MODELLING RETAIL SYSTEM DYNAMICS: AN APPLICATION TO THE SYSTEM OF MAJOR RETAIL CENTRES IN THE ST. JOHN'S METROPOLITAN AREA 1960-1980

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St. John's Metropolitan Area
1960-1980

by

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Abstract

A dynamic retail simulation model is applied to the St. John's metropolitan system of major retail centres for the period 1960-1980. The original model describing spatial competition among retail centres is modified in this study to incorporate a description of retailers' decision making behaviour and to account for planning constraints on retail centre growth. Time series data on size of major retail centres is calculated from municipal assessment records and used to calibrate the model. Simulation results from the calibrated model capture the pattern of retail system development in St. John's in terms of both relative centre sizes and the behaviour of individual centre trajectories. It was found that there was no need to calibrate parameters corresponding to individual centres, which strongly suggests that the model is robust and thus potentially useful as a planning tool.

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Chapter 1

Introduction

The development of major retail centres is an important concern in urban planning, and planners are faced with the difficult task of evaluating the impact of proposed planning policies and urban development projects on the existing retail system. Recently, research in non-linear dynamic modelling of spatial systems has resulted in the development of models which planners may be able to use for forecasting and managing retail system development. This thesis applies one such model to the system of major retail centres of the St. John's metropolitan area.

1.1 Introduction to Dynamic Modelling of Spatial Systems

Modelling of spatial systems in human geography began formally with the development of location and interaction theory.

> A wide range of problems were tackled: von Thunen on agricultural land use, the Chicago sociologists on residential land use, Weber on industrial location, Christaller and Losch on settlement structure, Ravenstein and others on elementary models of spatial interaction. Paelinck and Nijkamp (1975) ... usefully classified geographical location problems in terms of the nature of the activities of consumers... and producers... and in particular as to whether such activities are dispersed or concentrated. (Wilson and Bennet,1985,14)

The interest of geographers in **spatial pattern** and **spatial process** is clearly reflected in the types of problems mentioned above. Spatial patterns and processes have been widely dealt with using models which employ concepts of spatial analysis (Unwin,1981) and system analysis (Huggett,1980) within the context of spatial interaction theory (Fotheringham and O'Kelly,1989). In the context of this thesis, spatial pattern is reflected in the relative sizes of the retail centres and spatial process refers to the mechanism by which retail centres compete for market share.

Spatial interaction models which have been extensively applied in retail studies are location-allocation models of retail activity associated with the allocation of market areas amongst competing retail facilities. These models and other types of spatial interaction models (Fotheringham and O'Kelly,1989) tend to provide good descriptions of observed spatial patterns on the basis of optimizing an objective function. However, they are not useful for examining the relationship between spatial pattern and spatial process in a retail system.

Dynamic modelling provides a means of examining the relationship between spatial pattern and process. The complex interactions among the spatial variables which underlie spatial process are examined without the constraint of optimizing an objective function. Dynamic models provide more realistic and reasonable predictions of the development of spatial pattern. Dynamic modelling not only recognizes that spatial pattern results from the complex interaction of a number of spatial variables, it also recognizes that the relative influence of these spatial variables fluctuates within a constantly changing environment.

The potential of developing dynamic models for planning applications has been presented by Wilson (1984). It is the analytical power and realistic descriptions of actual systems offered by dynamic models which make them more promising than traditional static models which are purely theoretical and non-operational. Wilson made the following comments about the utility of dynamic modelling in the study of urban systems:

> First, it is important for us to understand cities and their nature as deeply as possible for the same sorts of reasons that we would pursue fundamental questions in physics, chemistry, biology, or literature. Urban modelling has a contribution to make to this understanding and it is important that this academic base should be articulated and defended. Second, some of the models developed in this way will have obvious uses: the siting of public facilities is an obvious example. These uses need to be spelled out. Third, it is important to engage with urban problems: to analyse them, to understand the social and political basis; where appropriate, even, to engage in the politics. We can explore the extent to which urban modelling can inform these analyses and debates. We can see whether the setting for new research priorities will potentially lead to the development of urban models which make a more fruitful contribution to problem solving. (Wilson, 1984, 1425)

Hagerstrand's work on "Innovation Diffusion as a Spatial Process" (1953) was the pioneering geographical research in modelling spatial dynamics. More recent examples are Wilson's (1972 with Bennett; 1974, 1984) work on dynamic urban and regional models, Dendrinos' (1985) work on urban evolution and White's (1974,1975,1977,1983 and 1984) work on simulation of retail system dynamics. Dynamic modelling of spatial systems has also been carried out by researchers in other disciplines. The ideas which underlie dynamic modelling of complex systems (i.e systems consisting of many variables and the non-linear interaction amongst them) have been developed in the work of physicist Ilya Prigogine (Nicholis, 1977) in his study of self-organizing systems. Several members of his group, notably Allen and Sanglier (1981), have applied his ideas to the modelling of urban and regional systems. They emphasize one of the basic characteristics of self-organizing systems seen in dynamic spatial models:

> It is through the action of elements not explicitly contained in the equations (fluctuations or historical 'accidents') that the choices are in fact made at various bifurcation points that occur during the evolution of any

particular system. Thus the spatial organization of a system does not result uniquely and necessarily from the 'economic and social laws' enshrined in the equations, but also represents a 'memory' of particular specific, deviations from these average behaviours, [as described by the equations]... However, for as long as the real long term consequences of a particular decision are a matter of pure conjecture, the policy remains a matter of conflicting ideals and political manoeuvre, which are not necessarily beneficial to the community. The further development of our models, while not answering...[all questions], at least would allow different strategies to be assessed in the light of the real consequences." (Allen and Sanglier,1981,168 and 183)

This concept of the self-organizing nature of complex systems was adopted by the French geographers Pumain, Saint-Julien and Sanders (1987), who have applied a model developed by Allen and Sanglier to a set of mid-sized French cities in order to understand their structural evolution. It was within this general theoretical context that White(1977) developed a dynamic retail model.

1.2 The Dynamic Retail Model

The dynamic retail model applied in this study distinguishes the exogenous from the endogenous factors of retail system development. The exogenous factors are inputs to the model and the endogenous factors are outputs of the model. More specifically the inputs are the spatial distribution of the population, retail expenditures, cost structure of individual retail centres, maximum limits on centre sizes, and retailers' response behaviour to changes in retail sales. Therefore, variations in the inputs reflect changes in the geography of the retail environment in which retail development takes place. The output of the model is the size of retail centres. Retail development is thus described in terms of the relative pattern of retail centre sizes and fluctuations in the size of individual retail centres. The model is based on a set of hypotheses describing the interaction between retailers and consumers. Basically, the model uses the theory of the firm to describe retailers' behaviour and spatial interaction theory to describe consumers' behaviour, and these two theories are linked to provide a description of retail centre dynamics.

1.3 Objectives of the Thesis

The task of this thesis is to calibrate a dynamic retail model to the system of major retail centres for the St. John's metropolitan area. In general, models which have been applied in planning practice are very detailed and comprehensive. Examples of such models are those applied by (1) Allen and Engelen (1983) to simulate the evolution of population distribution of the United States and to model the changing economic and demographic structure of the country, (2) Sanglier and Allen (1989) to simulate the demographic and economic evolution of the Belgian provinces and (3) Pumain et. al. (1984,1987) to simulate the dynamics of spatial structures in French urban agglomerations.

The major difficulties in the application of these detailed comprehensive models are that they require large amounts of data which are usually not readily available, the calibration procedures adopted involve 'fudging' of model parameters to simulate actual system behaviour (Lombardo,1986) and the results are difficult to interpret. These difficulties are major barriers to the application of such models as planning tools, because the models themselves are difficult to comprehend, the application of the models involves complicated calibration procedures and the model results do not yield information immediately useful for addressing planning questions.

The dynamic retail model applied here differs from these models in that it incorporates a general description of retail system dynamics as outlined in the previous section. The major premise of the model is that it is not necessary to develop a complicated and detailed model in order to obtain a useful model. In other words, though the model is simple, its successful application to an actual situation will demonstrate that it can provide robust, realistic, and therefore, useful results.

The primary objective of the thesis is to determine if the dynamic retail model is applicable to a real world situation. Prior to this thesis there has been no detailed application of the model. Therefore, this thesis represents original work in developing an adequate procedure for calibrating the model to simulate the development of a retail system qualitatively. In general, this involves determining adequate data requirements, developing a procedure for determining model parameters, developing a criterion for evaluating simulation results, and demonstrating the use of the model for planning applications. A detailed outline of the thesis is presented in the following section.

1.4 Outline

This thesis is the documentation and evaluation of the first detailed application of the retail model to an actual situation. There are basically seven parts to this thesis:

- delineating the study area encompassing the St. John's metropolitan area system of major retail centres;
- tracing the historical development of the retail system of the St. John's metropolitan area, in terms of changes in the sizes of the retail centres;
- describing the dynamic retail model in detail;
- calibrating a dynamic retail model to replicate the historical development of the retail system;

- evaluating the calibration results;
- evaluating short run predictions on development of the St. John's retail system; and
- evaluating the use of the dynamic retail model as a planning tool for forecasting retail system development.

These seven parts will be presented as follows. Chapter 2 discusses in detail how the limits of the St. John's metropolitan system were delineated and gives a general overview of the development of the St. John's metropolitan area. Chapter 3 presents the historical development of the St. John's Metropolitan Area. Chapter 4 is a detailed discussion of the assumptions of the model, the equations of the dynamic retail model, modifications made to the model, model output, interpretation of the model output and the scenario of the application of the model in this thesis. Chapter 5 presents both the data used to evaluate the output of the model and the input data required to calibrate the model. Chapter 6 describes the calibration procedure, and Chapter 7 provides the results of the calibration. Chapter 8 consists of an analysis and evaluation of the results, as well as an examination of the implications for use of the model as a planning tool. Finally, Chapter 9 summarizes the results and draws some general conclusions.

Chapter 2

Study Area

This chapter discusses the spatial extent of the retail system and its delineation for the purposes of this study. The focus in this thesis is on retail activity in high-order goods, also known as shopping goods. This is the retail activity that is associated with major retail centres. Thus, the study area as delineated should approximate the combined market areas of the major retail centres for high-order goods.

The following first section presents the criteria used in determining the study area and the second section discusses how a choice was made amongst the alternatives which were considered.

2.1 Criteria for Selecting Study Area

There are two criteria used to determine the study area. The first is the ability to separate the essential from the non-essential elements in delineating the retail system, so that the focus is on high-order retail competition amongst major retail centres. The second is the availability of adequate data for estimating high-order retail sales and centre sizes, necessary to calibrate the dynamic retail model.

2.1.1 Separating essential from non-essential elements

In reality, the retail system is spatially unbounded or open, but, it is necessary to treat it as if it were a closed system so that it is simplified for study at a manageable scale. In the case of St. John's, tourists and others from outside the region do make high-order goods purchases in St. John's but these purchases do not significantly affect the development of the retail system. Thus, it is not crucial to take them into consideration in this study. The shoppers who have significant influence on the development of the retail system are those who reside on the Avalon Peninsula; in particular, those in the vicinity of St. John's. Thus, frequent shoppers are distinguished from the occasional shoppers and the study area should be delineated to include the residential locations of frequent shoppers.

2.1.2 Adequacy of Data

The second criterion is the adequacy of data for calibrating the retail model. The data required for the purposes of this study is adequate if it is accurate enough to reflect the relative change in retail centres sizes and retail expenditures. Only a very limited choice of data is public and readily available. Ideally, therefore, one would like to collect original data for the purposes of the project, but this was not possible because of both time and resource constraints and the confidentiality of much of the required data. Furthermore, a more positive justification for using publicly available data is that planners tend to make decisions based on the data that is publicly available whenever possible. Therefore, it would be interesting to see if the use of such data is adequate for making planning decisions.

2.2 Selection of Study Area

Two alternatives were considered in selecting the study area:

(1) Census Division 1 (Avalon Peninsula); and

(2) St. John's Census Metropolitan Area (CMA).

An evaluation of these two alternatives in terms of the two criteria mentioned showed that using the St. John's CMA was the more appropriate choice.

2.2.1 Problems associated with selecting Division 1

In terms of the first criterion (Section 2.1.1), selecting Division 1 over the CMA would better ensure the inclusion of most of the frequent shoppers. In addition, an analysis of the Total Personal Disposable Income (TPDI) and Total Retail Sales (TRS) indicates that 60% to 70% percent of Division 1 TPDI and 60 to 90 of Division 1 TRS are associated with the CMA (Table 2.1). This might suggest that it would be more appropriate to use Division 1 as the study area instead of the CMA.

However, there are several problems associated with selecting Division 1 rather than the St. John's CMA. First, to include the area outside the CMA but within Division 1 would require that a representative census tract be created. Estimating the high-order retail sales associated with this 'tract' would involve computing the difference between Total Retail Sales for Division 1 and CMA and then using the formula for computing high-order retail sales as is done for the census tracts within the CMA. This formula is discussed in the next chapter. The problem with such an estimate is that it is based on data which is not verified by small area sampling as is carried out for CMA census tracts.

Another problem associated with any estimate for the representative tract is that the additive nature of variances (a measure of error) means that using two variables to estimate the third variable may result in an error so large as to render the result useless. This would mean that the estimate would not adequately represent high-order retail sales.

Table 2.1 Total Personal Disposable Income and Total Retail Sales for Census Division 1 (DIV.1) and St. John's Metropolitan Area (CMA)

YEAR	TOTAL PERSONAL DISPOSABLE INCOME (millions of $)			TOTAL RETAIL SALES (millions of $)		
	DIV.1	CMA	CMA/DIV.1	DIV.1	CMA	CMA/DIV.1
1960	163.6	95.6	0.58	142.9	109.0	0.76
1961		105.6			116.9	
1962	190.5	116.7	0.61	142.3	109.7	0.77
1963	151.3	119.6	0.79	202.9	117.6	0.58
1964	162.7	122.0	0.75	212.3	122.5	0.58
1965	174.9	138.3	0.79	237.6	134.7	0.57
1966				181.2	129.7	0.71
1967	271.5	170.9	0.63	191.6	157.1	0.82
1968	260.6	173.6	0.66	208.4	161.8	0.78
1969	281.4	196.0	0.70	210.9	168.9	0.80
1970	309.6	246.3	0.80	214.1	195.4	0.91
1971	415.3	308.8	0.74	243.4	221.5	0.91
1972						
1973	537.0	378.4	0.70	308.2	273.2	0.89
1974	621.0	422.8	0.68	369.6	324.0	0.88
1975	724.5	480.6	0.66	426.0	361.0	0.85
1976	908.3	632.3	0.70	507.5	462.0	0.91
1977	1000.4	700.3	0.70	523.9	434.9	0.83
1978	1116.0	785.7	0.70	591.2	492.6	0.83
1979	1203.7	850.6	0.71	665.9	556.9	0.84
1980	1261.5	898.6	0.71	721.5	605.5	0.84

Sources: Maclean Hunter, Financial Post Canadian Markets, 1981.
Maclean Hunter, Financial Post Survey of Canadian Markets, 1977 to 1980.
Maclean Hunter, Survey of Markets and Business Year Book, 1961 to 1976.

