WORKING PAPER 484

MODELLING STRUCTURAL CHANGE IN THE REGIONAL GROCERY SECTOR

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MODELLING STRUCTURAL CHANGE IN THE RETAIL GROCERY SECTOR

1. Introduction

The recent reviews by Clarke and Wilson (1983, 1985) show the significant progress made in investigating the theoretical properties of a range of dynamic models of urban spatial structure. The basis for illustrating this work has been the production-constrained retail location model (cf. Lakshmanan and Hansen 1965), modified through a number of mechanisms for modelling the equilibrium values of shopping centre size (cf. Harris and Wilson 1978).

However, it has not been easy to match the potential offered by such theoretical innovation with a corresponding depth of empirical testing, which is clearly vital if further theoretical progress is to be achieved. The main obstacle to effective empirical work has been the lack of suitable (time-series) data.

> "Much of this theoretical work can only been carried out adequately in the context of more effective empirical work. This is easier said than done given the difficulties of compiling time-series data, but it is a vital step."
>
> (Clarke and Wilson 1983, p.18)

A variety of data sources are required to begin the important empirical work demanded above. These are described in detail elsewhere (Clarke 1986a,b). On the retailing side, data has been collected on the size and structure of thirty-three or so, major shopping centres in Leeds since 1960 (see Appendix), as well as a detailed study of the local retail environment of a section of North Leeds for 1955 and 1983. In terms of the requirements of the retail location models, detailed population and expenditure data has been built-up for a 729 grid-square spatial zoning system for Leeds (see Figure 1).

Given such data, there are (at least) three basic types of empirical work which can be investigated (the first two of which are described in detail elsewhere). First, is the need to explore how well the structural models can reproduce the known sizes and locations of major retailing centres in Leeds and what these models reveal about the 'logic' of the present structures. This involves careful

specification of the attractiveness of individual centres and consideration of likely costs associated with such locations (see Clarke 1986b, Clarke and Wilson 1986). The second empirical exercise involves making the outputs of the location model more useful in some way, particularly in regards to key retail planning problems of the day. The argument here turns on the definition of suitable performance indicators, related to both residences and facilities. These ideas are explored further in Clarke and Wilson (1986).

The third broad empirical requirement is the examination of structural change in retailing, since an important component of the theoretical work on retail structures has been the identification of discrete change for small pertubations in the parameters of the system. In terms of structural change, a key example has been the so-called 'corner-shop to supermarket' transition in urban retailing (cf. Poston and Wilson 1977, Wilson and Oulton 1983 and Clarke, Clarke and Wilson 1985). The aim of this paper is to investigate the nature of this change in more detail. Section 2 briefly examines the changing nature of grocery retailing since the late 1950s, highlighting the components of this corner-shop to supermarket transition. This provides the background for exploring new forms of the retail model in section 3, especially the addition of prices and disaggregation by different shop types. In section 4 we look at how the parameters of the models, set up in section 3, are each capable of bringing discrete structural changes in the system. More realistic combinations of parameter values are sought in section 5 whilst section 6 introduces changes caused by the introduction of the larger supermarkets, the superstores or hypermarkets. Concluding comments appear in section 7.

2. The changing pattern of grocery retailing

The retail grocery market of the late 1950s, early 1960s, was still dominated by the small independent retailers and the corner-shop environment. Continuous belts of shops were laid out in classic 'ribbon' fashion along major routeways radiating from the city centre. In between these major routeways were the rows of terraces typical of inner city areas, with 'corner shops' quite literally at the end of each terrace. From Leeming (1959) it is possible to count 951 small

shops in the inner area of North Leeds in 1955, of which 212 were grocers. Cheer (1957) explains that the first choice of a local shopkeeper was invariably a grocery store since the keeping of everyday items came a lot easier than specialisation. This sort of retail environment was closely related to its market and hence was influential enough to take quite large shares of the grocery trade from the bigger shopping centres nearby. Outside the inner city areas the small shop was more often found in a number of purpose-built shopping parades: making up the 'set' would be a number of convenience food outlets (grocers, greengrocers, butcher and baker) and a small number of more specialist activities (i.e. chemist, hairdresser).

This grocery environment of the early 1960s was to change rapidly throughout the decade. The arrival of the supermarket was to have profound effects on the ability of many smaller retailers to survive in face of the increased competition, whilst slum-clearance programmes were to change the character of many former areas of ribbon developments. By 1983 for example, the 212 grocers in North Leeds had been whittled away to only 23 (Clarke 1985). On the other hand, the number of major supermarkets by 1966 had reached 13 with 7 smaller Co-op outlets also present. By 1971 the number of supermarkets had reached 28. Wilson and Oulton (1983) found a similar transformation for their case-study of Nottingham (see Figure 2).

The speed of this change seems to have been caused by a number of factors. The abolition of resale price maintenance in 1964 extended the range of goods that multiple traders could buy in discount. The effect of this was not only cheaper operational costs for those retailers who could buy in bulk, but also cheaper prices to the customer. The independent retailer could simply not buy so cheaply and hence pass on savings to the shopper. These economies of scale in both buying and selling were thus crucial.

Consumer behaviour was also changing rapidly during the 1960s. More people than ever before were able and willing to travel longer distances to enjoy the benefits of not only cheaper prices at supermarkets, but also wider choice as stores got progressively larger. Alongside increasing car ownership levels came a large increase in the number of

households able to purchase a refrigerator/freezer which in turn facilitated bulk buying of groceries on a weekly basis.

All of these advantages enjoyed by the supermarket in the 1960s were similarly enjoyed by the superstores in the 1970s, only on a far greater scale. (Most of the superstore operators themselves had grown from purely supermarket operators.) Very large firms could also enjoy a number of other benefits: the ability to pay far greater fixed costs for superstore developments (which would include land for car parking facilities): the ability to stock new lines of products alongside groceries: and the increasing ability to enjoy the benefits of mechanised distribution and handling facilities.

There is much debate on the impact of these new large stores on traditional retail environments. However, we can conclude that although many small shops have closed directly through competition, the small shop still has a role to play in the grocery industry through its ability to provide a convenient service throughout more hours of the day (especially to older and more disabled members of the community). Indeed we have seen recently that the supermarket is now at greatest risk from the arrival of the superstore, since the supermarket enjoys the advantage of convenience far less than the smaller store.

We shall explore the consequences of these developments in Leeds in sections 4 and 5. However, first we can begin to specify what these changes imply for the standard retail location models.

3. The implications of the grocery sector for the interaction shopping model

The changing retail grocery sector, described briefly in section 2, provides the impetus for looking at new kinds of service-supply models. By the 1980s we are clearly left with three levels of operation: the corner shop, the supermarket and the superstore. Each of these has been particularly important at different points in time and each have unique trading characteristics. Thus fixed and operational costs, prices and consumer loyalty all vary between the different levels of operation, and indeed are all important in explaining the changing market

share over time. Before we look at modifications to the model it is useful to repeat the aggregate model for completeness:

$$S_{ij} = A_i \, e_i \, P_i \, W_j^{\alpha} \, e^{-\beta c_{ij}} \tag{1}$$

where

$$A_i = \left(\sum_k W_k^{\alpha} \, e^{-\beta c_{ik}} \right)^{-1} \tag{2}$$

to ensure that

$$\sum_j S_{ij} = e_i \, P_i \tag{3}$$

The variables are as follows:

- S_{ij} is the flow of consumer expenditure from residential zone i to shopping centre j.
- e_i is the per capita expenditure in zone i.
- P_i is the population of zone i.
- W_j is the facility size, taken as a measure of shopping centre attraction.
- c_{ij} is travel cost or distance from residential zone i to shopping zone j.

α is the usual scale economies parameter and β the distance deterrence parameter.

The Harris and Wilson (1978) argument is based on the assumption that suppliers of retail facilities will expand operations if revenue exceeds costs or contract if costs exceed revenue. K is defined as the unit cost of providing retail floorspace and D_j is the revenue accruing to zone j.

$$D_j = \sum_i S_{ij} \tag{4}$$

The dynamics of the system work as follows:

If $D_j - KW_j > 0$ then W_j will expand

or if $D_j - KW_j < 0$ then W_j will contract

Hence the equilibrium conditions occur when revenue and cost are exactly balanced:

$$D_j = KW_j \qquad \forall_j \tag{5}$$

Traditional approaches have disaggregated the models in equations 1-3 to account for good type (g) (which in this case would be groceries) and person type (w). We assume here that the latter category can be adequately picked up in our detailed zonal expenditure and population totals which take into effect the differences in spending between various socio-economic groups. However, we now add a crucial new form of disaggregation store type h (cf. Wilson 1983), of which the corner shop, supermarket and superstore are the most important. The basic model is also extended by incorporating a price variable p_j explicitly (cf. Birkin and Wilson 1985). Thus the model becomes

$$S_{ij}^{gh} = A_i^{gh} (e_i P_i)^g W_j^{\alpha^{gh}} p_j^{-\gamma^{gh}} e^{-\beta^{gh} c_{ij}} \tag{6}$$

where

$$A_i^{gh} = 1/\sum_{kh} W_k^{\alpha^{gh}} p_k^{-\gamma^{gh}} e^{-\beta^{gh} c_{ik}} \tag{7}$$

to ensure that

$$\sum_{jh} S_{ij}^{gh} = (e_i P_i)^g \tag{8}$$

with

h = 1 : the corner shop
h = 2 : supermarket
h = 3 : superstore

and the other variables are as listed before.

(NB. Wilson (1983) explores the possibility of modelling a number of goods associated with a particular h category, but we do not pursue this here).

The travel cost or distance deferrence term c_{ij} is taken simply as a function of straight-line distance. However we can factor all

trips to the city centre (through a multiplicative parameter v) to reflect the fact that all major routes converge on the city centre and hence travel times are generally quicker Hence v takes a value less than one, so that costs are reduced to the city centre.

