij de problematiek van het toegepast onderzoek. In de tweede plaats, wanneer het fundamenteel onderzoek slaagt in het verschaffen van een goede wetenschappelijke onderbouwing van het specifieke onderzoek van de instelling, ontstaat het gevaar dat de voortgang van het fundamenteel onderzoek sterk belemmerd wordt, omdat de onderzoekers worden ingeschakeld bij het toepassen van de nieuwe inzichten. Een intensieve samenwerking met de universiteiten is gewenst om deze gevaren het hoofd te bieden.

-7-

Bij de bestudering van de invloed van part-time arbeid op verschillen in arbeidsintensiteit voor vestigingen van winkeltypen die zowel met bediening als met zelfbediening artikelen verkopen behoort men uit te gaan van het volgende causale schema:



waarbij arbeidsintensiteit gelijk is aan de hoeveelheid arbeid per eenheid omzet;

PT: het aandeel van part-time arbeid in de totale arbeid;

DISC: een indicator voor de discrepantie tussen de vraag naar en het aanbod van arbeid;

CS: het aandeel van de met bediening verkochte omzet in de totale omzet;

VF: een indicator voor de fluctuatie van het aantal klanten per tijdseenheid.

-8-

Deelneming in het risicodragend kapitaal van jonge, innovatieve ondernemingen door particulieren kan gestimuleerd worden door de genoten dividenden te onderwerpen aan de heffing van kansspelbelasting.