Another adjustment required if Division 1 were selected would be to take into account the effects of a competing retail centre in Division 1. This retail centre is located in the Bay Roberts, Carbonear and Harbour Grace area. A study of retail development for Newfoundland and Labrador (DeLCan,1982) indicates a Department Store Type Merchandise (DSTM) sales potential of $230 million for St. John's and

$48.1 million for Carbonear (DeLCan,1982,1-31&1-34). Assuming that the total of the sales for the two communities accounts for most of the retail sales for Census Division 1, this suggests that St. John's captures 80% of retail sales for Census Division 1. This is consistent with the difference in the proportion of CMA's to Census Division 1's TRS shown in the final column of Table 2.1. This also suggests that the reason for using Division 1 mentioned above becomes less crucial. The problems discussed so far associated with selecting Division 1 suggest that the inclusion of the additional 'tract' will not be significant in improving the quality of the study.

2.2.2 Reasons for selecting St. John's CMA

The most recent study of retail development at the provincial scale was conducted by DeLCan, and the study's delineation of the primary trade area for St. John's approximates the CMA. This delineation was determined by an analysis of the sales potential of DSTM. This suggests that it is more appropriate to use the CMA instead of Division 1 as the study area in order to accurately reflect the spatial extent of significant influence on the dynamics of the St. John's retail system. Another important reason for selecting the St. John's CMA is the availability of adequate data as described in Section 2.1.2. The relative sizes of the major retail centres in St. John's for the calibration period from 1960 through to 1980 can be estimated from property tax assessment records.

Therefore, the study area selected for calibrating the retail model is the St. John's Census Metropolitan Area(CMA) as delineated by Statistics Canada in 1981. It consists of a total of 33 census tracts. Figures 2.1 and 2.2 show the boundaries of the CMA and the individual census tracts.

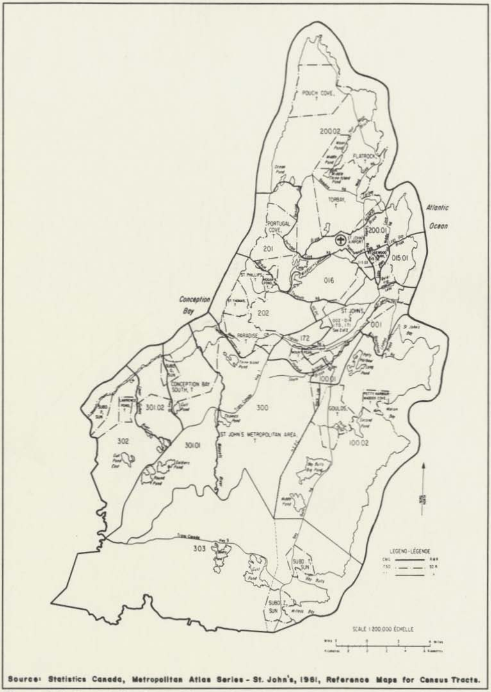
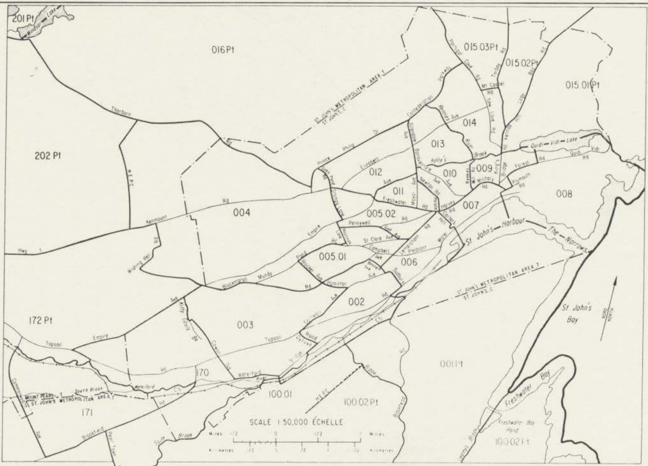


Figure 2.1 St. John's Census Metropolitan Area



Source: Statistics Canada, Metropolitan Atlas Series - St. John's, 1981, Reference Maps for Census Tracts.

Figure 2.2 City of St. John's (Inset to Figure 2.1)

Chapter 3

Historical Background

The calibration period selected is the interval from 1960 to 1980. This period was selected because significant changes in terms of the establishment of major retail centres occurred during this time. It would have been preferable to extend the period beyond 1980 to 1985, so that a period when there were no significant changes in the system could have been included, in order to obtain a better evaluation of the simulation results. However, the constraints of time and resources restricted the extension of the calibration period and since this extension is not crucial for the purposes of this study, it is left as an opportunity for an extension of this study in the future. To provide the context within which the St. John's system of major retail centres operated, a general description of the history of the St. John's metropolitan area is presented.

This chapter presents a historical description of the St. John's metropolitan area in terms of the following:

- Growth of the urban area;
- Population distribution;
- Development of the major road network; and

- Development of major retail facilities.

3.1 Areal Development

In this section the development of the St. John's metropolitan area is discussed in terms of the establishment of municipalities within the area between 1960 and 1980. Prior to 1963, the City of St. John's and the Town of Mount Pearl were the main urban areas until the incorporation of the St. John's Metropolitan Area (Metroboard) in 1963. Up to 1963, development in the St. John's metropolitan area took place largely

> as ribbon development along the well established highways leading out of St. John's; (i.e.) Topsail Road, Thorburn Road, Kenmount Road, Torbay Road, Logy Bay Road and the Southern Shore Road. There [was] also, however a definite though small development in the vicinity of Middle Cove and Logy Bay; St. Phillips and St. Thomas; at Blackhead; at Kilbride; and at the Goulds; as well as apparent nuclei around which settlements could develop at Pentaguishne and Paradise." (St. John's Metropolitan Area Board,1966,8).

In 1965, the first municipal plan for the Metropolitan Area was developed. By then the area consisted

> of all the land surrounding the City of St. John's and Mount Pearl stretching from the southern limits of the community of Torbay in the north to the northern edge of Bay Bulls Big Pond in the south, with the Atlantic Ocean providing the eastern boundary and the limits of the communities of St. Phillips and St. Thomas's the western boundaries." (St. John's Metropolitan Area Board,1966,1).

Between 1960 and 1970 the number of municipalities within the St. John's metropolitan area increased from two, the City of St. John's and the Town of Mount Pearl, to five with the addition of the Town of Holyrood and the Local Improvement Districts of Wedgewood Park and Petty Harbour-Maddox Cove (Table 3.1). In 1970 and 1971, Conception Bay South (i.e Topsail, Chamberlains, Manuels, Long Pond, Foxtrap, Kelligrews, Upper Gullies, and Seal Cove), Paradise, Lawrence Pond, and Hogan's Pond were added as local improvement districts and the towns of Pouch Cove, Torbay and the Goulds were incorporated. In 1975, the town of Flat Rock was incorporated and in 1977 the towns of Portugal Cove, St. Phillips and St. Thomas were incorporated. In 1981,all the existing local improvement districts were designated as towns (Figure 3.1).

In summary, except for St. John's itself and Mount Pearl, the incorporation of municipalities within the metropolitan area occurred during the two periods 1969-1971 and 1975-1977.

3.2 Population Distribution

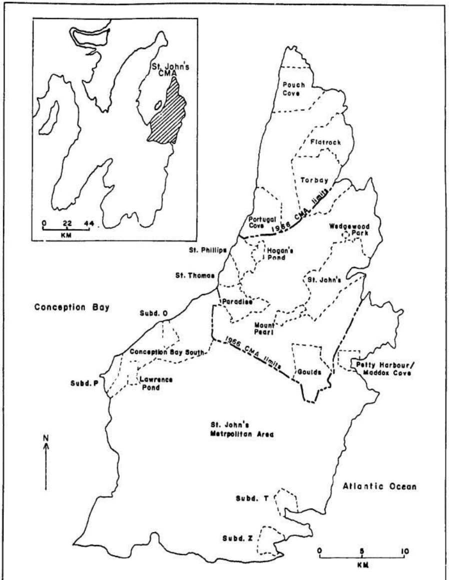
Changes in the population of the metropolitan area are difficult to trace because of boundary changes with the addition of municipalities during the intercensus period between 1961 and 1981. However, a description of the significant changes in the spatial distribution of population in the metropolitan area will be provided.

Table 3.1 Municipalities in the St. John's Metropolitan Area - 1971

Name of Municipality	Year of Incorporation
Existing in 1960	
City of St. John's	August 7, 1921
Town of Mount Pearl	January 11, 1955
Additions in the 1960's	
LID of Wedgewood Park	December 19, 1967
Town of Holyrood	March 25, 1969
LID of Petty Harbour-Maddox Cove	March 25, 1969
Additions in the 1970's	
Town of Pouch Cove	December 22, 1970
LID of Paradise	July 13, 1971
Town of Goulds	July 13, 1971
LID of Lawrence Pond	August 20, 1971
LID OF Conception Bay South	September 1971
LID of Hogan's Pond	October 12, 1971
Town of Torbay	October 24, 1971
Town of Flat Rock	October 31, 1975
Town of Portugal Cove	October 21, 1977
Town of St. Phillips	October 21, 1977
Town of St. Thomas	October 21, 1977

LID-Local Improvement District

Sources: Peterson Planning and Research Limited, St. John's Urban Region Study Interim Report No.2c Local Government Concepts, 1973, p.4.
Department of Municipal and Provincial Affairs, Province of Newfoundland and Labrador, Local Government Administrative Office, telephone enquiry.



Sources: St. John's Metropolitan Area Board, St. John's Metropolitan Municipal Plan, 1966, p. I.
Community Resources Services Ltd., Hibernia Demographic Impacts, 1985, Figure 3-2.

Figure 3.1 Municipalities in the St. John's Census Metropolitan Area, 1980

The City of St. John's remained the most populous urban area within the metropolitan area throughout the study period. But it experienced an out-migration of population, not only to its surrounding suburbs, but also to the area within the city but outside the downtown residential area. This out-migration of population from the central area was the most significant demographic change for the metropolitan area.

The city's proportion of the C.M.A. population fell from 84.7% to 54% between 1961 and 1981. Tables 3.2 and 3.3 present details of population changes for the metropolitan area. It was during this time that the downtown residential area of the City of St. John's "experienced a rate of population loss extreme by St. John's and even national standards...The Downtown was a low income area in 1971." (City Planning Office,February,1979,1) Between 1976 and 1981 the population in the downtown residential area declined by 3.3%. (Community Resource Services Limited, 1985, 3-13)

Tables 3.4 and 3.5 show the changes in population of the urbanized core, the urban and rural fringe, and individual municipalities of the Census Metropolitan Area for the two intercensus periods between 1971 and 1981. Mount Pearl and the urban portion of the St. John's metropolitan area experienced the largest growth in population. The major residential developments within the City limits were Virginia Park (1972-1975) and Cowan Heights(1973).

Table 3.2 Population, St. John's CMA, 1961-1981

		1961	1966	1971	1976	1981
CMA	(a)	91 654	101 161	---	---	---
	(b)		117 553	131 814	143 390	---
	(c)	108 206	119 294	133 622	145 400	154 820
City	(a)	74 519	79 884	---	---	---
	(b)		80 016	88 414	86 576	---
	(c)				86 653	83 770
Rest of	(a)	27 135	21 277	---	---	---
CMA	(b)		37 517	43 400	56 818	---
	(c)				58 747	71 050

(a) 1966 Boundaries (b) 1976 Boundaries (c) 1981 Boundaries
Source: Community Resources Services Ltd., Hibernia Demographic Impacts, 1985, Table 3-6.

Table 3.3 Demographic Change, St. John's CMA 1961-1981

		Population Change			
		1961-66	1966-71	1971-76	1976-81
CMA	(a)	9 507			
	(b)		14 261	11 576	
	(c)				9 420
City	(a)	5 365			
	(b)		8 398	-1 832	
	(c)				-2 883
Rest of CMA	(a)	4 142			
	(b)		5 883	13 418	
	(c)				12 303

(a) 1966 Boundaries (b) 1976 Boundaries (c) 1981 Boundaries
Source: Community Resources Services Ltd., Hibernia Demographic Impacts, 1985, Table 3-6.

Table 3.4 Demographic Characteristics of the St. John's CMA, 1971, 1976

	POPULATION 1971	1976	Total Change	% Change
TOTAL REGION	141 129	152 456	11 327	8.0
URBANIZED CORE	**100 964**	**106 679**	**5 715**	**5.7**
St. John's C	88 414	86 576	-1 838	-2.1
Mount Pearl	7 211	10 193	2 982	41.3
St. John's Area, LID	4 922	8 674	3 752	76.2
Wedgewood Park, LID	417	1 236	819	196.4
FRINGE (TOTAL URBAN AND RURAL)	**30 850**	**36 711**	**5 861**	**18.9**
Urban Fringe	**12 498**	**14 913**	**2 415**	**19.3**
Conception Bay South, T	8 041	9 524	1 483	18.4
Pouch Cove, T	1 204	1 212	8	0.6
Sub. IP, Kelligrews	1 384	1 978	594	42.9
Torbay, T	1 869	2 199	330	17.6
Rural Fringe	**18 352**	**21 798**	**3 446**	**18.7**
Conception Bay South, T	171	219	48	28.0
Flatrock, T	701	743	42	5.9
Goulds, T	2 280	3 317	1 037	45.4
Hogan's Pond, LID	191	110	-81	-42.4
Lawrence Pond, LID	-	11	-	-
Paradise, T	1 697	2 131	434	25.5
Petty Harbour-Maddox Cove	1 006	930	-76	-7.5
Pouch Cove, T	279	331	52	18.6
St. John's (Metro) Area LID	9 118	10 373	1 255	13.7
Sub. IP, Kelligrew	466	547	81	17.3
Sub. IS, St. John's East Extern	1 954	2 377	432	21.6
Torbay, T	489	709	220	44.9

Source: Fenco Ltd, St. John's Urban Development Plan, 1980, Figure 2-3.