Before looking at the cost term (K_j) in more detail a number of points about the model above should not noted. First, the balancing factor A_i^{gh} ensures that the total amount of spending on groceries is distributed between the different store types (failure to sum over h would allocate spending three times over). This means that the competition between store types and locations is explicitly modelled. Secondly, the (e_i P_i) variable is calculated specifically for the grocery trade, that is, spending on groceries was also recorded in the expenditure totals calculated. Finally, the model can be run for a number of different time periods. The superscript (t) (for different time periods) has not been included in equations 6-8 for ease of presentation. The key years are going to be those between 1966 and 1971 for this part of the analysis.

To make the costs in equation 5 more realistic we can divide the cost parameter into two main terms: i.e.

$$K_j^h = OC_j^h + PC_j^h \qquad (9)$$

where

K_j^h represents total unit costs for store type h

OC_j^h represents unit occupancy costs for store type h

PC_j^h represents unit purchasing costs for store type h

Occupancy costs are made up of rents, rates and power (McClelland, 1966): here we also add labour costs which are a similar kind of fixed cost (at one period of time). Purchasing costs are the costs involved in buying stock to retail. These two main types of cost are explored in greater detail in McClelland (1966). The increasing number of parameters in this type of model makes their operation somewhat more difficult: it relies on the compilation of another kind of time-series data (costs and prices). However, it is important to realise that all of these new parameters are important in explaining the structural changes in the grocery sector discussed in section 2. We discuss each of the new parameters in turn below and examine the effects each has on the ability to produce a structural shift between shop types. In section 5 we then attempt to include some more realistic combinations of these values to explore structural change in Leeds.

4. The corner shop v. supermarket issue

For now, in order to examine how the model solutions vary with the different parameter values, we set up a 'base set' for two of the three store types: the corner shop and the supermarket. (Concentrating on just two types also enables the impact of each parameter to be illustrated more easily). The population and expenditure data is for 1966, this being the time when greatest change was occurring. Since the corner shop can be found in all areas of the city we allow the model to allocate facilities in all 729 zones of our case-study (for the h=1 level). With 729 demand zones the spatial system for the corner shop is thus 729 x 729. However, the larger supermarkets were locating in the main shopping centres which, of course, were already well-established across the city. To capture this element of inertia we specify the 729 x 33 (for the h=2 level) spatial zoning system by allowing supermarkets to only locate in the main shopping areas (this can be achieved most simply within the 729 x 729 zoning system by setting all non-shopping centre zone W_js to zero).

We specify the base set of values as follows:

$p_j^{-\gamma 1} = 1.00$	$p_j^{-\gamma 2} = 1.00$	(price index)
$OC_j^{\,1} = 1.00$	$OC_j^{\,2} = 1.30$	(unit fixed costs)
$PC_j^{\,1} = 1.00$	$PC_j^{\,2} = 1.00$	(unit purchase costs)
$\beta_{(j)}^{\,1} = 2.50$	$\beta_{(j)}^{\,2} = 2.50$	(ease of travel)
$\alpha_{(j)}^{\,1} = 1.00$	$\alpha_{(j)}^{\,2} = 1.00$	(consumer scale economies)
$v = 0.95$	$v = 0.95$	(city centre scaling)

The difference between the two store types is thus the unit fixed costs which we set higher for the supermarket case. Running the model with this base set thus allocates all facilities to the corner-shop environment, since the supermarket has no advantages as yet.

4.1 Price variation

In Figure 3 we plot the effects of steadily decreasing the price index for the supermarket case (holding all other parameters constant). As we saw in section 2, the abolition of resale price maintenance meant that supermarkets were more able to offer discount prices on a far wider range of goods. Clearly, price reductions were a major incentive to shop at supermarkets. As price decreases in Figure 3 we see the progressive development of a more supermarket dominated environment (note that the plots are scaled according to the largest values recorded in each figure).

4.2 Variation in purchasing costs

The effects of varying the purchasing costs of retailers in supermarkets is shown in Figure 4. Clearly cheaper purchasing costs are also a result of the abolition of resale price maintenance and lower costs overall produce a similar transformation to the supermarket case.

4.3 β variation

As the 1960s progressed it is clear that travel was becoming relatively easier as levels of car ownership increased, and many planned centres acquired new car parking facilities and improved local transport communications. In Figure 5 we show how decreasing our 'ease of travel' parameter β for the supermarket case also leads to a 'supermarket transition'. The speed of transition for β change here is very rapid: a small change around β = 2.43 produces the most dramatic shift in terms of the amount of facilities allocated between the two store types.

4.4 α-variation

Traditionally the α parameter has represented consumer scale economies or more generally, the attractiveness of a particular centre (usually disaggregated in this instance to α_j). We saw in Clarke 1986b how we could specify unique attractiveness terms for individual centres as a function of size, 'importance' (reflected in the number of multiples) and the shopping environment.

In Figure 6 we plot the model solutions given a higher α_j value for the six largest shopping centres in Leeds in 1966, rather than all centres: this again helps to build in the existing structure. The centres clearly emerge as key providers of facilities as their α_j values are steadily increased (see also section 6).

4.5 Summary

It is clear from the results shown in Figures 3-6 that all the parameters studied are capable of producing a shift from a corner shop to a supermarket environment. Indeed the examples above show how similar the transformations are as the parameters are changed. In section 5 we aim to provide some evidence of price and cost comparisons which help to produce a more realistic combination of parameter values.

For now it is interesting to note the competition between the two shop types as the parameters change. The clearest examples are seen in Figures 3c, 4c and 5c: here the corner shop can only survive where there is an absence of supermarkets (to the north, west

and south west of the city especially). However, the competition between the shop types is often quite subtle. In Figure 7 we highlight the nature of this competition by listing the amount of facilities allocated to each zone for the model runs plotted in Figure 6. Figure 7a shows the corner shop case (when α_j = 1.015 for the supermarket: Figure 6a), when all facilities were allocated to it. Figure 7b and Figure 7c show the corner shop and supermarket cases respectively, when the main centres have an α_j value of 1.025 (this corresponds to Figure 6c) and facilities were allocated to both shop types. A comparison of Figures 7b and 7c show how the corner shop environment is much reduced in the locality of these main supermarket centres (see the boxed area).

The second major feature of the competition between store types is that the change between the two structures can occur very rapidly. This was seen most clearly with β, β = 2.43 being a critical threshold below which the supermarket case began to dominate. This idea of rapid structural change will be re-examined in section 6.

5. Towards a realistic combination of parameters

In section 4 we saw how the parameters of the model in equations (6-9) are each capable of bringing about a corner shop to supermarket transition. The reality of such a transformation clearly involves some combination of all these parameters. Data on the changing scale of costs and prices is extremely difficult to obtain. Much of the literature on retail costs takes retailing activity generally, or gives comparisons between different types of good: it is much harder to locate studies which take account of different shop sizes for particular goods.

However, one valuable source which sheds some light on the different prices and costs of local grocers and supermarkets is the National Board for Prices and Income (NBPI) (1971). They were particularly concerned with prices, profits and costs in food distribution during the 1960s and we exploit much of their data here (noting that these are <u>average</u> differences).

5.1 Prices

The NBPI study found that of eighteen nationally advertised products, the small independent grocer was on average 6 per cent more expensive than the average supermarket. Hence we assume the following differences in prices for the two store types:

$$(p_j^{-\gamma})^1 = 1.00$$

$$(p_j^{-\gamma})^2 \leq 0.94$$

5.2 Unit occupation (fixed) costs

The NBPI report found very high differences in the occupation or fixed costs between small independent shops and the major multiple supermarkets. Costs on rates, rents and salaries (pa) were seven to eight times higher for the average supermarket compared to the independent retailer. Since the average supermarket is some four or five times the size of the small shop we can scale our unit occupation costs accordingly:

$$OC_j^1 = 1.00$$

$$OC_j^2 \geq 1.70$$

5.3 Unit purchasting costs

Details of the costs of purchasing goods from wholesalers and manufacturers are difficult to average out because of the vast number of individual arrangements between firms. NBPI simply point out that the larger a retailer's sales then the greater is the power to negotiate a variety of concessions from the suppliers. They suggest however that larger retailers could obtain aggregate discounts of between 10 and 30 per cent in total or 10-15 per cent additionally over the 'minimum case price'. For our purpose we thus suggest:

$$PC_j^1 = 1.00$$

$$PC_j^2 \leq 0.85$$

5.4 Ease of travel and shopping centre attraction

We have seen in Figure 6 that an α_j value of around 1.02 for larger centres provides a reasonable proxy for the greater attractiveness of these centres over smaller centres. The ease of travel parameter is somewhat more difficult to estimate. The NBPI report found that only 16 per cent of customers travelled by car to small independent shops, compared to 25 per cent for larger supermarkets. Thus we suggest the following β values for experimentation:

$$\beta^1 = 2.50$$
$$\beta^2 = 2.20$$

5.5 The combined set

Figures 8 and 9 are illustrative of the types of structures which emerge when these parameters are combined. It can be seen that Figure 9 (lower cost term $PC_j^2 = 0.80$) begins to show a pattern of supermarket provision which is a reasonable approximation to the number and size of centres in Leeds in 1966. We might expect that an element of 'fine tuning' between these parameter values would begin to get much closer to the Leeds set (see next section). Nevertheless it seems reasonable to suggest that the set of cost and price parameters derived from the NBPI report (for the late 1960s) provides a good indication of the differences between the two shop types.

6. The impact of hypermarkets

6.1 Structural change

In this section we complete the model presented in equations 6-9 by adding the third store type (h): the hypermarket. Although we again lack detailed data on prices and costs it is possible to make reasonable estimates based on knowledge of the values for the small shop and supermarket. The new base set is given below.

$p_j^{-\lambda^1}$	=	1.00	$p_j^{-\lambda^2}$	=	0.90	$p_j^{-\lambda^3}$	=	0.85 (price index)
OC_j^1	=	1.00	OC_j^2	=	1.70	OC_j^3	=	3.00 (unit fixed costs)
PC_j^1	=	1.00	PC_j^2	=	0.80	PC_j^3	=	0.75 (unit purchase costs)
β_j^1	=	2.50	β_j^2	=	2.20	β_j^3	=	1.90 (ease of travel)
α_j^1	=	1.00	α_j^2	=	1.02	α_j^3	=	1.02 (consumer scale economies)

(for large centres only)

Since these parameters are working in the same way as before (sections 4 and 5) we simply take two illustrations of structural change, using 1971 as our base year and then, as usual, varying the parameters over time. Figure 10 shows the effect of slowly reducing the price index for hypermarkets whilst Figure 11 shows a decreasing value of β. Both changes result in similar solutions. As the price index and β come down, the hypermarket case can begin to compete more effectively with the other store types (overcoming the disadvantage of higher fixed costs) and the nature of the structures change very rapidly. Once again, it can be seen that small changes in each of these parameters are capable of producing major shifts in the nature of the solutions.