Table 3.5 Demographic Characteristics of the St. John's CMA. 1976, 1981

	POPULATION			
	1976[1]	1981	Total Change	% Change
CENSUS METROPOLITAN AREA, St. John's	**145 500**	**154 820**	**9 320**	**6.5**
URBANIZED CORE	**106 756**	**110 022**	**3 266**	**3.1**
Mount Pearl, T[3]	10 193	11 543	1 350	13.2
St. John's. C	86 653	83 770	-2 883	-3.3
St. John's Metropolitan Area, T(P)	8 674	13 483	4 809	55.4
Wedgewood Park, T	1 236	1 226	- 10	-0.8
FRINGE	**38 644**	**44 798**	**6 154**	**15.9**
Urban Part	**19 201**	**21 672**	**2 471**	**12.9**
Conception Bay South, T (P)	9 533	10 372	839	8.8
Division No.1 Subd. Q. Sun	1 978	2 292	314	15.9
Goulds, T (P)	2 276	3 205	929	40.8
Portugal Cove, T (P)	2 003	2 322	319	15.9
Pouch Cove, T (P)	1 212	1 176	-36	-3.0
Torbay, T (P)	2 199	2 305	106	4.8
Rural Part	**19 443**	**23 126**	**3 683**	**18.9**
Conception Bay South, T (P)	210	484	274	130.5
Division No. 1 Subd. P. South	542	631	89	16.4
Division No. 1 Subd. T. South	1 115	1 081	-34	-3.0
Division No. 1 Subd. Z. South	895	907	12	1.3
Flatrock, T	743	808	65	8.7
Goulds, T (P)	1 041	1 037	-4	-0.4
Hogan's Pond, T	110	129	19	17.3
Lawrence Pond, T	11	46	35	317.2
Paradise, T	2 131	2 861	730	34.3
Petty Harbour-Maddox Cove, T	930	853	-77	-8.3
Portugal Cove, T (P)	18	39	21	116.7
Pouch Cove, T (P)	331	346	15	4.5
St. John's Metropolitan Area, T(P)	8 930	11 002	2 072	23.2
St. Phillips, T	1 227	1 365	138	11.2
St. Thomas, T	500	448	-52	-10.4
Torbay, T (P)	709	1 089	380	53.6

1. Based on 1981 area.

2. Definitions: CMA-CA Part: Census metropolitan areas (CMAs) are divided into four parts: largest city, remainder of urbanized core, urban fringe and rural fringe. The parts are always made up of complete enumeration areas, but often comprise only part of municipalities. Not all four parts will necessarily be found in each CMA. Urbanized Core: Continuous build-up area including the largest city and, where applicable, the urban part of surrounding municipalities. To be considered as continuous, the build-up area must not have a discontinuity exceeding one mile (1.609 kms). Largest City: Most populated municipality around which a census metropolitan area (CMA) is delineated. It is automatically part of the urbanized core, Usually the name is used as the name of the CMA. Remainder (of urbanized core) : Part of the urbanized core of the census metropolitan area located outside of the largest city. It is always comprised of complete enumeration areas, but not necessarily complete census tracts or complete census subdivisions (municipalities). Fringe: Part of a census metropolitan area (CMAs) outside the urbanized core. The fringe consists of urban parts and rural parts which may cut across municipalities but never across enumeration areas. In a CMA, the fringe comprises all the municipalities surrounding the core which meet the established criteria for inclusion into the fringe.

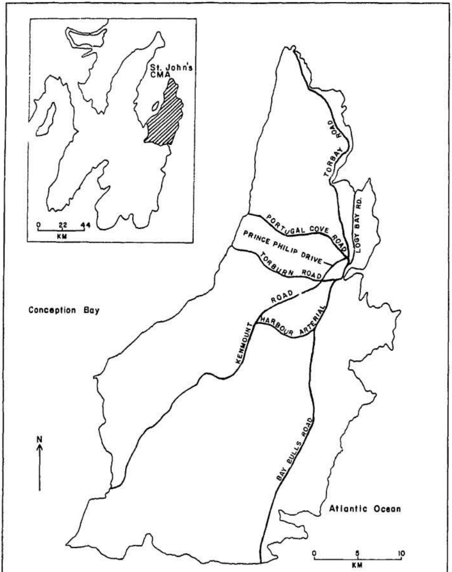
3. T = Town; C = City; (P) = part of

Source: Community Resources Services Ltd., Hibernia Demographic Impacts, 1985, Table 3-7.

In summary, the total population of the metropolitan area increased rapidly and the spatial distribution of the population changed from a concentration of population in the downtown of the City of St. John's to areas on the periphery of the city and then to newly established municipalities. Increased urbanization and rapid population growth of the metropolitan area were also accompanied by improvements in the major road network to improve linkages amongst the different municipalities and accessibility within the City of St. John's. The next section provides a general description of changes to the major road network.

3.3 Road Network

The Trans Canada Highway across Newfoundland was completed and paved in 1965 and the major changes in the road network of the metropolitan area occurred between 1975 and 1979. Figure 3.2 shows the major road network for the St. John's metropolitan area. The major roads existing within the City of St. John's in the mid-sixties were the Torbay Highway, Portugal Cove Highway, the Trans Canada-Kenmount Highway, and the Topsail Highway from the Trans Canada Highway Overpass west. The major changes between the mid-sixties and 1980 were the completion of the Prince Philip Parkway in 1975, the addition of the Harbour Arterial and the widening of Kenmount Road in 1979 (St. John's Metropolitan Board, 1966,90). The section of the crosstown Arterial from Prince Philip Drive to Topsail Road under various stages of construction



Sources: Statistics Canada, Metropolitan Atlas Series - St. John's. 1981, Reference Maps for Census Tracts.
C munity Resources Services Ltd., Hibernia Demographic Impacts; 1985, Figure 3-2.

Figure 3.2 Major Road Network of the St. John's Metropolitan Area, 1980.

in 1980 (Fenco Ltd.,1980,2-74).

In summary, there were few significant changes in the major road network between 1960 and 1980. This suggests that the relative accessibility of major retail centres within the metropolitan area did not change significantly during this period. The next section provides a description of the development of major retail centres in the St. John's metropolitan area.

3.4 Development of Major Retail Centres

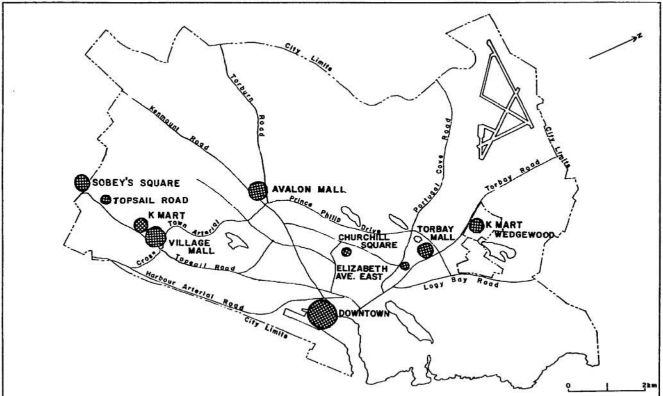
Major shopping facilities were concentrated in St. John's and Mount Pearl during the period between 1960 to 1980. (Department of Municipal Affairs and Housing, Provincial Planning Office,1977,7) High-Order retail activity in the metropolitan area had been centralized in the St. John's Downtown until the development of planned shopping centres beginning in the 1960's. The first three planned shopping centres which developed were located on Elizabeth Avenue: Churchill Square (1952), Elizabeth Avenue West (1960) and Elizabeth Avenue East (1965). It should be noted that though Elizabeth Avenue East was established in 1965, it experienced a major expansion with the opening of Canadian Tire and a drug store in 1974. Kenmount was also established prior to the development of the Avalon Mall with the opening of Canadian Tire in 1964 (Table 5.1). These planned shopping facilities were part of housing development projects of the St. John's Housing Board whose primary concern was not with shopping facilities but who made land available to developers of commercial and industrial facilities. Subsequently, the Avalon Mall (the first major shopping mall in the metropolitan area) was developed on land banked by the St. John's Housing Board. The Avalon Mall opened in 1967 and following its opening, five other major shopping facilities were developed outside the downtown district (Table 3.6). The development of all these planned shopping facilities provided strong competition for the Downtown (Figure 3.3). In 1977 the Downtown responded to the competition by attempting to revitalize retailing with the development of Atlantic Place and the Murray Premises in the hope of recapturing its position as the major retail centre. (DeLCan, 1982, E-22)

In this study, a major retail centre refers to a concentration of high-order retail units in a geographic location that was recognized as serving a major part of the metropolitan area at the time of its establishment. In the case of St. John's, planned shopping facilities in the metropolitan area have developed into major retail centres with the establishment of other retail units around the location of these shopping facilities, and the Downtown is struggling to maintain itself as a major retail centre.

Table 3.6 Opening Year of Shopping Facility by Major Retail Centres

Major Retail Centre	Shopping Centre	Date Opened
Kenmount	Avalon Mall	1967
Torbay Road	Torbay Mall	1970
K-Mart Torbay	K-Mart Plaza	1971
Elizabeth East	Elizabeth East	1974
Topsail Road	The Village Mall	1978

Source: City of St. John's Planning Office, Planning Fact Sheet #5, 1980, p.1.



Source: City of St. John's Planning Department, A Satistical Profile - City of St. John's, 1983, Map VI.

Figure 3.3 Location of Major Shopping Centres in St. John's Area, 1983

Chapter 4

The Dynamic Retail Model

Chapters 2 and 3 discussed the study area for the application of the Dynamic Retail Model in this study. In this chapter, a detailed description of the model (Appendix III, in pocket) will be presented in the following order:

- input requirements;
- model assumptions;
- mathematical representation;
- modifications to the model;
- model output; and
- interpretation of parameters in planning applications.

4.1 Input Requirements (The Scenario)

In addition to defining the boundaries of a retail system, it is necessary to describe the environment of the system. The various aspects of the environment consist of the economic condition, the nature or type of retail activity, the spatial distribution of population in the market area, the location of the major retail centres, distances between retail centres and centres of population and initial sizes of the retail centres. Thus, it is appropriate to refer to the environment of the system as the **scenario** of an application. However, in technical terms, these aspects are the input requirements of the retail model.

The first two aspects of the scenario, economic condition and type of retail activity, are represented by parameters in the equations which form the model. For the purposes of this study some modifications to the retail model have been introduced to incorporate other aspects to make the scenario more realistic. These modifications are discussed in section 4.4, and section 4.7 presents a more detailed discussion of all the model parameters which are used in this application.

The other aspects of the scenario are variable inputs into the model at the beginning of the calibration period or during each iteration (Section 4.3). These aspects differ from those mentioned in the previous paragraph in that they appear as variables in the equations of the model. They are, however, determined exogenously, that is, outside the model. They are incorporated into the model in the form of data on i) the location of major retail centres and census tract centro. ii) retail expenditures by location of the origins of shopping trips (in this case, the centroids of census tracts), and iii) the initial centre sizes. These inputs reflect the locational situation of the retail centres and the population within a study area. Chapter 5 presents the actual input data which are used to calibrate the model in this study.

Changes in any aspect of the scenario can be updated as frequently as required to reflect changes in the actual environment. In this study, retail expenditure is the only aspect which is changed during each iteration of the model during the calibration period.

4.2 Model Assumptions

The dynamic retail model consists of a set of rules which describes how major retail centres compete within an urban retail system and is used to simulate the behaviour of a system within a given scenario. The rules of the model reflect the assumptions or more precisely a hypothesis which is tested every time the model is applied.

The model is based on the dynamic central place theory developed by White (1977,227):

> The basic premise of the theory is that any central place pattern is the result of the differential growth (or decline) of the various centres making up the system. In addition, it is assumed that the growth (or decline) of each centre depends on what may be called its profitability; when the revenue attracted by a central place significantly exceeds the costs of providing the goods and services, the centre will grow, whereas if costs exceed the revenue, the centre must in the long run decline. Since the revenue received by a retail centre depends on the spatial behaviour of consumers, and the costs incurred depend on the cost structures of the firms or retail sectors involved, the theory is essentially a fusion, within a dynamic framework, of spatial interaction theory and the theory of the firm.

Basically, the dynamic retail model translates the dynamic central place theory into the context of retail system development. It incorporates factors which are endogenous (i.e. associated with the characteristics of the retail system) and exogenous factors (i.e. those primarily associated with the environment of the system). The combined effect of these factors determines the growth or decline of each retail centre. And the centre's size relative to the sizes of its competitor centres indicates the centre's overall competitiveness within the retail system.

In the model, a centre's profit is a function of its revenue and cost. Positive profits provide the opportunity for centre growth and losses tend to lead to decline in centre size. Both revenue and cost are functions of centre size; that is, the larger the centre the greater its capacity to generate revenue and the greater the cost of operations. But revenue is a function of the propensity of consumers to shop at a particular location, and thus it is also determined by accessibility (an exogenous factor). Greater relative accessibility of a centre implies greater propensity of consumers to shop at that location and thus larger potential revenue for the centre. The next section presents the retail model in the form of a set of difference equations.

4.3 Mathematical Representation

Difference equations treat time as a series of discrete points. Therefore, the development of a retail system through time is represented in terms of the relative sizes of the retail centres which are computed at specified time intervals over some period. In this study, the specified time interval is referred to as the iteration period and represents one year. The calibration period is 20 years. For each iteration, the model computes the sizes of the retail centres using a set of difference equations. Each equation represents an individual retail centre, and all the equations together represent the entire retail system. The following sub-sections present the equations which represent the retail model.

4.3.1 Change in Retail Centre Size

Change in the size of the retail centre is a function of profit:

$$ {}^{t+1}S_i = {}^{t}S_i + g(R,C)\ [{}^{t}R_i - {}^{t}C_i] $$

for all retail centres $i = 1,\ldots N$, and times $t = 0,1,\ldots,T$
where:

${}^{t}S_i > 0$ = size of centre i at time t.

$g(R,C)$ = growth function

${}^{t}R_i$ = revenue function for centre i at time t.

${}^{t}C_i$ = cost function for centre i at time t.

t and t+1 = years 1960 to 1980

4.3.2 Revenue Function

The revenue function is calculated according to the gravity equation. In other words, the proportion of revenue from each census tract or subdivision going to a given retail centre is calculated, and the total revenue at a centre is the sum of revenue from all census areas.

$$ {}^{t}R_i = \sum_{k=1}^{N} p\, {}^{t}P_k \left({}^{t}S_i / D_{ik}^{\,n} \right) / \sum_{i=1}^{N} \left({}^{t}S_i / D_{ik}^{\,n} \right) $$

where:

$k = 1...N$ = census tracts or census division

${}^{t}R_i$ = revenue of centre i at time t.

${}^{t}P_k$ = population of census tract or census division k.

p = per capita expenditures on Department Store Type Merchandise (DSTM).

D_{ik} = distance from centre i to census tract or census subdivision k.

n = the interaction parameter.

4.3.3 The Cost Function

$$^{t}c_i = b + c\ ^{t}s_i^m$$

where:

$^{t}c_i$ is the cost incurred by centre i at time t;

b = fixed cost: and

c, m = marginal cost parameters.

4.4 Modifications to the Growth Function

In section 4.1, it was mentioned that modifications to the model were made to introduce more realistic characteristics of the system environment. In reality, retail centre growth or decline does not necessarily result from the occurrence of profit or loss. Instead there are constraints on maximum centre sizes, threshold profit levels which would result in the expansion or decline of centres sizes, and also time lags between the occurrences of a profit or loss and the consequent change in centre size. The following sub-sections describe each modification.

4.4.1 Maximum Centre Size

Constraints on the maximum size of retail centres can be in the form of planning regulations, or existing and competing land uses. For example, land use zoning by-laws may constrain centre size by limiting the amount of land available for retail development at particular sites.

4.4.2 Threshold Levels of Sensitivity to Changes in Profits/Losses

Threshold levels are introduced to reflect the amount of profit or loss required to motivate a change in centre size. For example, entrepreneurs are more likely to respond to profits or losses which are perceived to be relatively stable into the future than to those which are perceived to be short lived. There may be differences in entrepreneurs' decisions to expand or reduce centre sizes as a result of inertia. Such differences can be reflected by using two different threshold levels for the addition and reduction of retail space. The threshold levels introduce inertia, but they also represent the willingness to speculate and take risks.

4.4.3 Stepped Growth Behaviour

In reality, retailers do not respond immediately to the slightest changes in profits. Increases in profits have to be large enough to be an incentive for retailers to expand, and losses have to be large enough to warrant reducing retail space. Thus, changes in retail space tend to occur in spurts rather than gradually. To introduce this kind of behaviour a stepped growth function is used. The stepped growth is a result of a combination of factors. One of these is the time required to expand retail centres; for example, building permits have to be obtained and plans drawn up for establishing new retail outlets. Another is the desire of entrepreneurs to see whether profits (or losses) will be sustained before making a decision or expansion (or down-sizing).