6.2 Competition and convenience

It can be seen from Figures 10 and 11 that the hypermarket case develops mainly at the expense of the small shop environment, which, in the model as it now stands, has by far the least attractive set of parameter values. As we suggested earlier, the small shop still provides an active retail environment and seems to satisfy approximately 20-30 per cent of grocery trade today (estimated from Leeds City Council 1984). There seems to be, therefore, an element of the attractiveness of the small shop which we have not represented in the model so far. This is clearly the general convenience of the small shop compared to other store types.

It is relatively straightforward to add a new parameter into the interaction model to represent convenience: this can be done in a similar way as the price term p_j. If we let y_j^{σ} be our new convenience factor then the model (ignoring good type g) becomes

$$S_{ij}^{h} = A_i^{h}(e_i P_i) W_j^{\alpha^h} p_j^{-\gamma^h} y_j^{\sigma^h} e^{-\beta^h c_{ij}} \qquad (10)$$

The effects of increasing the convenience factor for the small shop environment is illustrated in Figure 12 (with the parameter values as shown on the figure). It can be seen that an increase in the convenience factor of only 5 per cent is able to produce a much more realistic spread of facilities for the small shop environment. Moreover, with this increased attractiveness for the small shop, it is possible to produce a much more realistic allocation of facilities between the three store types. Leeds City Council (1984) figures suggest a reasonable solution would involve the allocation of between 20-40 per cent of facilities to the small shop, 30-50 per cent to the supermarkets and the final 20-40 per cent to the hypermarkets. Figure 13 shows a model solution which can reproduce this kind of allocation in a plausible way.

Having incorporated the new attractiveness term for the small shop, it seems likely that the hypermarket will compete far more strongly with the supermarket environment in the models. This we might argue is a step forward in that researchers on hypermarket impacts have generally agreed the developments have greater impacts on supermarkets rather than small shops (i.e. Cole 1975). To test this idea, and to add a further element of reality, we can refine the spatial system for the hypermarket (h=3) case by allowing development in a limited number of sites only. This has the advantage of concentrating facilities far more which, in turn, allows a better picture of competition. The sites for the hypermarket case are naturally the present-day real locations: listed below with their zone numbers in brackets (stand alone sites are marked X on the Appendix, the others are as listed on the map).

Bramley (303),	Holt Park (88),	Sainsburys Moortown (121),
ASDA Pudsey (436)(X^1),	Horsforth Town St.(195),	Whitkirk (401) (X^2),
Crossgates (320),	Middleton (609) (X^3),	Beeston Road (471),
Hunslet (447),	Kirkstall (306) (X^4),	Oldfield Lane (416) (X^5),
City centre (365).		

The model and associated parameter values shown in Figure 13 can now be re-run for the refined h=3 spatial system. [To recap we now have a 729 x 729 system for the small shop: 729 x 33 for the supermarket case and 729 x 13 for the hypermarket case.] Comparing Figures 13, 14 shows some major differences. All of the limited number of hypermarket sites attract facilities, as one might expect, (NB - the sites that do particularly well: Bramley, Horsforth, Moortown, Beeston and city centre), but the nature of competition becomes more interesting. The case of Horsforth Town Street to the west (see Appendix) is a good example. Here the model is able to locate either supermarket or hypermarket facilities. In Figure 13 it allocates supermarket facilities with hypermarket facilities more widely spread. Yet with the number of hypermarket sites limited in Figure 14 the model allocates hypermarket facilities to Horsforth and subsequently the supermarket facilities cannot compete and fall to zero. It also is interesting that the shut-down of the former Co-op supermarket in Horsforth New Road Side in the early 1980s came soon after the development of the hypermarket at Horsforth Town Street.

Clearly with a more refined model it is possible to look at many impact analyses with a wide range of possible locations. These possibilities are pursued in detail elsewhere (Clarke, G.P. and Wilson 1986).

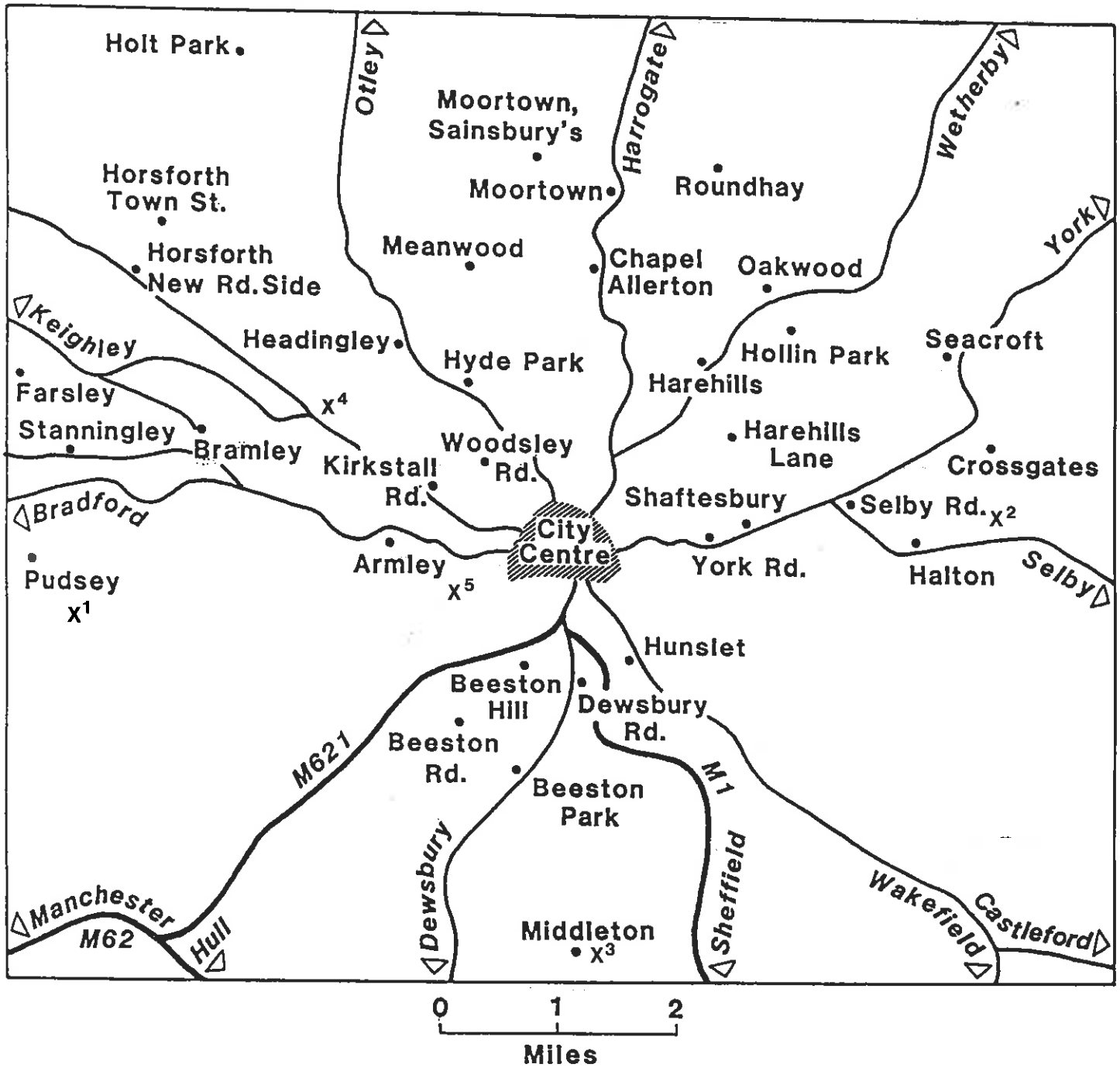
7. Conclusions

The case-study of changing grocery retailing has provided useful insights into the behaviour and properties of dynamic retail location models. To begin to model such transformations as the corner shop to supermarket/hypermarket transitions in retailing it has been necessary to disaggregate the models to include different store types. Each store type then has a unique set of parameter values for all the major variables of the model: hypermarkets have cheaper prices and unit

purchasing costs whilst the corner shop has cheaper fixed costs and a higher index of convenience. Clearly such a fine-resolution model enables a rich set of individual parameter values to be built up for each store type and crucially allows competition between the store types in different locations to be explicitly modelled.

Having made the extension to dynamics, it has been shown that actual trajectories can be broadly reproduced and that there is empirical evidence to back up the theoretical ideas that key parameters can achieve critical values beyond which the nature of the structure of provision changes. Indeed, all the mainvariables, prices, ease of travel and retail costs were seen to be capable of producing rapid structural change at key parameter values.

The exercise has clearly demonstrated that such detailed dynamic studies are time-consuming in terms of data collection, and yet one of the obvious tasks for future research involves the search for even better data, especially in terms of costs and prices and on consumer flows. Nevertheless, it has been shown that considerable progress can be achieved using mainly published, secondary data sources, which will hopefully encourage others to explore other sub-systems of interest.



The shopping centres of Leeds

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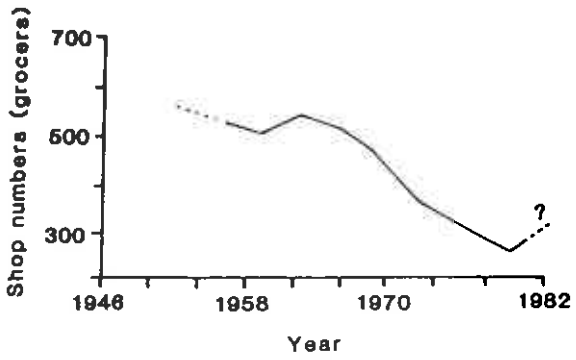
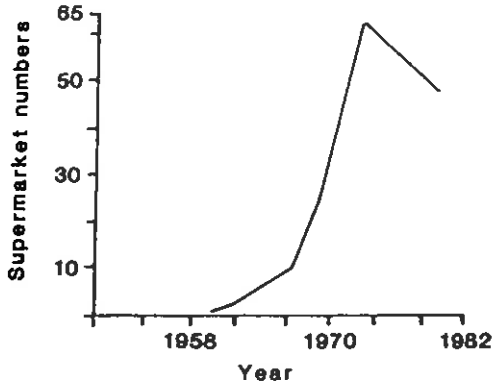
Figure 1. 729 grid-square spatial zoning system for Leeds

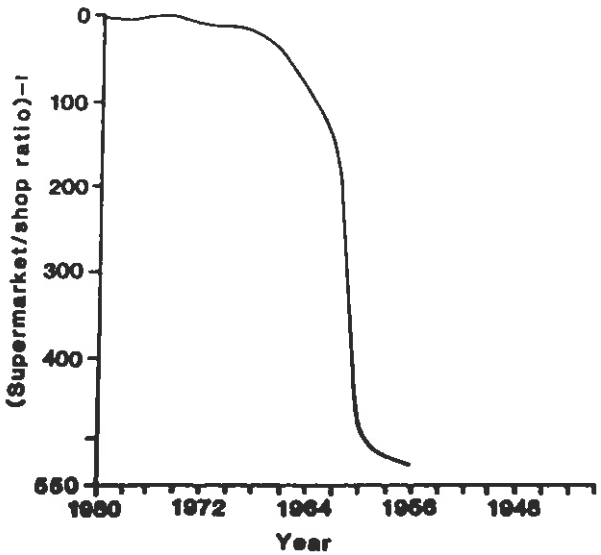
Figure 2. The corner shop to supermarket transition



(a) Number of grocers in Nottingham



(b) Number of supermarkets



(c) An index of supermarket dominance

Source: Wilson and Oulton (1983)