Thus, the growth function used by White (1977) has been modified to simulate such realistic growth behaviour by introducing i) constraints on maximum centre size, ii) threshold levels of sensitivity to profits which would affect changes in retail centre size, and (iii) stepped growth behaviour in which growth occurs in spurts rather than through continuous additions over time. The following sections continue from section 4.3 to provide the mathematical representation of the growth function after the modifications.

4.5 The Growth Function

The growth function is implemented in the retail model as conditional statements together with an equation to compute the magnitude of the change in centre size. The conditional statements and equation together contain four parameters **L**, **u**, **d** and **y**. These parameters correspond to the individual modifications which were presented in Section 4.4. The parameter **L** is the limit on the maximum size of the retail centre. The threshold parameters **u** and **d** represent the level of accumulated profits and losses over a specified time period required to trigger a response of retail centre growth or decline, respectively. The time delay in the response of retail centre growth to profits is represented by the parameter **y**, specifying the number of iterations for which profits are to accumulate in order to determine the magnitude of the change in centre size.

The change in centre size is computed based on a moving average profit over the specified time delay and accumulated total profit as follows:

$$\textbf{IF} \quad \frac{\text{Moving Average Profit}}{\text{Revenue for Current Year}} > \text{Growth Sensitivity Level}$$

$$\textbf{and} \ \text{Previous Centre Size} + \textbf{g}(\text{Accumulated Profits}) < \text{L}$$

OR

$$\textbf{IF} \quad \frac{\text{Moving Average Profit}}{\text{Revenue for Current Year}} < \text{Decline Sensitivity Level}$$

THEN

Change in Centre Size = **g** (Accumulated Profits)

ELSE

No Change in Centre Size

The following equations are the mathematical representation of the growth function:

$$\text{IF } \left[\frac{\sum_{i-y}^{i} [R_i - C_i] \,/\, y}{R_i} \right] > u$$

$$\text{and } \left[S_{i-1} + g\left(\sum_{i-y}^{i} [R_i - C_i] \right) \right] < L$$

OR

$$\text{IF } \left[\frac{\sum_{i-y}^{i} [R_i - C_i] \,/\, y}{R_i} \right] < d$$

THEN

$$g = g\left(\sum_{i-y}^{i} [R_i - C_i] \right) \qquad \text{ELSE} \qquad g = 0$$

where :

- g — is the response rate of change in centre size to profits or losses.
- y — is the time lag of the growth response to profits or losses.
- u — is the threshold sensitivity level to expand retail space.
- d — is the threshold sensitivity level to reduce retail space.
- L — is the limit on maximum retail size of a centre.

4.6 Model Output

Having presented the equations of the model in the previous sections, this section describes very briefly the output of the model. The output of the model is the size of individual centres over the calibration period at one year intervals. Thus, the behaviour of individual centres can be analyzed by observing the individual trajectories of the retail centres, and the behaviour of the entire system can be analyzed by observing changes in the relative sizes of the retail centres. Classification techniques such as ranking the size of retail centres and linear regression techniques of describing the relationship between parameter values and centre sizes can be used to gain a better understanding of the dynamics of a retail system. In this application, the results will be analyzed in terms of the individual behaviour of each retail centre trajectory and the behaviour of all the trajectories relative to each other. Most of the results will be plotted graphically for easier analysis (Chapters 7 and 8).

4.7 Interpretation of Model Parameters

The purpose of this section is to provide a summary of the results from theoretical experiments which have important implications for calibrating and interpreting the parameters of the model. The results also provide useful insights into the significance of parameter values which are associated with certain system characteristics, such as the relationship between the interaction parameter and the order of retail services provided at retail centres.

White (1977) provided results of a simulation approach used to analyze the aggregate behaviour of retail systems for various hypothetical scenarios reflecting realistic conditions within which retail systems develop. Regular, irregular, dispersed and clustered initial location patterns of centres were used to carry out simulations based on various sets of parameter values. The simulation results were evaluated using regression analysis of centre sizes against aggregate distance to the three nearest neighbours and distance to the edge of the hypothetical region within which the retail centres were located. Aggregate distance to the three nearest neighbours is a measure of the importance of the local situation of a centre, and distance to the edge is a measure of the importance of centrality in a region. The results of this simulation experiment provided useful observations relating to the sensitivity of the retail model to three of its parameters, the interaction parameter **n** and the cost parameters **c** and **m**.

In particular, this experiment demonstrated that for higher values of **n** ($n > 1.8$) both aggregate distance to the three nearest neighbouring centres and centrality within the region are the determinants of centre size, while for lower values of **n** ($n < 1.3$) centrality within the region is the main determinant of centre size. The values for the interaction parameter **n** used in the simulations ranged from 0.5 to 3.0 for the gravity equation. This range of values encompasses values which were determined from empirical studies of consumer interaction behaviour based on the gravity model of consumer behaviour (White,1977,230). The results also indicate that values outside this range affect the convergence rate and not the results themselves. These observations appear to be independent of the initial size and location of retail centres and also independent of the type of interaction equation used (i.e both the gravity and exponential form of the spatial interaction equation give equivalent results). In other words, the relationship between the parameter values and the results of the model are not sensitive to the initial sizes and configuration of the retail centres.

On the other hand the experiment demonstrated that qualitative changes in system structure which depend on changes in parameter values occur within a limited range of critical parameter values. Within this range of values the system structure cannot be reliably predicted, because the nature of the underlying process is in the process of change. Outside the critical range of parameter values the system is structurally stable, so it is possible to make short run predictions about the development of the retail system and even simulate possible changes in the system structure based on different scenarios of expected changes in the system environment or the addition and elimination of centres as perturbations to the system.

Chapter 5

Data

In Section 4.1, the input requirements of the model were presented in terms of two different categories of data; data required for evaluating simulation results and input data required to run the model. In this chapter, data will be presented for the system of major retail centres of the St. John's CMA as delineated in Chapter 2.

5.1 Data for Evaluating Simulation Results: Retail Centre Sizes 1960-1980

The data required to evaluate the simulation results of the retail model are the sizes of the retail centres between 1960 and 1980. The variable used to measure the sizes of the retail centres is the total space (in square feet) occupied by retail units specializing in high order goods. These values are determined by identifying the individual high order retail units at each centre and summing the floor space of these units to give the retail centre size.

5.1.1 High Order Type Retail Units

In general, the criteria used to determine whether a store is a high order type depends on whether it offers a service or good where distance is not an important determining factor in the choice of shopping location. Thus, a high order type store tends to service the entire me.ropolitan area as opposed to the neighbouring area immediately around its location. In this study, some types of retail stores which are not normally considered high order were included: specifically, specialty food stores, drug stores, restaurants, taverns, fast food and take-out establishments and liquor stores. Motor vehicle dealers, which are usually considered high order, were excluded. Table 5.1 lists the types of stores which are considered to be high order retail units.

Table 5.1 High Order Type Retail Units

Department Stores	Drug Stores	Jewellery Stores
Shoe and Clothing Stores	Fixtures and Houseware Stores	Furniture Stores
Appliances Stores	Specialty Stores	Liquor Outlets
Restaurants and Taverns	Fast Foods and Take-out Establishments	Hardware and Building Supply Stores

The decision was made to include specialty food stores such as Auntie Crae's in Churchill Square and Mary Jane's Downtown because they serve the entire urban population, not just the surrounding local area. Drug stores offer goods and services which overlap between high order and convenience types, and since it is difficult to assign the proportion of space between these two types, it was decided to treat them as high order stores.

Restaurants, taverns, fast foods and take-out establishments in major retail centres tend to serve the entire urban area as opposed to just the neighbouring area. So though they are usually treated as convenience goods in most retail studies they are included as a high order retail units. Liquor stores are licensed retail stores which serve the entire urban area; therefore, they are also included as high order stores.

Motor vehicle dealers are excluded because of large space requirement for displaying and storing the vehicles and because they do not necessarily share the same kind of correlation between profits and retail space as the other types of high order retail stores. Also, the organization of published retail expenditure data provides a feasible method of excluding this category.

5.1.2 Retail Centre Size

Accurate and reliable data on retail space is crucial to calibrating the retail model since it provides the basis for evaluating the results of the model. Therefore, it is very important that the data used reflect the actual high order retail space for each year during the study period There is no readily available published data on retail space that is specific to the high-order definition used in this study. Therefore, in order to determine the actual high order retail space by retail centre between 1960 and 1980, it is necessary to trace the use of all retail properties at each retail centre location using property assessment data.

Property assessment records are kept by the St. John's City assessment office for municipal tax purposes. These records contain descriptions on the use and size of all taxable properties within the jurisdiction of the City of St. John's. Since it is required by law that property owners inform the assessment office of all renovations, expansions and improvements to buildings on the properties as well as changes in their use, it provides a reliable and up-to-date data base for determining high order retail units and retail space.

High order retail units (based on Table 5.1) at the location of each retail centre were listed for each calibration year and their floor space added together to give the size of each retail centre for each year. There are some minor problems with the assessment data in terms of missing data for earlier years, but these were easily dealt with without affecting the reliability of the data in terms of its reflecting the relative sizes of the retail centres. The main problem encountered was missing data; technical drawings or a written description of space actually used for retail purposes were sometimes missing. This problem was most frequently associated with determining the sizes of retail units in the Downtown during the earlier years when it was the largest retail centre. To estimate retail space in such cases, it was assumed that the first storey of the building space on each property was used for retail purposes. The retail centre sizes computed for the earlier years reflects that the actual situation where the Downtown was the largest centre; therefore, it is adequate for the purposes of this study.

For later years large proportions of high order retail space for each centre were located in planned shopping centres. Assessment records on shopping centres give the total retail space (including high order retail units), thus, it was necessary to use detailed lists of tenants for each shopping centre to determine the high order retail units and the years for which they were in operation. A retail unit must be operating for at least six months in any year to be included in that year; this rule is also applied to retail units which were not located within shopping centres. The sizes of high order retail units and their period of operations determined using this procedure were verified to be reasonable by personnel of the shopping centre administrative offices through interviews. Appendix I lists high order retail units by retail centre, their sizes and the commencing and final years of operation. The size of each retail centre was computed by adding up the sizes of operating retail units year by year for each retail centre (Table 5.2 and Graph 5.1; all graphs are collected at the end of the chapters in which they appear.)

5.2 Input Data

The data required for running the model, as listed in Section 4.1, are as follows: the initial retail centre sizes and year of establishment; the locations of retail centres and centroids of census tracts; and high order goods expenditure by census tracts for the St. John's CMA for the years 1960 to 1980.

5.2.1 Initial Centre Sizes and Year of Establishment

The initial centre sizes were determined from city assessment records as discussed in the previous section 5.1. The year in which a retail centre was added to the system was taken to be the year in which the planned shopping centre associated with that retail centre started operations. This is true for all retail centres except for the Downtown, Churchill Square, Elizabeth West, Elizabeth East and Kenmount as discussed in Section 3.4. Table 3.6 shows data published by the St. John's planning department indicating the year of opening of the major shopping facilities.

5.2.2 Location of Retail Centres and CT Centroids and Distances between them

Each census tract was allocated a centroid for calibration purposes and the position of the centroid was determined by centring it amongst the residential areas of the tract. The location of retail centres and centroids was digitized and the euclidian distances between centroids and retail centres were then calculated in a sub-routine and used as input to the model. This may appear to be rather too simplistic a method for determining relative accessibility of retail centres from the census tracts, but the simulation results

Table 5.2 Retail Centre Sizes for 1960-1980 (Square Feet)

YEAR	CHURCH	ELIZE	ELIZW	KENMOUNT	WEDGEWOOD	TOPSAIL	TORBAY	DOWNTOWN
1960	12105	6875	1740	0	0	0	0	812969
1961	18009	6875	1740	0	0	0	0	823694
1962	18009	6875	2340	0	0	0	0	854032
1963	59553	10375	2340	0	0	0	0	841994
1964	62844	10375	2340	52164	0	0	0	857582
1965	63469	10375	2340	52164	0	0	0	821253
1966	63469	10375	2340	52164	0	0	0	862049
1967	64426	10375	2340	131278	0	0	0	886498
1968	62911	10375	3340	149233	0	0	0	913833
1969	62911	10375	3340	371699	0	0	0	910152
1970	60970	9185	3340	425916	93288	0	0	937002
1971	59079	9185	3340	412069	93288	111948	70830	915496
1972	62815	9185	2340	407259	95788	110448	71410	933033
1973	62190	30285	2340	408673	95788	111813	72610	920378
1974	56427	49807	2340	419062	95788	111813	73510	926635
1975	56427	49807	2340	419172	95788	113695	74632	906269
1976	56427	48617	2340	415451	95788	111569	79057	896606
1977	58078	48617	2340	416134	95788	118035	72805	867966
1978	58878	48617	2340	541323	95788	540192	69577	1175400
1979	59559	45117	2940	533400	95788	538367	69577	1156854
1980	59559	45117	2340	533400	95788	518481	75955	1264930

Source: Author's Computation

appear to be adequate, so no attempt was made to apply a more sophisticated method of measuring distances. The adequacy of the method may indicate that changes in the actual road network during the period 1960 to 1980 were not significant enough to change the relative accessibility of the retail centres. As already indicated in Section 3.3, the major road changes during this period were the completion of the Prince Philip Parkway in 1975, and the addition of the Harbour Arterial and the widening of Kenmount Road in 1979.

5.2.3 High Order Retail Expenditure by Census Tracts.

High order goods expenditures were estimated because no existing data sources provide information on high order goods expenditures by census tracts. The estimates were established by using total retail sales data for the entire St. John's CMA and allocating it to individual census tracts in proportion to the population of each tract. Total retail sales data are published annually in the Financial Post Survey of Markets and Business Year Book which was renamed Financial Post Survey of Markets in 1965. It would be useful to restate some notes which accompany the data published in that source. In general, retail sales estimates are based on the previous census distribution projected to the current year to take into account the different rates of growth in various provinces, cities and other areas. These estimates are adjusted to correspond to current baseline estimates as well as to Statistics Canada's census area and retail category definitions. Since a variety of sources and methods were used over the years comparison of estimates between years is not encouraged.

High order retail sales for 1967 to 1976 except 1973 were computed by taking total retail sales for the St. John's CMA less retail sales categorized under Grocery and Combination Stores and Motor Vehicle Dealers. High order goods sales for 1977 to 1980 were computed by taking total retail sales less retail sales categorized under Food Stores, Motor Vehicle Dealers and Service Stations. The reason why different categories were used to compute retail sales in the two periods is that Financial Post adopted a different set of categories for retail sales in 1977. This change in categories seems to account for the sharp difference in high order retail sales between 1976 and 1977 (Table 5.3). This difference in retail sales is also reflected in the results of the retail model and will be discussed in more detail in Chapter 8.

High order sales by categories were not published for 1960 to 1963 so high order sales could not be estimated directly (Table 5.3). Since total retail sales were published for 1960 to 1963, an estimate of high order retail sales was made based on the average ratio of high order retail sales to total retail sales for subsequent years, applied to the total of retail sales for the CMA (see footnote 1, Table 5.3 for details). High order retail sales for 1966 were estimated based on the average ratio of high order retail sales to total retail sales for 1964-71 (see footnote 2, Table 5.3 for details). No retail data at all were published for 1972 so high order retail sales were estimated as the average of the high order retail sales for 1971 and 1973. The estimated high order retail sales data were converted to 1980 dollars by a subroutine in the model (using consumer price indices published by Statistics Canada) and used as input data for this study.

Table 5.3 High Order Retail Expenditures for the St. John's CMA (1960-1980)

YEAR	TPDI (MIL)	PERPDI	TSALES (MIL)	PERSALES	HOSALES (MIL)	PERCENT
1960	95.6	1100	109.0	1260	59.90	55.00[1]
1961	105.6	1160	116.9	1290	64.29	55.00[1]
1962	116.7	1240	109.7	1170	60.33	55.00[1]
1963	119.6	1240	117.6	1220	64.68	55.00[1]
1964	122.0	1270	122.5	1280	71.00	57.96
1965	138.3	1390	134.7	1360	76.20	56.57
1966	m	m	129.7	m	69.50[2]	53.59[2]
1967	170.9	1660	157.1	1520	75.10	47.80
1968	173.6	1630	161.8	1520	90.90	56.18
1969	196.0	1780	168.9	1530	95.00	56.25
1970	246.3	1940	195.4	1540	111.70	57.16
1971	308.8	2340	221.5	1680	125.00	56.43
1972	m	m	m	m	136.50[3]	m
1973	378.4	2820	273.2	2040	148.00	54.17
1974	422.8	3180	324.0	2440	176.50	54.48
1975	480.6	3670	361.0	2760	192.80	53.41
1976	632.3	4420	462.0	3230	243.80	52.77
1977	700.3	4830	434.9	3000	201.10	46.24
1978	785.7	5360	492.6	3360	223.80	45.43
1979	850.6	5708	556.9	3737	234.80	42.16
1980	898.6	5964	605.5	4019	260.90	43.09

1 Average percentage share of high order goods sales to total retail sales for years 1964-76, except 1966 and 1972, calculated as 55.00, used to compute the estimates of high order goods sales for 1960-63.

2 1966 percentage share of high order goods sales to total retail sales estimated from 1964-71 data, used to compute estimate of high order goods sales for 1966.

3 Estimated as average of high order goods sales for 1971 and 1973.

Notes: m (Data not published), TPDI(Total Personal Disposable Income for CMA), PERPDI(Per Capita Personal Disposable Income), TSALES(Total Retail Sales for CMA), PERSALES(Per Capita Retail Sales), HOSALES(High Order Retail Sales for CMA), PERCENT(Ratio of HOSALES/TSALES)

Source: Author's Calculations and Financial Post Survey of Canadian Markets

5.2.3.1 Population

Population data by census tracts is published by Statistics Canada for census and interim census years (i.e. 1956, 1961, 1966, 1971[1], 1976, and 1981). However, data have to be adjusted to ensure comparability by census tracts because of (i) the subdivision of census tracts and (ii) the addition of new census tracts as a result of boundary changes of the census metropolitan area. The census tracts of 1981 were selected as the base for determining corresponding census tracts for other years because all previous delimitations of the metropolitan area are contained within the 1981 boundaries.

Population data for the previous census year by census tracts of the subsequent year were available beginning with 1971; therefore, there is no need to make estimates for 1976 population by 1981 tracts. However, population by 1971 tracts had to be converted to correspond to 1981 census tracts. This was done by assigning the populations of the 1971 tracts which were subdivided in 1976, weighted by the ratio of the population of the tracts in 1976, to the corresponding 1981 tracts.

Conversion tables are also published by Statistics Canada which indicate the corresponding census tracts between census years for interim census and census years since 1966. The conversion table of 1971 tracts to 1976 tracts was used to determine the 1971 tracts which were split in 1976. Since there were only additions of census tracts between census years prior to 1971, the same 1976 tracts corresponding to 1971 tracts were also used to determine the 1976 tracts corresponding to 1956, 1961 and 1966 tracts. The total population for each split tract for each census year (i.e. 1956, 1961 and 1966) was then assigned to the corresponding 1976 tracts based on the ratio of the population amongst these tracts in 1971. These population figures were in turn assigned to 1981 tracts using the same method as used for assigning population of 1971 tracts to 1981 tracts. The adjusted population data by 1981 census tracts (Table 5.4) were used as input for the retail model.

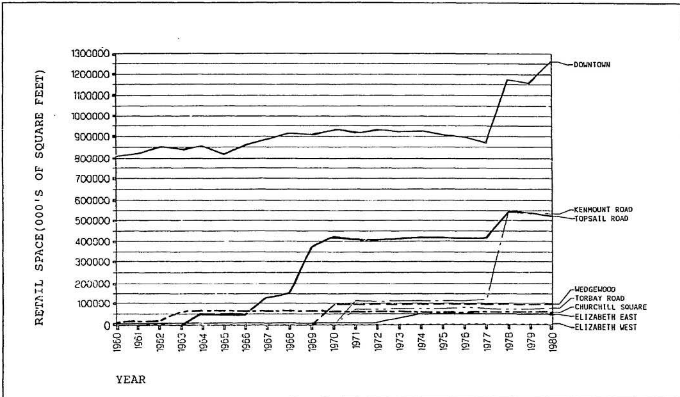
5.2.3.2 Allocating High Order Goods Expenditure to Census Tracts

For census years (i.e. 1956, 1961, 1966, 1971, 1976 and 1981) total high order retail sales for St. John's CMA were allocated to census tracts in proportion to individual census tract population. For non-census years total high order retail sales were allocated to census tracts in proportion to census tract population of the previous census year. For example, for 1960 total high order retail sales were allocated based on 1956 population data. The resulting high order retail expenditures by CTs for 1960 to 1981 are shown in Appendix II.

Table 5.4 Population by CMA and Census Tracts for Census Years

	1956	1961	1966	1971	1976	1981
CMA	74792	91609	101161	131814	145400	154820
1.00	992	1845	1941	2236	2279	2337
2.00	3443	6404	6738	7761	7294	6627
3.00	1711	2030	2813	4555	6815	8141
4.00	2119	2515	3485	5642	5004	6582
5.01	1479	4549	4455	4936	3925	3437
5.02	1970	6062	5938	6578	5595	4980
6.00	6792	10813	9132	8266	6250	4841
7.00	11465	7061	6970	6434	4867	3651
8.00	5461	3657	3443	2997	2250	2405
9.00	3252	1193	1043	914	756	695
10.00	9920	3603	3695	3326	2703	2355
11.00	1303	5615	5744	5616	4692	4008
12.00	1488	5835	5919	5603	4805	4118
13.00	0	3320	3168	3022	2775	2389
14.00	4393	4552	5406	5818	5068	4509
15.01	1045	1240	1719	2783	6088	6672
15.02	1230	1460	2023	3275	6973	8066
15.03	1450	1721	2385	3862	2828	3286
16.00	2780	3300	4573	7404	7250	7472
100.01	1016	1206	1671	2706	4028	5015
100.02	1131	1342	1860	3012	4483	5434
170.00	1525	1809	2508	4060	6151	6280
171.00	1674	1987	2754	4458	4395	4370
172.00	1393	1653	2291	3709	8260	13259
200.01	564	669	928	1502	1854	2943
200.02	2021	2399	3325	5383	6645	7452
201.00	742	881	1221	1977	2141	2365
202.00	1374	1631	2261	3660	4647	5611
300.00	1059	1257	1742	2821	3339	3915
301.01	0	0	0	3476	4344	4419
301.02	0	0	0	2281	2850	3337
302.00	0	0	0	1741	2035	2651
303.00	0	0	0	1839	2010	2197

Source: Author's calculations and Statistics Canada



Graph 5.1 Observed Retail Centre Sizes for High-Ordered Retail Goods for the St. John's Metropolitan Area (1960-1980)

Chapter 6

Calibration Procedure

This chapter starts by presenting the rationale for applying simulation as a technique for calibration, and the rest of the chapter discusses how the ranges of trial parameter values were selected and describes the calibration procedure applied to arrive at the best combination of parameter values for this application.

6.1 The Rationale for Simulation as a Calibration Technique

Much of the research in dynamic modelling has focused on developing models and testing them theoretically; however, attempts at testing the operational capability of dynamic models are still very recent (Pumain et al, 1986). A major difficulty faced by researchers in any kind of modelling is calibration, which involves determining parameter values of a model to best replicate the behaviour of an actual system. In the calibration of non-linear dynamic models the only method generally available is a systematic 'trial and error' simulation approach (Allen and Sanglier, 1981). The simulation approach is adopted here in calibrating the dynamic retail model. However, for some parameters it is possible to put empirical limits on the range of values to be considered (White, 1977). Section 6.3 discusses this in more detail. For other parameters the only test of the reasonableness of the parameter values selected is to compare the model results to observed spatial patterns and observed dynamics. In this application the focus is on spatial pattern in terms of the pattern of relative centre sizes during the calibration. This will be elaborated on in the next section.

6.2 Qualitative Features of the St. John's System of Major Retail Centres

Simulation can be either quantitatively or qualitatively accurate. Quantitatively accurate simulations are necessary when the purpose is to calibrate a model for predictions. In the case of the retail model, these may be predictions of the actual magnitude of change in centre sizes. Since our objective is to evaluate the performance of retail centres relative to each other it is sufficient to capture the qualitative features of the actual system behaviour. The qualitative features in this application can be categorized as either 'global' or 'local', which are defined as follows.

Global features represent the dynamics of the interaction among retail centres. The indicators of these features are changes in total retail space of the entire system and the pattern of sizes of the retail centres relative to each other. Local features are associated with the individual centres, and are expressed by the pattern of changes in individual centre sizes.

In this study, the objective of the calibration is to determine the set of parameter values for the retail model which best captures the behaviour of retail centre sizes between 1960 and 1980 as shown in Graph 6.1. The most prominent features of the system during this period are (1) that retail space for the entire system remained relatively stable except for 1978 when there was a significant increase in total retail space; (2) that between 1960 and 1977, the Downtown dominated as the largest centre followed by

Kenmount and a cluster of five similar sized centres, with Elizabeth West as the smallest centre; and (3) that a change in this relative pattern occurred in 1978 when the Downtown experienced a significant increase in its size and Topsail increased its size to match that of Kenmount. The rest of this chapter discusses how the appropriate range of parameter values for trial is determined for calibrating the model in this study.

6.3 Determining the Appropriate Range of Parameter Values

Selection of trial values for each parameter is constrained within a certain range of values. These constraints are determined by previous empirical studies and theoretical analysis to determine the robustness and the realism of the model results under a range of hypothetical scenarios (Section 4.7). As already mentioned in Section 4.1, the scenario of an application is incorporated into the model in the form of input data and parameter values. The input data has been presented in Chapter 5. In this section appropriate ranges for parameter values are determined.

6.3.1 <u>Interaction Parameter **n**</u>

In section 4.2.7, it was pointed out that the interaction parameter **n** reflects the order of a retail system. Since we are dealing with a high order retail system, it is expected that the value of **n** would be < 1.3. This reflects centrality as a more important factor than proximity to competing retail centres in determining centre competitiveness or size within a high ordered retail system. In exploratory simulations of the retail model, White (1977) noted that there is a gradual transition between different system structures when **n** is assigned values between 1.2 and 1.7. This indicates that within this range the system is structurally unstable and one would expect to see major changes in the trajectories of the retail centres following on minor changes in **n**. Values outside this range had little effect on system structure. Given this knowledge about the significance of **n**, to ensure that the parameter value chosen does not result in simulations reflecting instability in the system and at the same time does represent a high order retail system, values of **n** between 1.3 and 0.5 were used.

6.3.2 Fixed and Marginal Cost Parameters b, c, and m.

The fixed cost parameter **b** reflects the threshold level of cost which has to be incurred by a retail centre whether it is in operation or not. Fixed cost is set at zero and the justification for this is that in the long run it is the variable cost which determines the expansion and decline of retail centres. Furthermore, in the long run fixed costs become variable. Thus, it is assumed that fixed cost is not a significant determinant of the relative competitiveness of the retail centres. Therefore, all the simulations were carried out with parameter **b** set at 0.

The cost parameters **c** and **m** together reflect the marginal cost. Parameter **c** can be interpreted as a scaling constant. The parameter **m** indicates diseconomies or economies of scale: values of **m** greater than 1 indicate diseconomies of scale (decreasing returns to scale) and values of **m** less than 1 indicate economies of scale (increasing returns to scale).

Table 6.1 presents the operating costs per square foot for Canadian shopping Centres in 1966. A higher operating cost was incurred by regional shopping centres than by community shopping centres, thus suggesting that shopping centres within the size range covered by these two categories were operating under diseconomies of scale. Consequently, in the current calibration, it is hypothesized that the system of major retail centres for St. John's is operating near constant returns to scale but with small diseconomies of scale. Thus, the trial values of **m** selected for calibration are 1.05, 1.1 and 1.15.

Table 6.1 Operating Expenses per square foot by Centre Size

	Gross Leasable Area (ft^2)	Operating Expense ($ per ft^2)
Regional Shopping Centres	338,021	0.97
Community Shopping Centres	159,871	0.84

Source: Urban Land Institute, Dollars and Cents of Shopping Centres 1969, 1969, p.145-146.

Therefore, for every **m** there is a corresponding **c** value which is calculated by substituting the value of **m** into the cost equation while equating total cost to total revenue. Specifically, the computation of **c** is achieved by equating total cost to total revenue in the initial year (1960), with the fixed cost **b** at zero and **m** at 1.05, 1.10, or 1.15. By substituting these values into the cost equation we obtain the corresponding values of **c** as 95.6, 48.35 and 24.45. The parameter **c** in this case is also the ratio of total cost to (the mth power of) total floor space for the entire retail system in 1960.

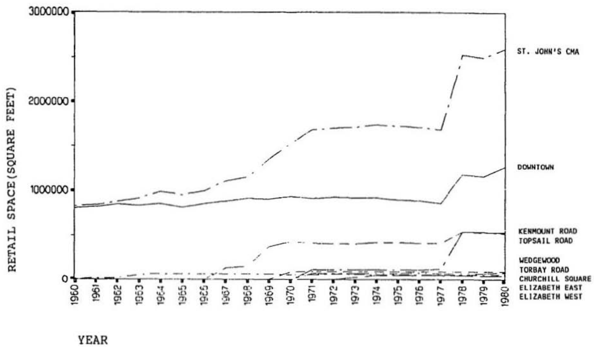
It is important to emphasize that when equating total cost to total revenue the assumption is that the retail system is in equilibrium in 1960. In this case, the relatively stable trend between retail expenditures and retail space between 1960 and 1975 suggests that in 1960 the St. John's system was near equilibrium.