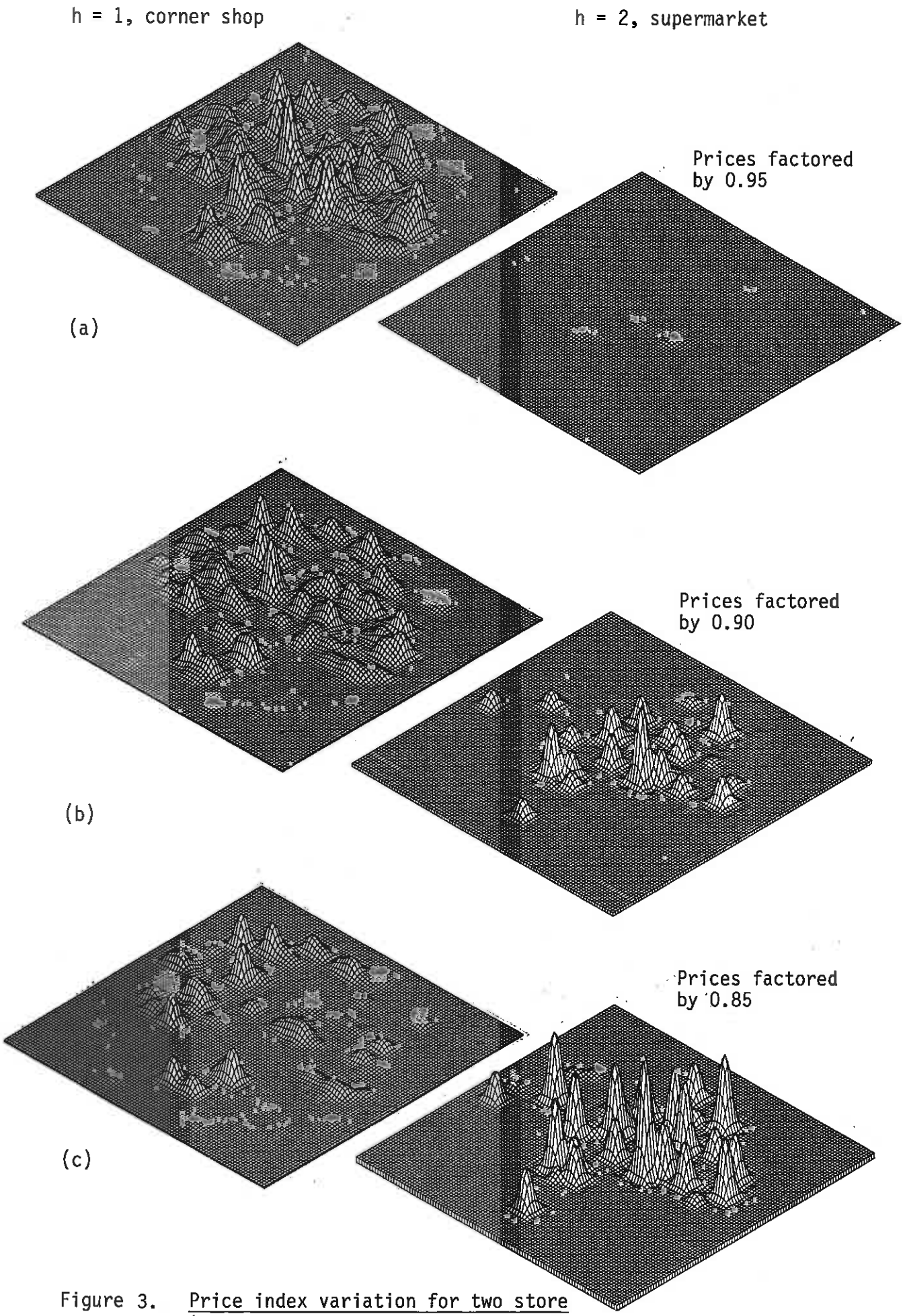


Figure 3. Price index variation for two store types

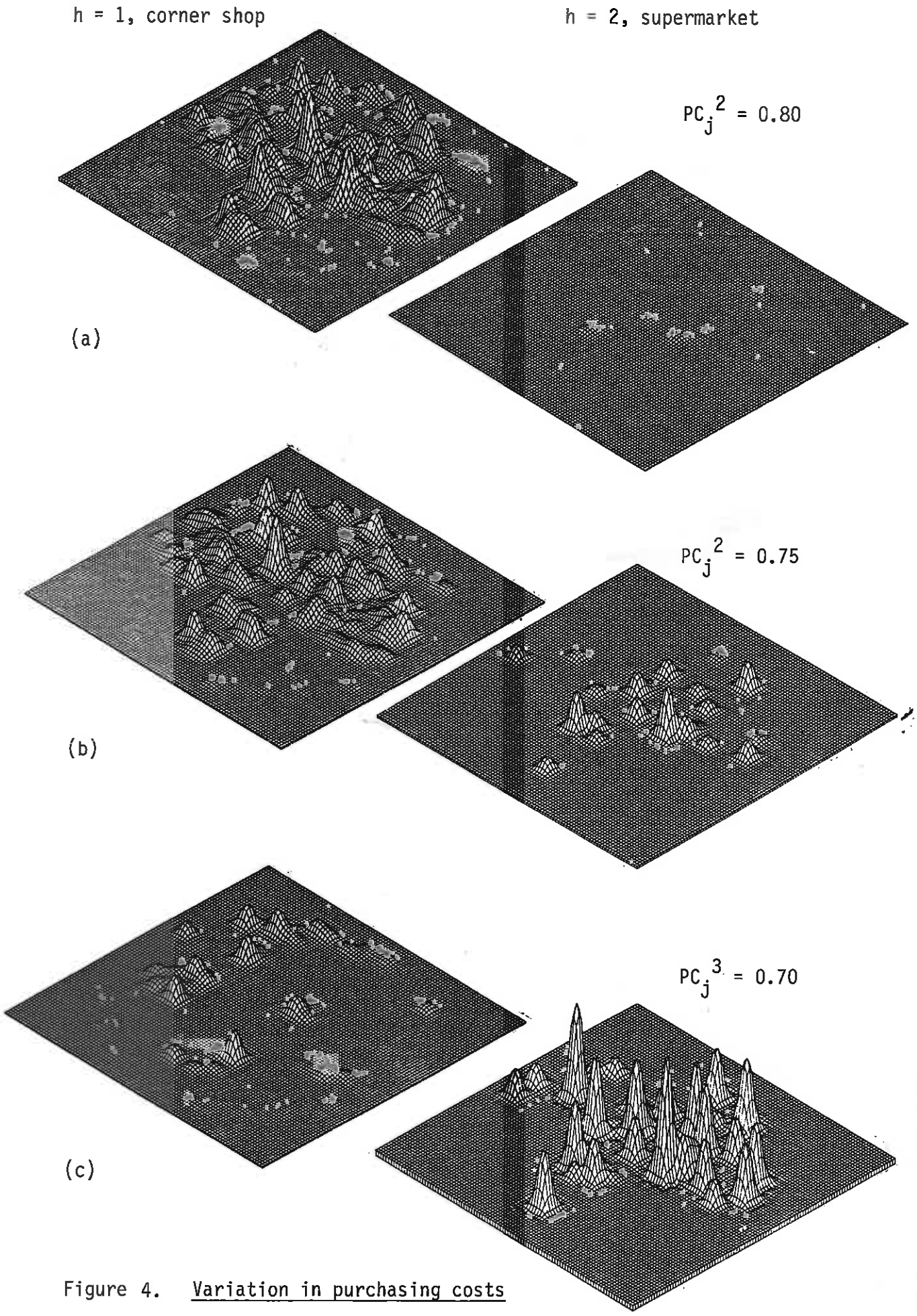


Figure 4. Variation in purchasing costs

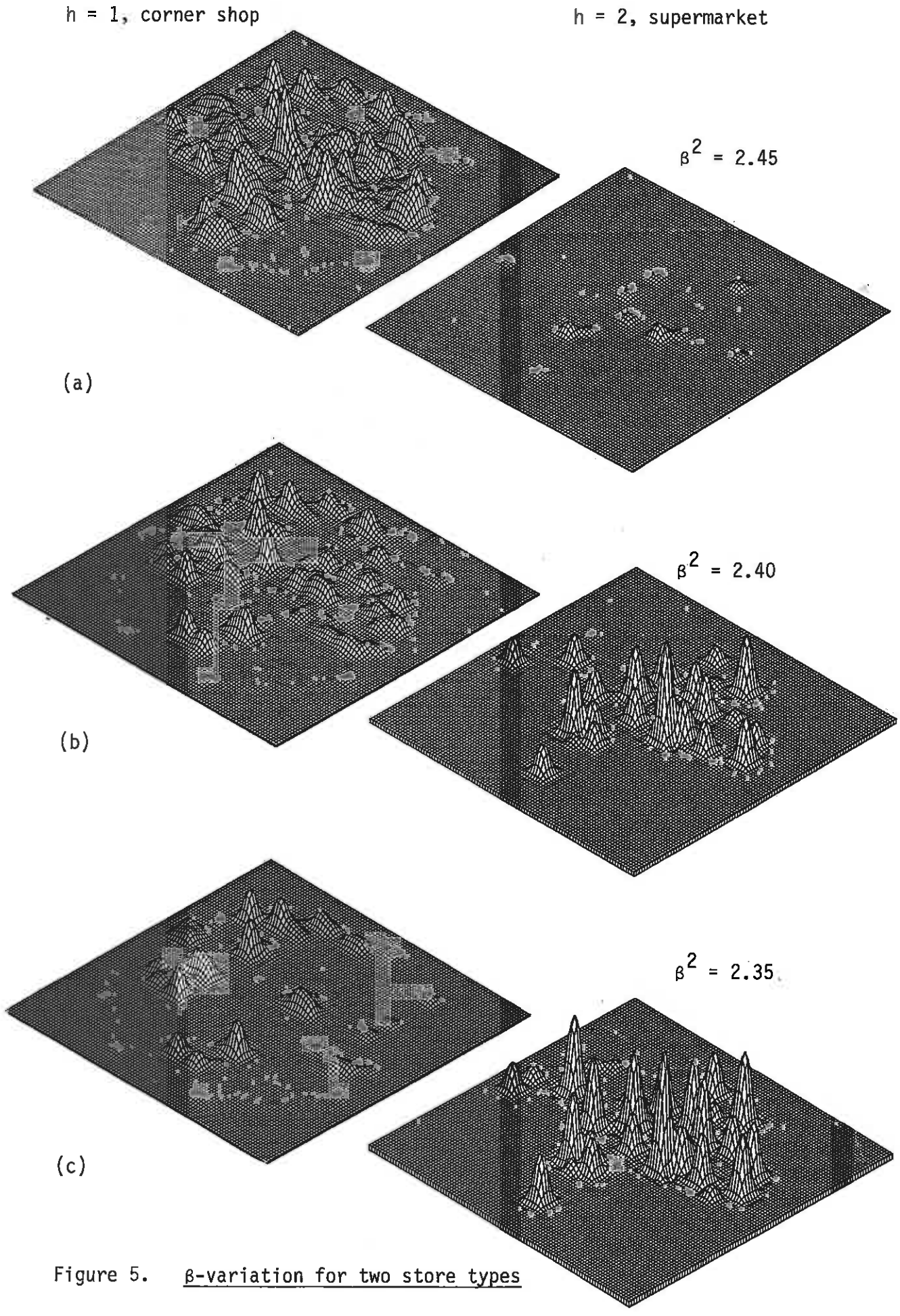


Figure 5. β-variation for two store types

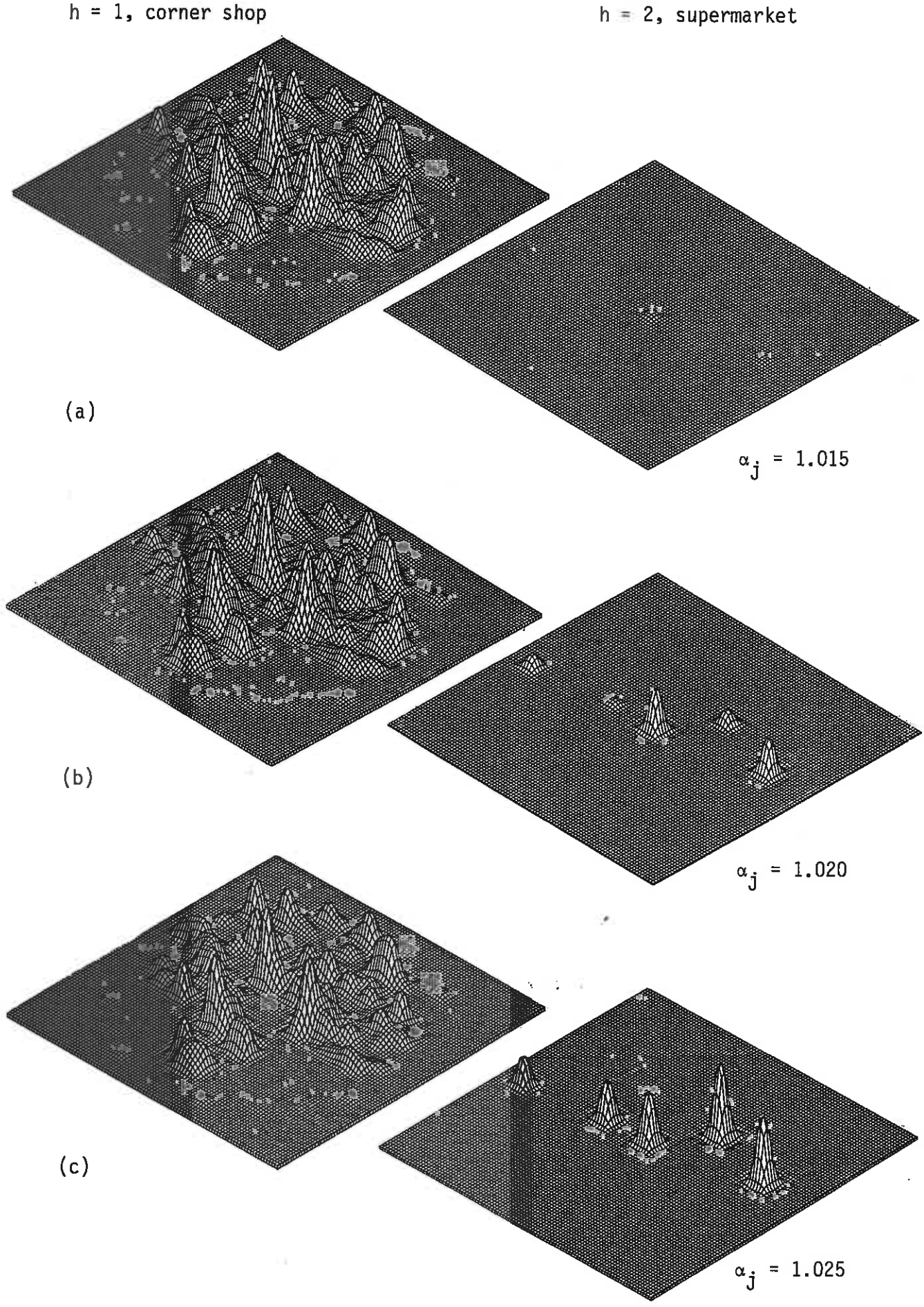
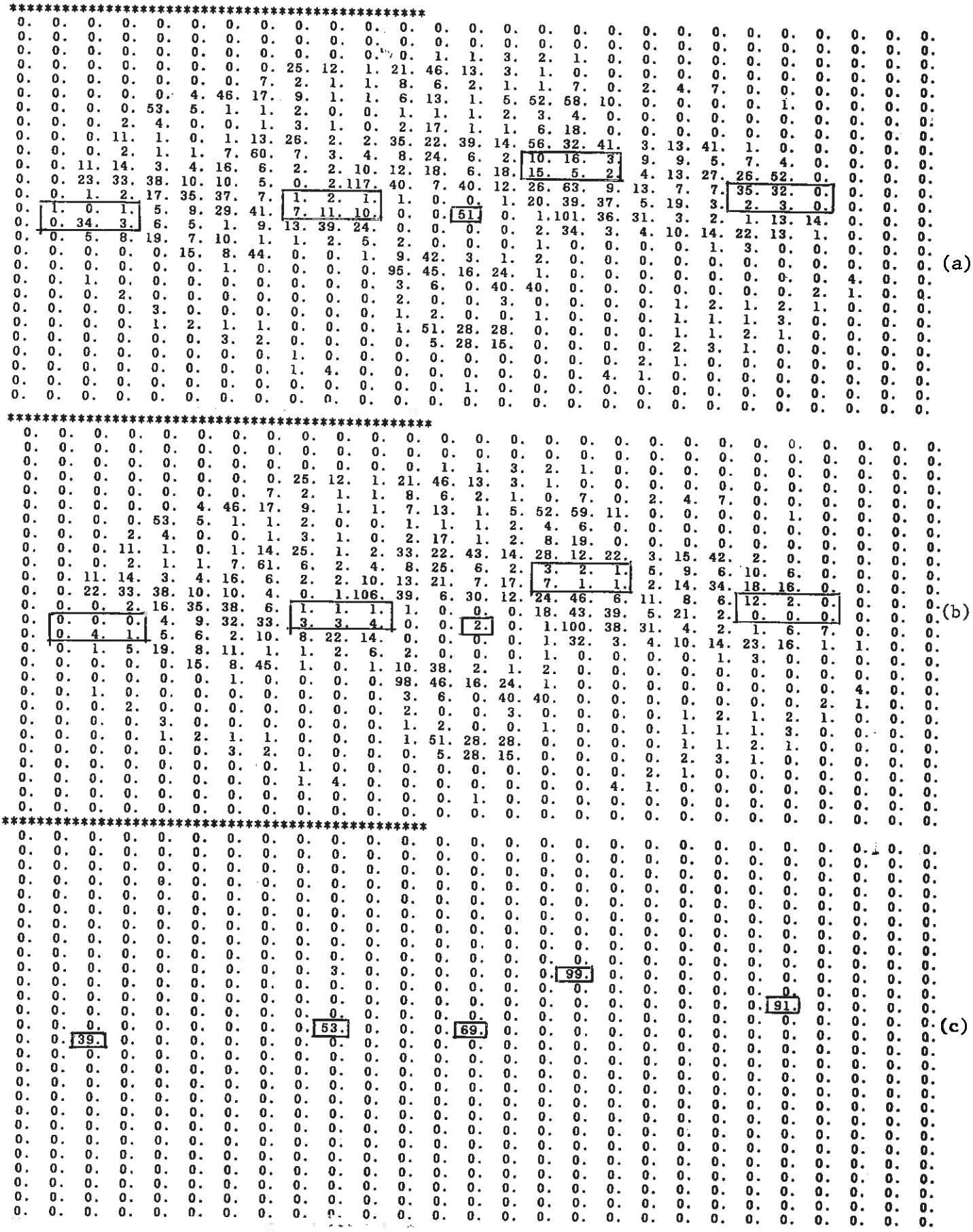