6.3.3 Growth Function

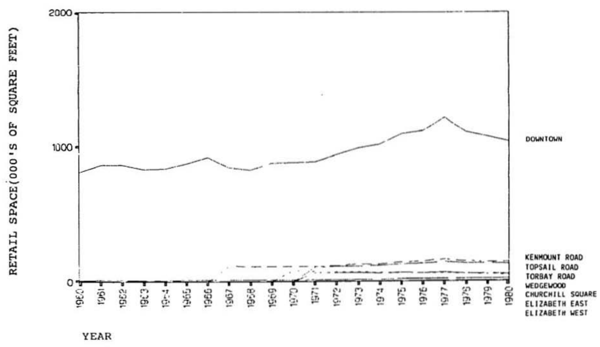
The growth parameter g is the response rate of retail space to profits generated from high order retail sales. The value of g is a scaling factor and its magnitude depends on the data used for calibrating the model. In this case, we are using floor space measured in square feet and high order retail expenditures in dollars. The initial value of g is determined by assuming that the retail system dynamics are relatively stable in that the change in retail space for individual centres is smooth (i.e. without oscillations).

The initial value was estimated by using the ratio of change in actual retail space to the change in high order goods expenditure for the entire retail system to estimate the value of g between 1960 and 1961 (Tables 5.2 and 5.3). The value of g is (850318 - 833689)/[10^6 X (64.29 - 59.9)] which is 0.00378. A set of simulations for g values ranging from 0.002 to 0.01 was carried out and it was observed that around the value of 0.005 oscillations begin to occur in the retail centre sizes for the calibration period. This suggests that for values of g close to 0.005 the retail system begins to become unstable. Graphs 6.2 to 6.5 show the transition from a stable to an unstable system. Therefore, this value was used as an upper limit on trial values of g.

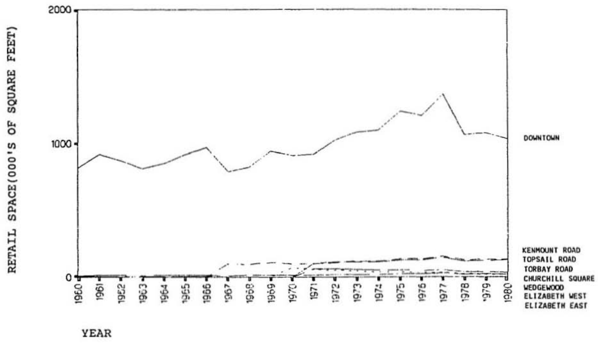
Having determined the range of parameter values for calibration, simulations using various combinations of parameter values were tried to determine the best combination of parameter values to replicate the observed system behaviour. The following chapter describes the process by which the values of the parameter values were determined to simulate the historical development of the St. John's system of major retail centres.



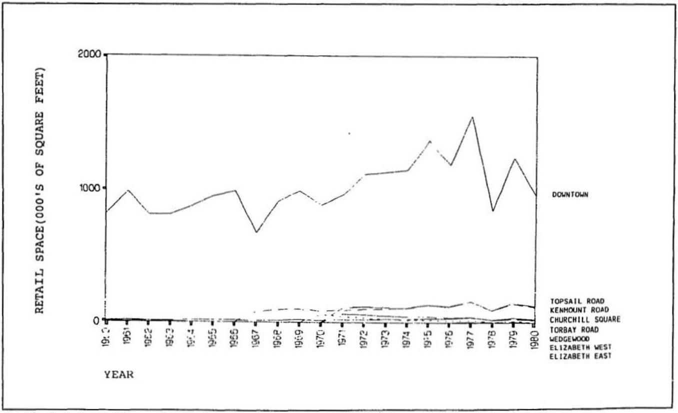
Graph 6.1 High Order Retail Space for the St. John's Metropolitan Area and its Major Retail Centres (1960–1980)



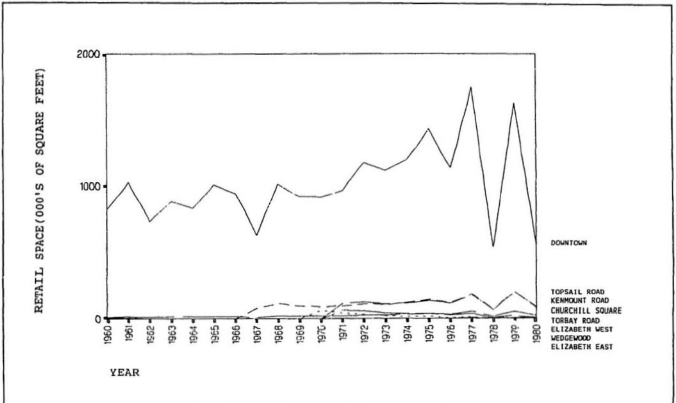
Graph 6.2 Cost Parameters: b=0, c=189.04, m=1.0; Distance Exponent: n=0.5;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



**Graph 6.3 Cost Parameters: b=0, c=189.04, m=1.0; Distance Exponent: n=0.5;
Growth Parameters: g=0.005, y=1, u=0.0, d=0.0; No limits on centre sizes.**



Graph 6.4 Cost Parameters: b=0, c=189.04, m=1.0; Distance Exponent: n=0.5;
Growth Parameters: g=0.008, y=1, u=0.0, d=0.0; No limits on centre sizes.



Graph 6.5 Cost Parameters: b=0, c=189.04, m=1.0; Distance Exponent: n=0.5;
Growth Parameters: g=0.01, y=1, u=0.0, d=0.0; No limits on centre sizes.

Chapter 7

Calibration Results

In the previous chapter it was emphasized that the simulations carried out were intended to be qualitatively accurate. In terms of St. John's this means replicating the system behaviour represented in Graph 7.1. A detailed description of the specific features which the simulations aim to capture is presented in Section 7.1. The rest of the chapter discusses how the initial set of parameters ($g = 0.0025$, $m = 1.1$, $c = 48.35$, and $n = 0.7$) was selected and adjusted; and how the growth parameters were calibrated. Each step of the calibration is based on an evaluation of previous sets of simulations and represents a hypothesis about the nature of the St. John's retail system.

7.1 Actual Patterns of Relative Centre Sizes

The actual system behaviour which is to be replicated is presented in Graph 7.1. The objectives of the calibration are to capture the pattern of the relative sizes of existing retail centres, the convergence of trajectories and the fluctuations in the trajectories of the retail centres. The specific features of the system which are the focus of the current calibration are as follows.

(1) During the calibration period there were basically three patterns to the relative sizes of the eight retail centres:

- Prior to 1969, the system consisted of one dominant centre and six small centres.
- Between 1969 and 1977, it consisted of one dominant centre, an

intermediate sized centre and six small centres.

- After 1977, the pattern was the same as the previous except that there were two intermediate sized centres and five small centres.

(2) During 1977 the trajectories of the Topsail and Kenmount retail centres converged.

(3) The individual trajectories of the retail centres display two noticeable jumps for Kenmount (occurring between 1966 and 1970 and in 1978) and one noticeable jump each for the Downtown and Topsail centres (occurring in 1978).

Qualitative Feature 1 represents a change in the structure of the entire retail system as a result of the underlying dynamic processes as hypothesized by the retail model. Feature 2 represents the relative competitiveness amongst individual retail centres. And Feature 3 represents an expansion of retail space which involves some time lag as opposed to an immediate response to profits. Thus, successful calibration of the model to capture these features will improve confidence in the underlying hypotheses of the retail model concerning retail system dynamics, at least in relation to these three aspects.

7.2 Determination of Initial Parameter Values

The approach used to determine an initial combination of parameter values was to vary **n** for all combinations of **m** and **c**, with no constraints of maximum centre sizes and with no growth thresholds. First, the values of **m** and **c** were determined by an analysis of all the simulation runs with the same values of **n** but different combinations of **m** and **c**. Second, the value of **n** was determined by an analysis of all the simulations with the selected combination of **m** and **c** values but with different **n** values.

7.2.1 Simulations Without Constraints

The first set of calibrations was carried out by varying the values of the cost parameters and the interaction parameter systematically. To exclude the effect of size constraints resulting from planning regulation in determining **n**, no limits were imposed on individual centre sizes and no growth thresholds were used. The scenario reflected in these simulations is representative of a situation where there is little planning control over the development of retail centres.

Values of **m** equal to 1.05, 1.10 and 1.15 were used, and for each, the corresponding value of **c** was used as a scaling factor to convert dollars to floor space as a measure of centre size. For each value of **m** the values of **n** = 0.5 to 1.3 in increments of 0.1 were used to generate a total of 24 calibrations. The results of these simulations were primarily used to determine the influence of distance on the relative size of retail centres. It was observed that the simulation results for the three pairs of **m** and **c** values with the same **n** values only resulted in a larger magnitude of change with similar relative sizes for the centres between 1960 and 1980 (Graphs 7.2 to 7.4). Thus, the values of **m** =1.1 and **c** =48.35, which represent the middle of the range of the three scenarios, were selected for calibrating the retail model.

7.2.2 Simulation Runs to Determine n

A comparison of the results of **m** =1.1 and **c** =48.35 for varying values of **n** was used to determine the value of the interaction parameter **n**. It is important to note that the value of **n** reflects the type of retail system and has a direct effect on determining the number of retail centres which would survive in a system as well as which specific centres would survive. It is important to recall from Section 6.3.1 that in general high order retail systems are associated with values at the lower end of the range of the values of **n** between 0.5 and 1.3. Thus, a lower value of **n** near 0.5 is expected to be a more suitable value for this application since distance is not as important a determinant of the accessibility of a high order retail centre as compared with a low order centre.

Simulations for **n** = 0.5 to 1.3 at 0.05 increments with **m** = 1.1 and **c** = 48.35 indicate a convergence of the trajectories of the medium sized centres when **n** = 1.0 (Graphs 7.3, 7.5 and 7.6). This is similar to the observed behaviour of the Kenmount and Topsail retail centres in 1978 (Graph 7.1). That the convergence occurs only at a value as high as **n** = 1.0 is somewhat surprising if the centres are truly high order. Therefore, a somewhat lower value, **n** =0.7, is selected as the initial value.

Having determined the initial set of parameter values for **n**, **m** and **c**, additional simulations were carried out to fine tune these parameter values and to determine the values of additional parameters which are associated with maximum size and growth threshold constraints on changes in retail centre sizes. Thus, simulations under conditions which included the effects of a maximum centre size constraint and a growth threshold were carried out. The results of these simulations are presented in the following sections.

7.3 Evaluating the Interaction Parameter n

In the previous section, the initial value of **n** = 0.7 was selected based on simulations under the scenario of no constraints on centre growth. Simulations within this scenario help determine the role of **n** without the effects of external constraints on system behaviour. The results of these simulations show that Feature 1 is captured for the entire range of **n** values between 0.5 and 1.3 at 0.05 intervals for all three combinations of **m** and **c**. An example of this effect is presented in Graphs 7.4 to 7.6.

As for Feature 2, larger **n** values result in a more rapid convergence of the Topsail and Kenmount Road trajectories and a decline in the Downtown trajectory. This can be observed by comparing Graphs 7.3, 7.5 and 7.6. It was also observed that for the three different combinations of **c** and **m** (i.e. 95.6 and 1.05, 48.35 and 1.1, and 24.45 and 1.15, respectively), which represent increasingly important diseconomies of scale, simulations of Feature 2 do not significantly differ, though for **n** = 1.3, the values **c** = 95.5 and **m** = 1.05 give the best result. This can be observed by comparing Graphs 7.6, 7.7 and 7.8.

As for Feature 3, none of the simulations captures the 1978 jump in the Downtown trajectory. Instead the results indicate the opposite, that is, a decline in the trajectory. The next step in the calibration was to improve the simulation of Feature 3.

7.4 Improving the Simulation of Individual Centre Trajectories (Feature 3)

In an attempt to capture the jump in the Downtown trajectory, a second set of runs, introducing constraints on maximum centre size, was undertaken. The same combinations of **g**, **c**, **m** and **n** as in the previous set of runs were used (i.e the different combinations of **c** and **m** with **n** were as in Section 7.2.1). The results are similar to those of the first set; however, it was observed that while a larger value of **n** captures the convergence of the Topsail and Kenmount trajectories, the trajectory of the Downtown becomes more downward sloping (Graphs 7.4 and 7.8). None of the simulations of this second set of runs captures either the general upward trend or the jumps in the trajectory of the Downtown.

Having observed this, it was hypothesized that the increase in the downtown trajectory is perhaps due to some external effect, possibly related to the growth constraints (Section 4.4). Consequently, a third set of simulations, incorporating growth thresholds, was run to determine whether this version of the model could capture the increase in the trajectory of the downtown (Feature 3) while maintaining the competition between Topsail and Kenmount (Feature 2).

7.5 Determining the Initial Value of the Expansion Threshold Parameter u

Prior to introducing the expansion threshold parameter **u** to simulate Feature 3, the initial value of **u** has to be determined. The modifications to the model which were presented in Section 4.4 were made primarily to introduce two kinds of external constraints on retail system behaviour. External constraints on the maximum size of retail centres and a delay in growth response of retail centres were introduced to reflect, respectively, planning regulations and the decision making behaviour of retailers.

The parameter values associated with these modifications are **L**, **u**, **d** and **y**. As described in Section 4.5, the parameter **L** is the maximum limit on the size of the retail centre, and **u** and **d** are the threshold parameters (representing the level of accumulated profits and losses over a specified time period) required to trigger a response of retail centre growth or decline. Parameter **y** represents the time delay in the response of retail centre growth to profits and it is specified in terms of the number of iterations for which profits are to accumulate for determining the magnitude of the change in centre size.

Three sets of runs were carried out using parameter values of **g** = 0.0025, **c** = 95.6, **m** = 1.05 and **n** = 0.7, which were carried over from the previous set of simulation runs. Limits on the maximum size of retail centres **L** were set at the actual maximum size of each centre observed during the calibration period (Table 5.1).

The first set of runs comprise simulations with **y** values of 1, 2 and 3, with the threshold for retail centre decline set at a very large negative value of **d** = -10. This value of **d** was selected to eliminate the effect of the threshold for retail centre decline so that the threshold for retail centre expansion, **u**, could be tested independently. The values of **d** and **u** were determined by looking at the range of the ratio of accumulated profits to revenue (r-ratio) of the previous set of simulation runs (Section 7.2.1). The value of **d** = -10 is less than the least of the r-ratios generated for each iteration in all the previous simulations. The initial value of **u** was set at 0.1, which is approximately the average positive r-ratio of the previous simulation runs. This is to ensure that the effect of the expansion threshold is activated in the simulations. The simulations were carried out by setting **y** = 1, 2 and 3 and at the same time varying **u** from 0.1 in increments of 0.1 until the downtown trajectory indicated no changes (i.e. a straight line). A straight line trajectory indicates that the expansion threshold value was high enough to prevent all change.

From the results it was observed that a critical **u** value, where the downtown trajectory no longer displays fluctuations, is reached more slowly with larger values of **y**. Specifically for **y** = 1 ,2 and 3 the respective critical values of **u** are 0.4, 0.5 and 0.6 (Graphs 7.9, 7.10 and 7.11).

7.6 The Expansion Threshold and Individual Centre Trajectories

Based on the simulations used to determine the initial value for **u**, it was observed that as the trajectory of the Downtown loses its fluctuations the two intermediate centres become larger relative to the smaller centres, and at the same time the steps in their trajectories become more pronounced (Graphs 7.12 to 7.14 and 7.9). The lowest value of **u** (u = 0.1) results in the most number of jumps in the Downtown trajectory, occurring in 1961, 1966, 1975, and 1977 (Graph 7.12). These jumps disappear one by one as the value of **u** increases, until the critical value of **u** is reached at which the trajectory becomes a straight line (Graphs 7.12 to 7.14 and 7.9). In addition, these simulations capture the positive slope of the Downtown trajectory.

A final set of simulations varying **u** between the small values of 0.01 and 0.05 was run with **y** set at 1 to ensure that a straight line trajectory was reached most rapidly; the other parameter values were **n** = 1.3, **g** = 0.0025, **b** = 0, **c** = 95.6, **m** = 1.05, and **d** = -10. These results show jumps in the trajectory of the Downtown occurring much earlier during the calibration period and at the same time capture the convergence of the intermediate sized retail centres (Graphs 7.18, 7.20 to 7.22).

Generally, the simulation results with the growth constraints are better than the simulations results without **u**, since the positive slope of the Downtown trajectory is captured along with the convergence of the Topsail and Kenmount trajectories, and the relative sizes of the centres are more realistic.

7.7 Re-Evaluation of Parameter n with Growth Constraints

Before proceeding with the calibration a re-evaluation of parameter **n** is necessary for simulations with growth constraints. In section 7.3, simulations without growth constraints showed that **n** = 1.3 gave the best results. In this section, the parameter **n** is re-evaluated to determine if **n** = 1.3 still gives the best results with growth constraints. Two sets of simulations were carried out to re-evaluate the value of **n**.

A set of simulations was run using combinations of **n** = 0.7, 1.0 and 1.3 with the **y** values of 1 and 3 (Graphs 7.14 to 7.19) and **g** = 0.0025, **c** = 95.6, **m** = 1.05 and **u** = 0.3. The results indicate that the combination of **n** = 1.3 with **y** = 1 or 3 gives the best results and the combination of **n** =0.7 with **y** = 1 or 3, the poorest. For the combination of **n** = 1.3 with **y** = 1 or 3, the simulations do not capture the jumps in the Downtown trajectory but do capture the positive slope of the trajectory and the convergence of the Topsail and Kenmount trajectories.

Another set of simulations, with **n** varying between 0.7 and 1.3 and with limits on maximum centre sizes and **u** = 0, was also carried out (Graphs 7.22 to 7.26). The results capture the positive slope of the Downtown trajectory and the convergence of the Topsail and Kenmount trajectories. As in the previous set of runs, the simulation with **n** = 1.3 gives the best results.

Thus, the simulations verify that **n** = 1.3 gives the best results and so that value is retained. The next step in the calibration is to test the effect of the threshold for centre decline associated with parameter **d**.

7.8 Determining the Initial Value of Decline Threshold Parameter d

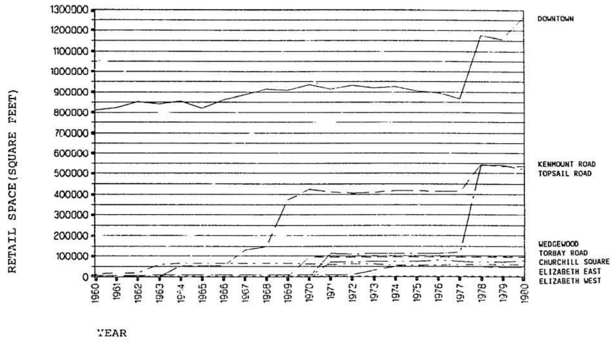
A set of simulations was carried out by setting parameter values at **n** = 1.3, **b** = 0, **c** = 95.6, **m** = 1.05, and **u** = 0 for the values of **d** between -0.2 and -0.5 (at 0.05 intervals) to determine the most appropriate value of **d**. These combinations were carried out for values of **g** between 0.0025 and 0.005 at increments of 0.0005 to verify the best value for **g**.

It was observed that **d** = -0.45 is a critical value, with the trajectories showing significantly more fluctuations for d ≤ -0.45 (Graphs 7.27 and 7.28). This critical value of **d** only applied where **g** < 0.005 because the system becomes unstable at **g** = 0.005. This verifies that the critical value for an unstable system (determined in Section 6.3.3) of **g** = 0.005 is robust (Graph 7.29).

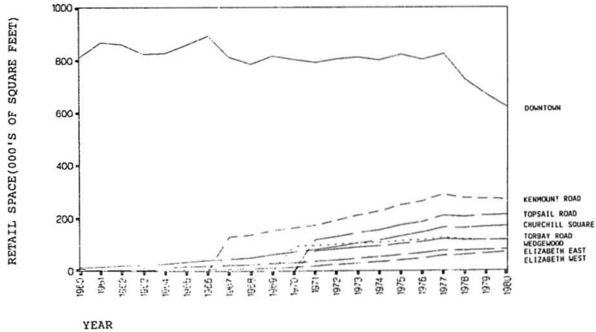
Comparing the results of **d** = -0.45 for the various values of **g** ≤ 0.004, the trajectories of the individual retail centres seem to be displaced downward, but the relative patterns of the trajectories are similar. The results where **g** = 0.0035 (Graph 7.30) best simulate the actual behaviour of the system, capturing a jump up in the Downtown trajectory in 1961 and a period of relative stability until 1977, when a jump down occurred. In reality, however, a jump up was experienced by the Downtown in 1978. The convergence of the Topsail and Kenmount trajectories was also captured.

Two more runs were carried out for **g** = 0.0035, one with no external constraints and another with just the constraints on maximum centre sizes (Graph 7.31 and 7.32). The results of these two runs are similar to those of the simulation with growth constraints, except that the individual trajectories of the larger centres are displaced upward in the latter case. The simulation with just maximum centre size constraints captures a Downtown trajectory with a slightly positive slope and with fluctuations which resemble the actual behaviour, except that again it shows a jump down instead of a jump up towards the end of the calibration period. These results suggest that setting values of **u** and **d** to 0 with maximum size constraints, and allowing the system to adjust purely by intrinsic system dynamics, provides better results.

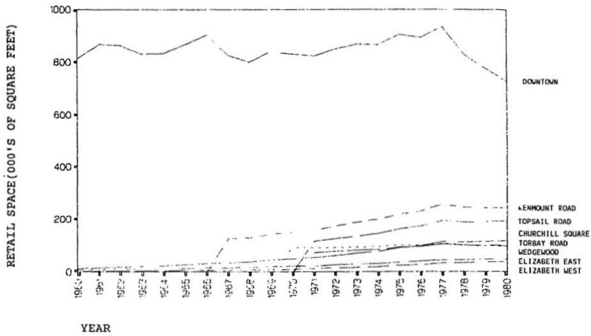
In conclusion, it was determined that the best combination of parameter values is **g** = 0.0035, **b** = 0, **c** = 95.6, **m** = 1.05, **n** = 1.3, **d** = 0 and **u** = 0, since results using these values best represent the qualitative features of the St. John's retail system.



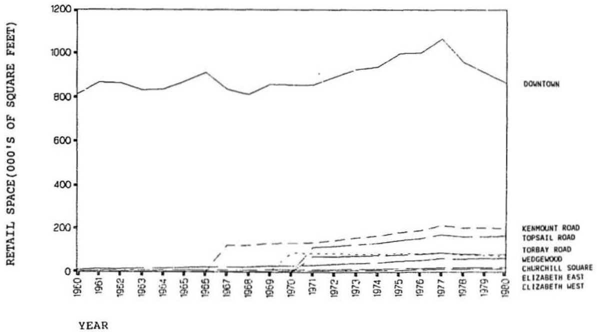
Graph 7.1 High Order Retail Space by Major Retail Centres for the St. John's Metropolitan Area (1960-1980)



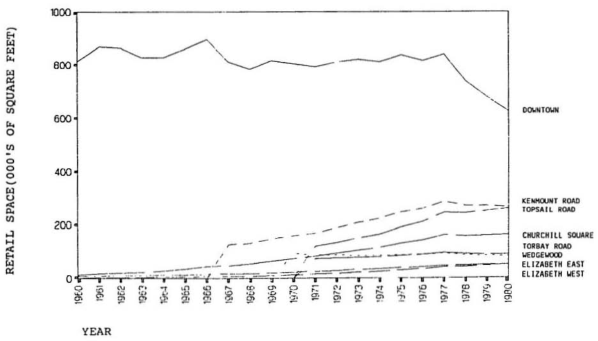
Graph 7.2 Cost Parameters: b=0, c=24.45, m=1.15; Distance Exponent: n=0.5; Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



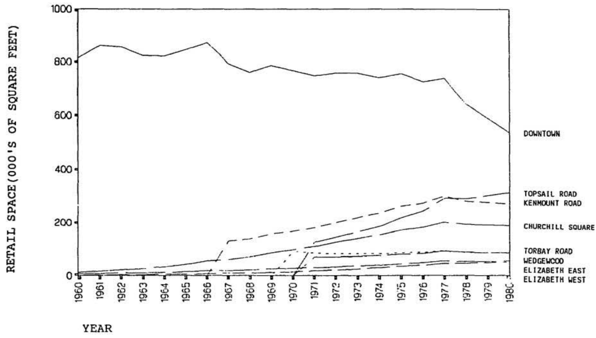
Graph 7.3 Cost Parameters: b=0, c=48.35, m=1.1; Distance Exponent: n=0.5;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



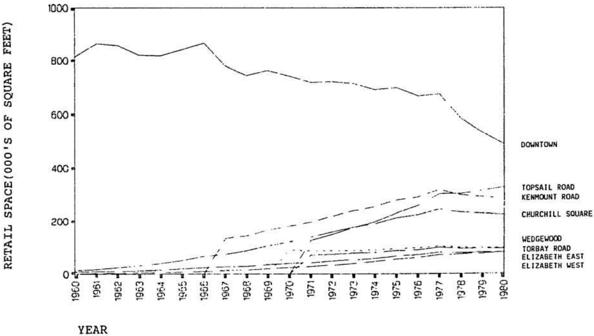
Graph 7.4 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.5;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



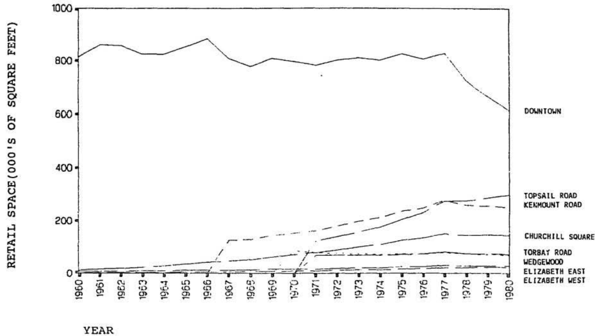
Graph 7.5 Cost Parameters: b=0, c=48.35, m=1.1; Distance Exponent: n=1.0;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



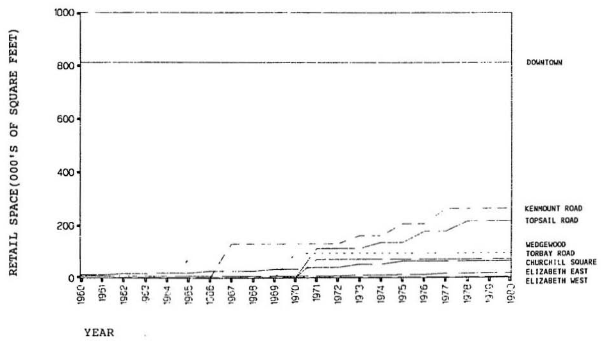
Graph 7.6 Cost Parameters: b=0, c=48.35, m=1.1; Distance Exponent: n=1.3;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



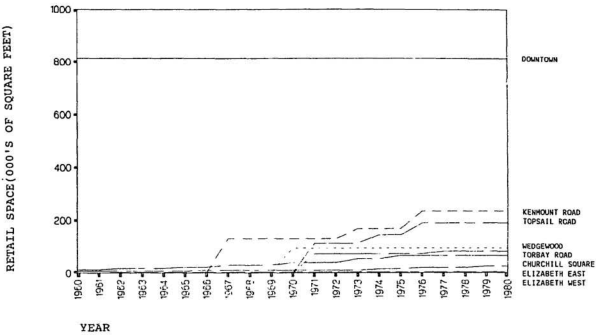
Graph 7.7 Cost Parameters: b=0, c=24.45, m=1.15; Distance Exponent: n=1.3;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



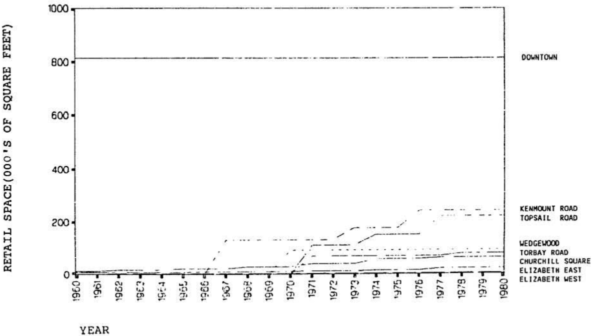
Graph 7.8 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0025, y=1, u=0.0, d=0.0; No limits on centre sizes.



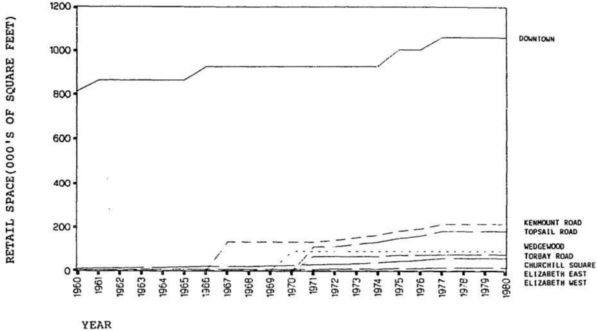
**Graph 7.9 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;
Growth Parameters: g=0.0025, y=1, u=0.4, d=-10.0; Limits on centre sizes.**



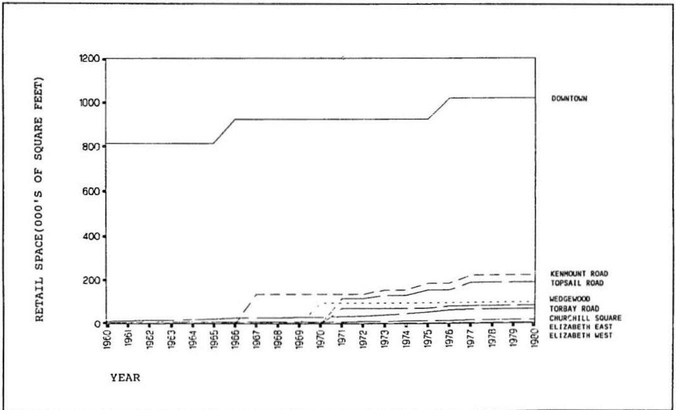
Graph 7.10 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;
Growth Parameters: g=0.0025, y=2, u=0.5, d=-10.0; Limits on centre sizes.



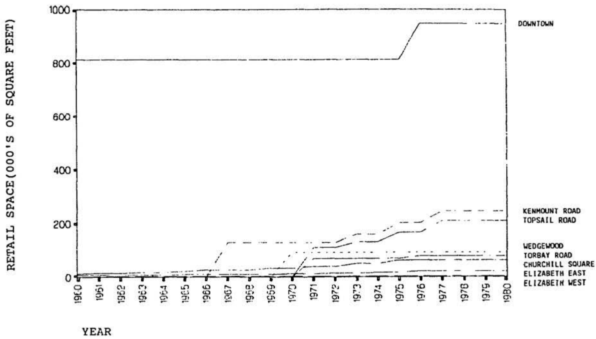
Graph 7.11 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;
Growth Parameters: g=0.0025, y=3, u=0.6, d=-10.0; Limits on centre sizes.