Figure 6. Incorporating α_j values

Figure 7. Effect of competition from the larger stores



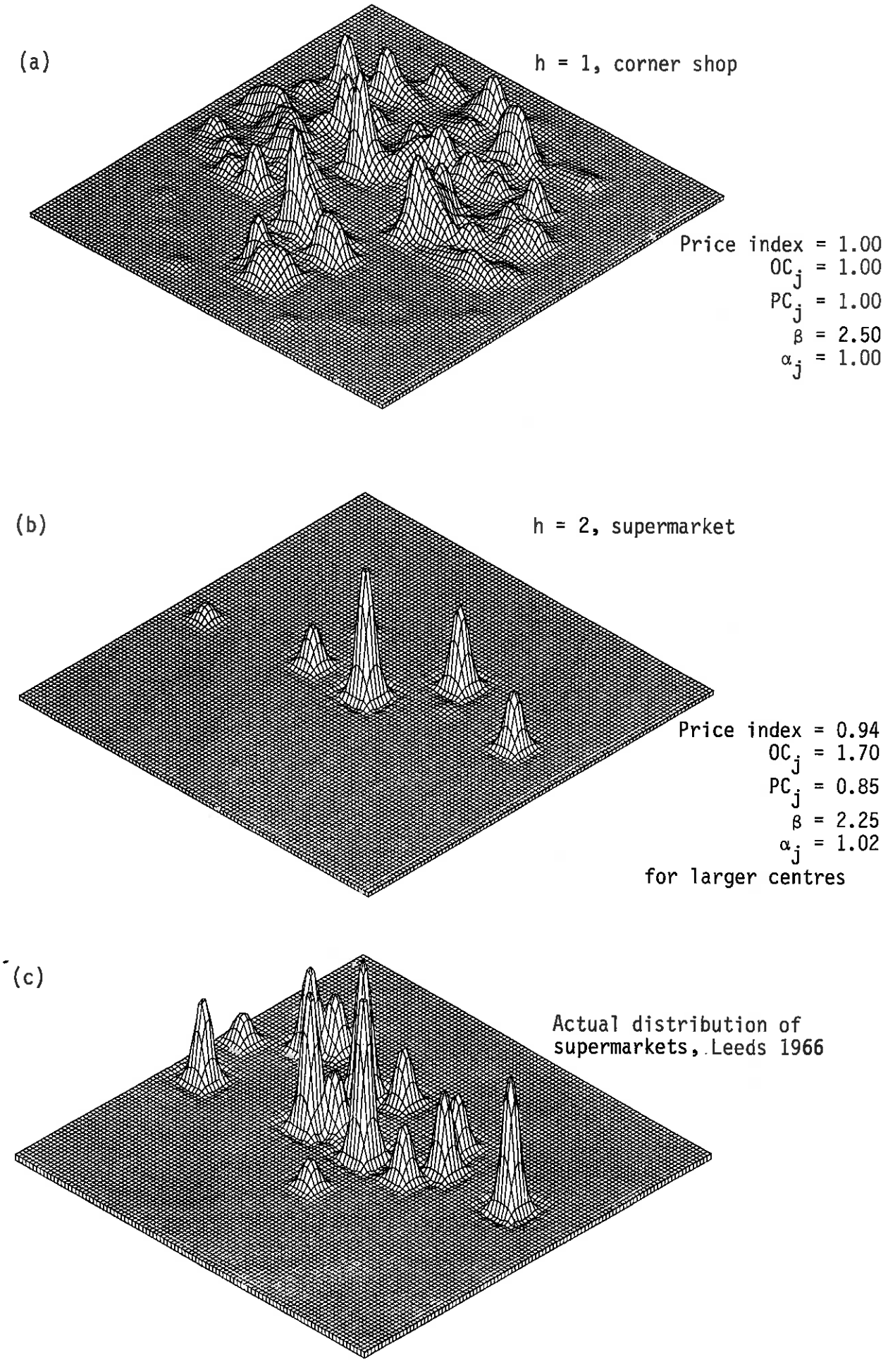
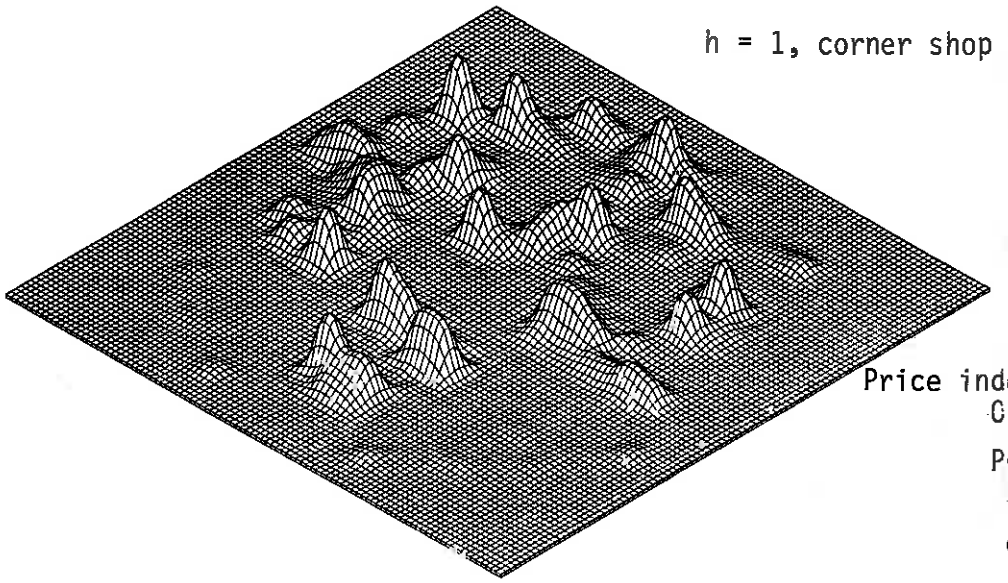
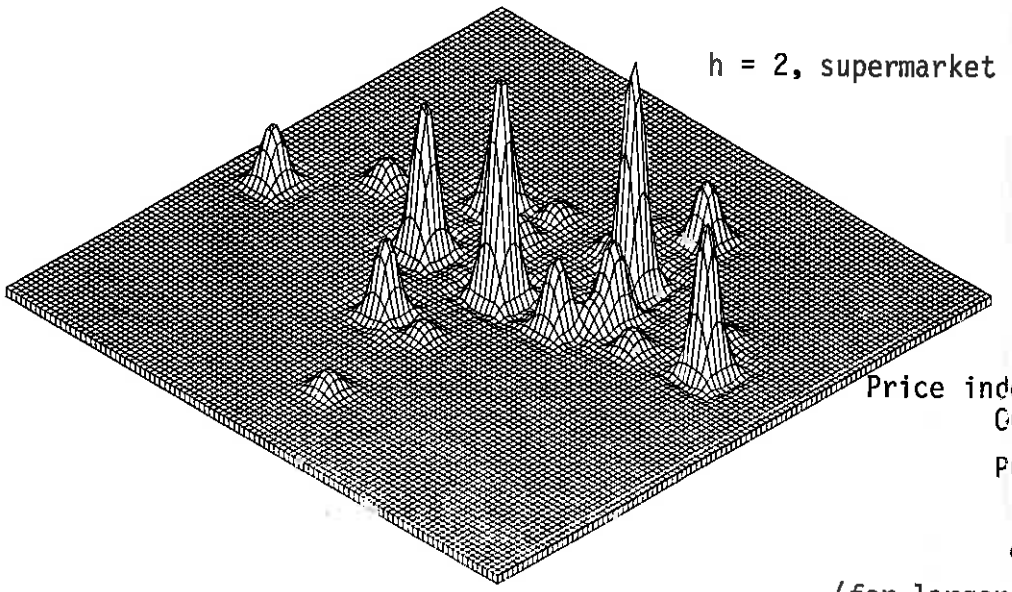


Figure 8. Combined prices and costs (i)



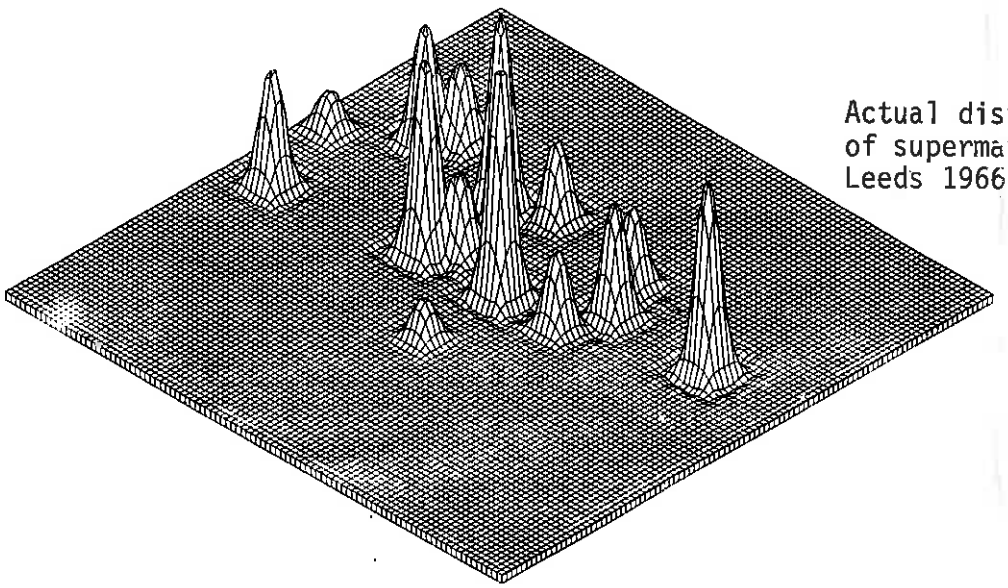
h = 1, corner shop

Price index = 1.00
CC_j = 1.00
PC_j = 1.00
β = 2.50
α_j = 1.00



h = 2, supermarket

Price index = 0.94
CC_j = 1.70
PC_j = 0.80
β = 2.25
α_j = 1.02
(for larger centres)



Actual distribution of supermarkets, Leeds 1966

Figure 9. Combined prices and costs (ii)

Parameter values

h = 1	h = 2	h = 3
Price index = 1.00	Price index = 0.90	Price index (as below)
β = 2.50	β = 2.25	β = 1.90
OC_j = 1.00	OC_j = 1.70	OC_j = 3.00
PC_j = 1.00	PC_j = 0.80	PC_j = 0.75
α_j = 1.00	α_j = 1.02	α_j = 1.02

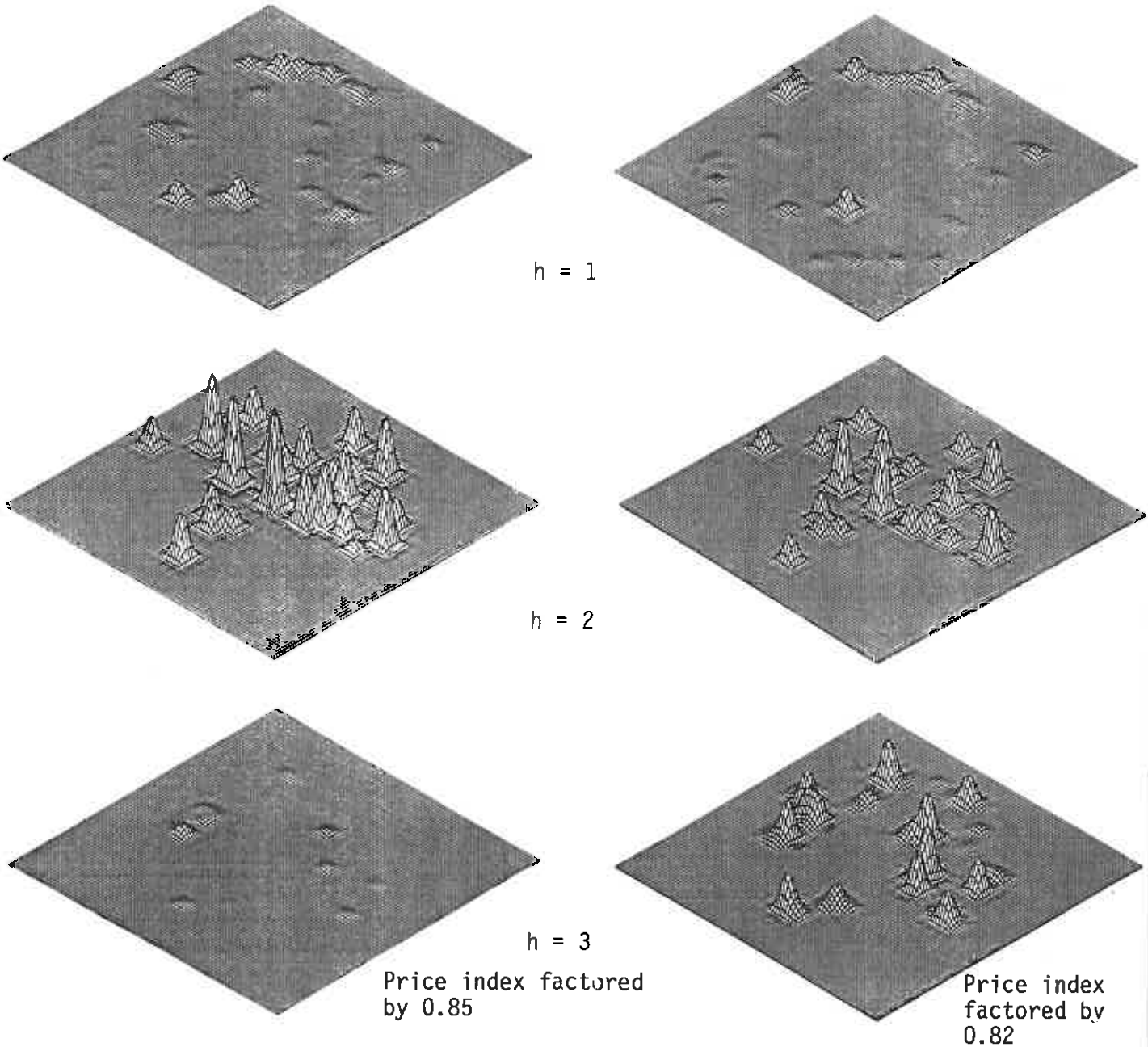


Figure 10. The effect of cheaper prices for hypermarkets

Parameter values

h = 1	h = 2	h = 3
Price index = 1.00	Price index = 0.90	Price index = 0.85
β = 2.50	β = 2.25	β = (as below)
OC_j = 1.00	OC_j = 1.70	OC_j = 3.00
PC_j = 1.00	PC_j = 0.80	PC_j = 0.75
α_j = 1.00	α_j = 1.02	α_j = 1.02

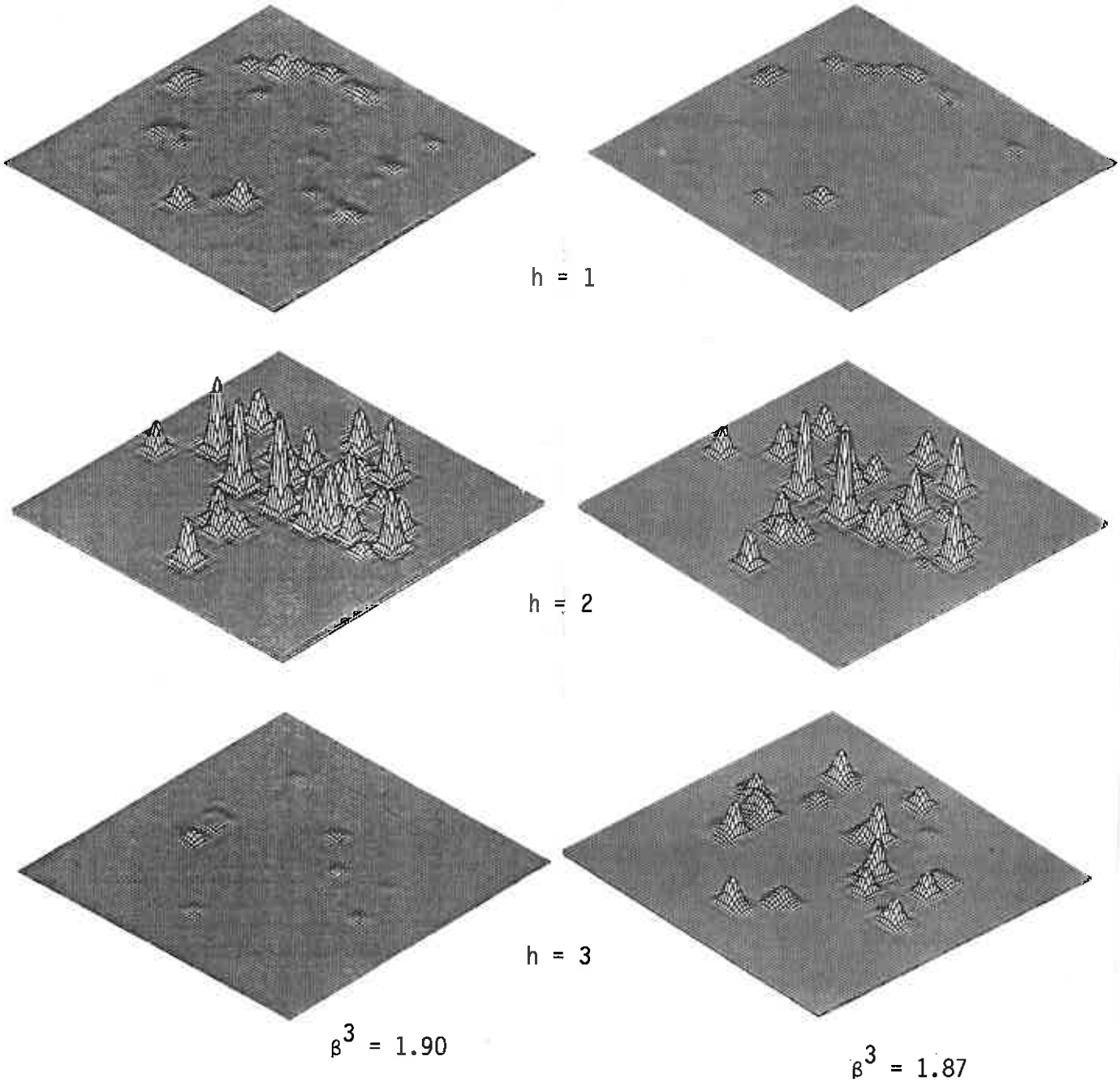


Figure 11. The effect of decreasing β for hypermarkets

Parameter values

h = 1	h = 2	h = 3
Price index = 1.00	Price index = 0.90	Price index = 0.85
β = 2.50	β = 2.25	β = 1.85
OC_j = 1.00	OC_j = 1.70	OC_j = 3.00
PC_j = 1.00	PC_j = 0.80	PC_j = 0.75
α_j = 1.00	α_j = 1.02	α_j = 1.02

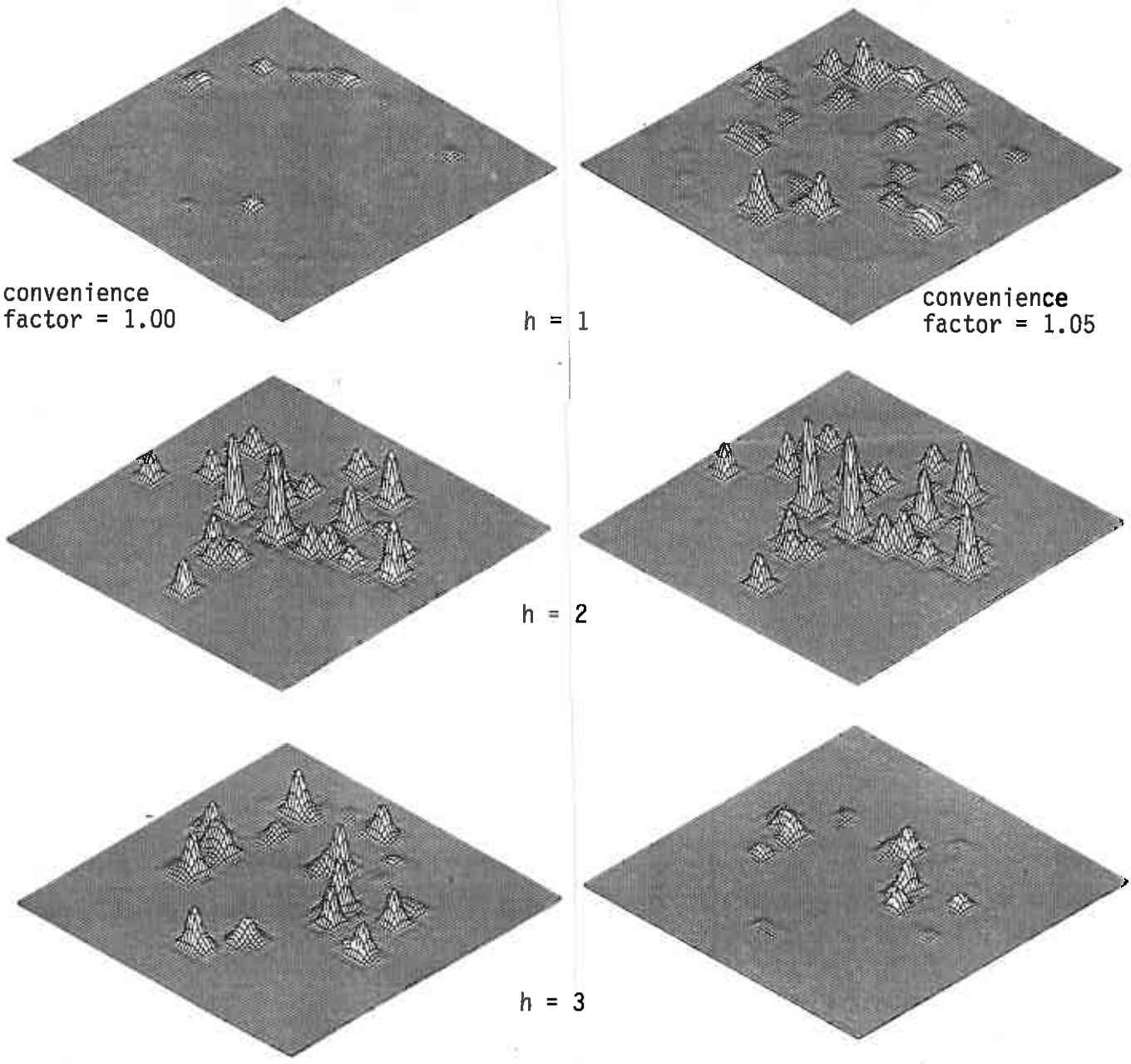
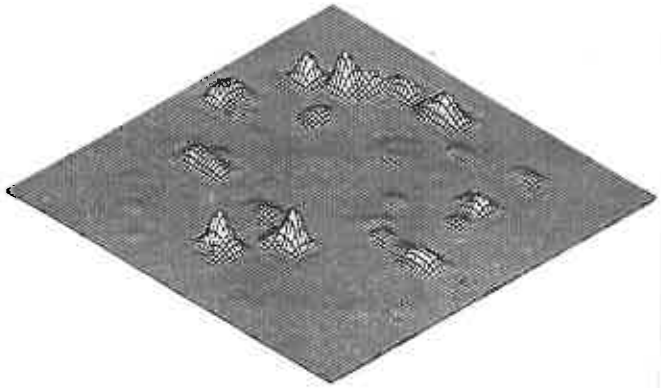


Figure 12. The effects of increasing the convenience factor for the small shop (h = 1)

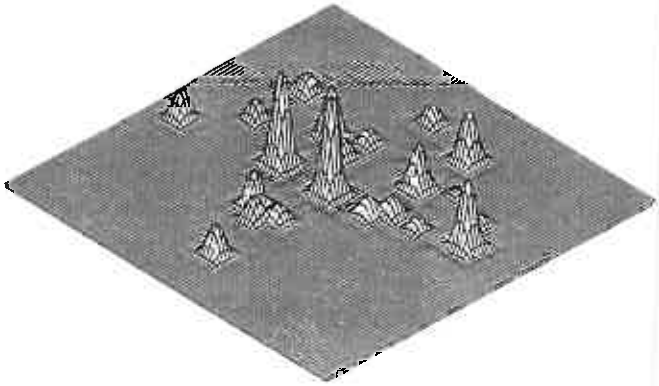
Parameter values

h = 1		h = 2		h = 3	
Price index	1.00	Price index	0.90	Price index	0.81
β	2.50	β	2.25	β	1.85
OC_j	1.00	OC_j	1.70	OC_j	3.00
PC_j	1.00	PC_j	0.80	PC_j	0.75
α_j	1.00	α_j	1.02	α_j	1.03
y_j	1.05	y_j	1.00	y_j	1.00

h = 1



h = 2



h = 3

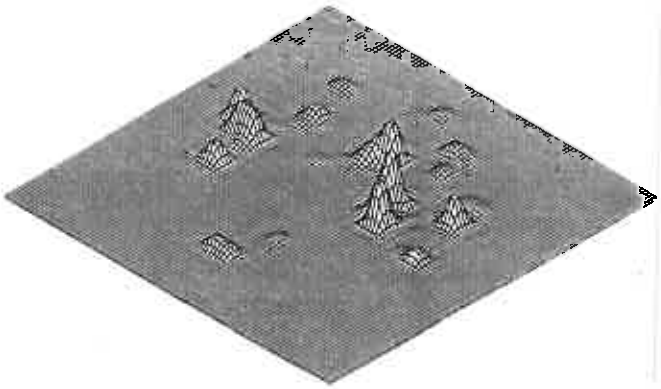
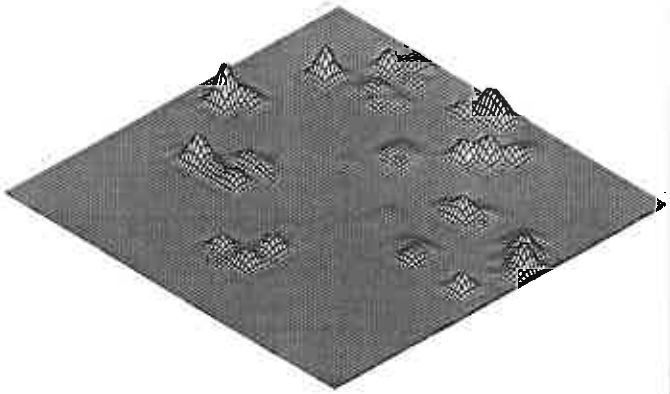


Figure 13. Balancing facilities between the three store types

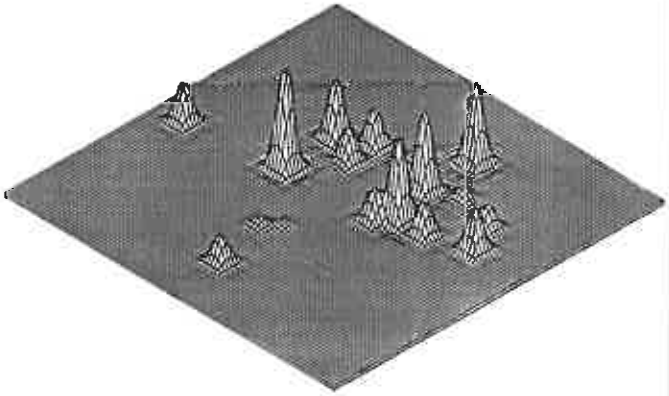
Parameter values

h = 1		h = 2		h = 3	
Price index	1.00	Price index	0.90	Price index	0.81
β	2.50	β	2.25	β	1.85
OC_j	1.00	OC_j	1.70	OC_j	3.00
PC_j	1.00	PC_j	0.80	PC_j	0.75
α_j	1.00	α_j	1.02	α_j	1.03
y_j	1.05	y_j	1.00	y_j	1.00

h = 1



h = 2



h = 3

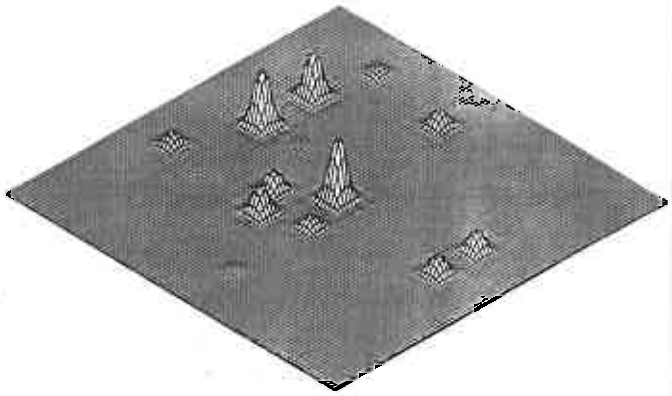


Figure 14. Refining site locations for the hypermarket case