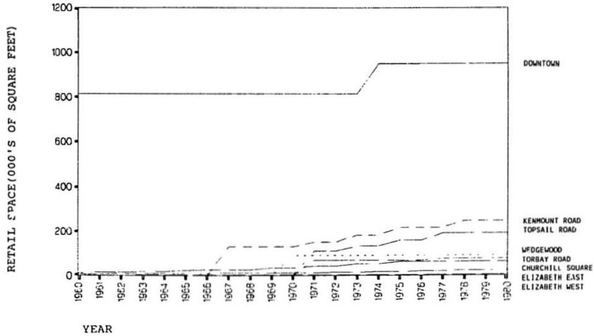
Graph 7.12 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;
Growth Parameters: g=0.0025, y=1, u=0.1, d=-10.0; Limits on centre sizes.



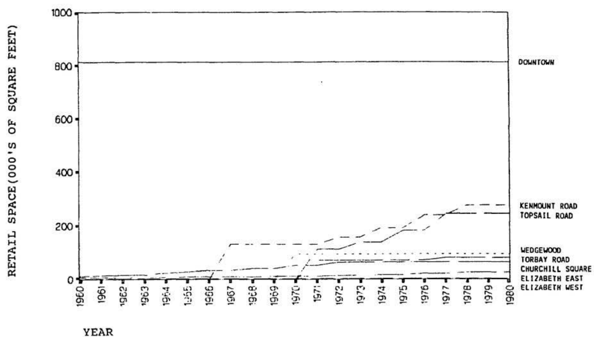
Graph 7.13 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7; Growth Parameters: g=0.0025, y=1, u=0.2, d=-10.0; Limits on centre sizes.



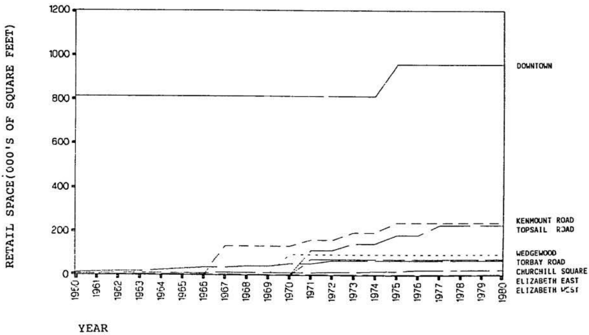
Graph 7.14 **Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;**
Growth Parameters: g=0.0025, y=1, u=0.3, d=-10.0; Limits on centre sizes.



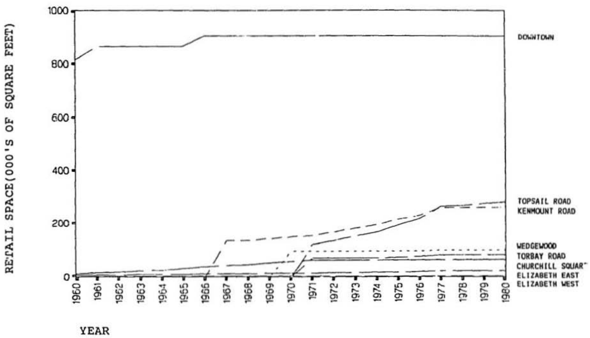
Graph 7.15 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;
Growth Parameters: g=0.0025, y=3, u=0.3, d=-10.0; Limits on centre sizes.



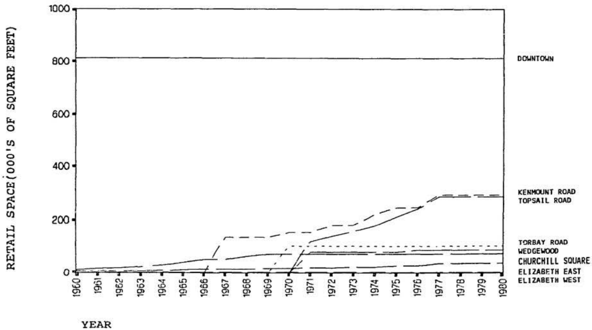
Graph 7.16 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.0;
Growth Parameters: g=0.0025, y=1, u=0.3, d=-10.0; Limits on centre sizes.



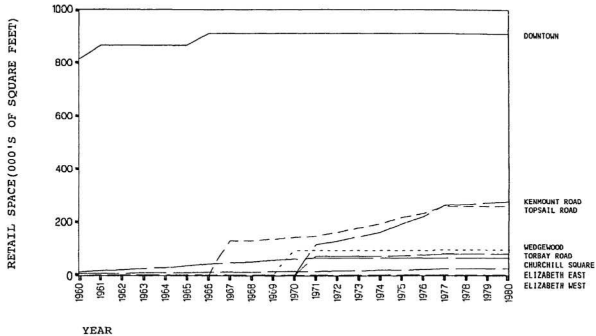
Graph 7.17 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.0;
Growth Parameters: g=0.0025, y=3, u=0.3, d=-10.0; Limits on centre sizes.



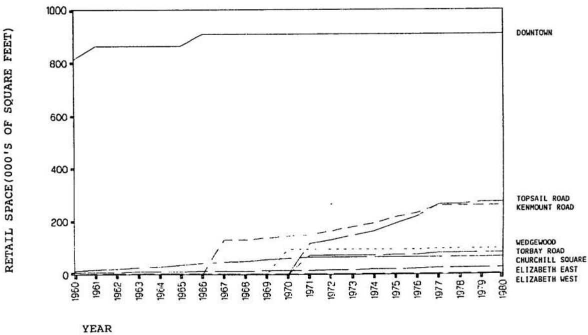
Graph 7.18 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0025, y=1, u=0.01, d=-10.0; Limits on centre sizes.



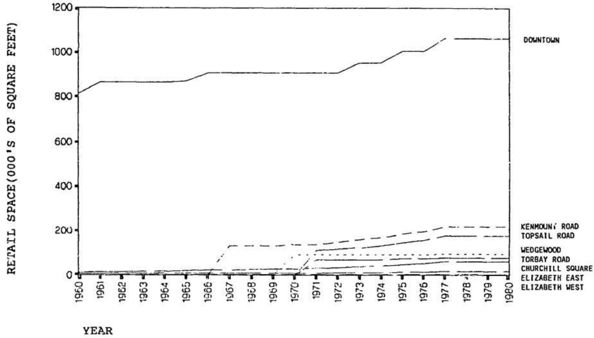
Graph 7.19 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0025, y=3, u=0.2, d=-10.0; Limits on centre sizes.



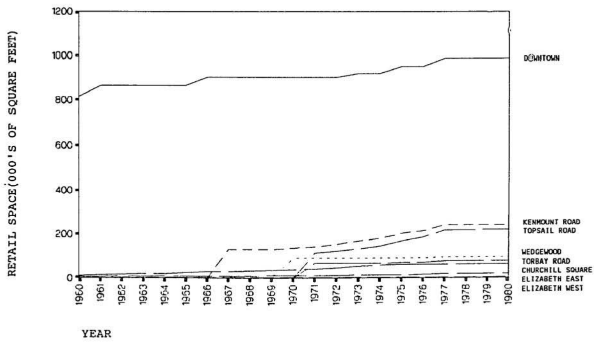
Graph 7.20 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3; Growth Parameters: g=0.0025, y=1, u=0.02, d=-10.0; Limits on centre sizes.



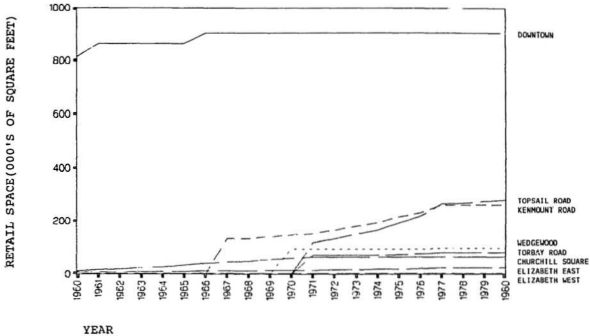
Graph 7.21 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0025, [illegible], u=0.05, d=-10.0; Limits on centre sizes.



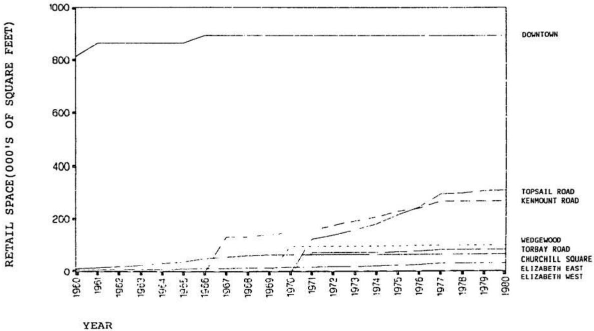
Graph 7.22 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=0.7;
Growth Parameters: g=0.0025, y=1, u=0.0, d=-10.0; Limits on centre sizes.



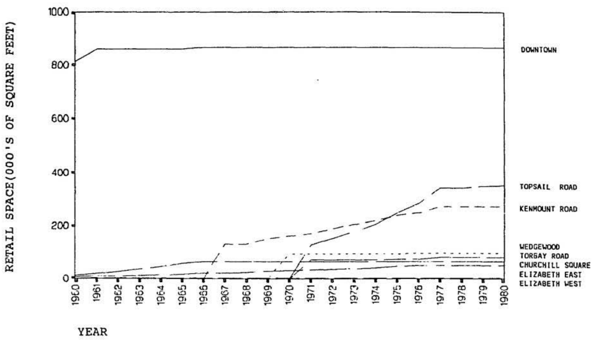
Graph 7.23 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: η=1.0;
Growth Parameters: g=0.0025, y=1, u=0.0, d=-10.0; Limits on centre sizes.



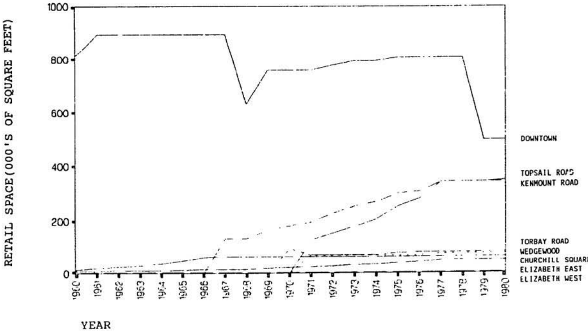
Graph 7.24 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3; Growth Parameters: g=0.0025, y=1, u=0.0, d=-10.0; Limits on centre sizes.



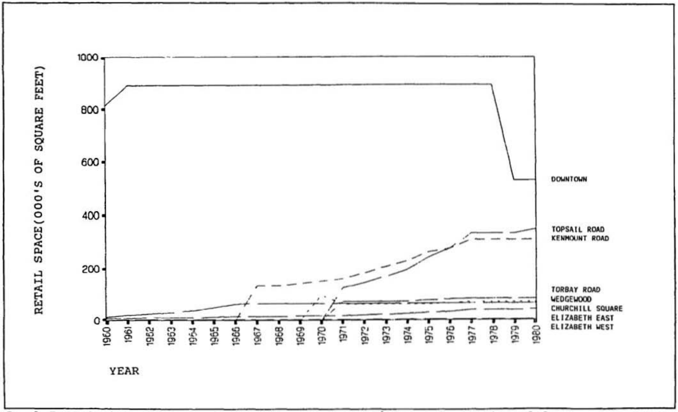
Graph 7.25 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.5; Growth Parameters: g=0.0025, y=1, u=0.0, d=-10.0; Limits on centre sizes.



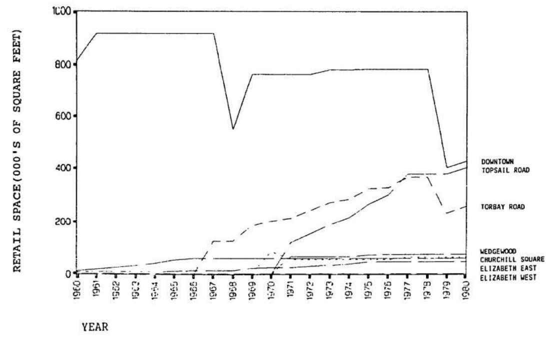
Graph 7.26 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1,8;
Growth Parameters: g=0.0025, y=1, u=0.0, d=-10.0; Limits on centre sizes.



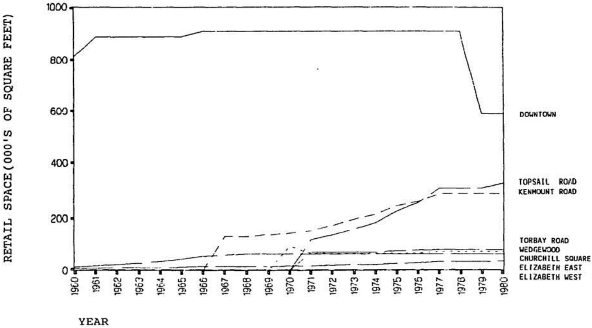
Graph 7.27 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.004, y=1, u=0.0, d=-0.45; Limits on centre sizes.



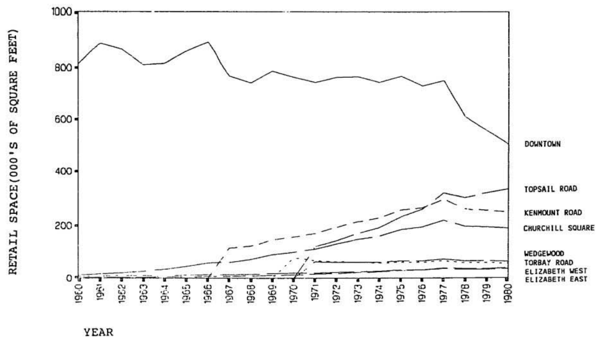
Graph 7.28 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.004, y=1, u=0.0, d=-0.5; Limits on centre sizes.



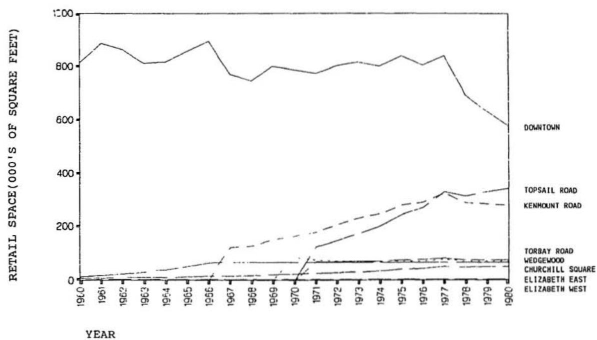
Graph 7.29 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.005, y=1, u=0.0, d=-0.45; Limits on centre sizes.



Graph 7.30 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3; Growth Parameters: g=0.0035, y=1, u=0.0, d=-0.5; Limits on centre sizes.



Graph 7.31 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3; Growth Parameters: g=0.0035, y=1, u=0.0, d=0.0; No limits on centre sizes.



Graph 7.32 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0035, y=1, u=0.0, d=0.0; Limits on centre sizes.

Chapter 8

Discussion of Results

In general, the calibration of the retail model to simulate the qualitative features described in Section 7.1 was satisfactory. In terms of the pattern of relative centre sizes (Feature 1), the three different groups of centre sizes were captured without much effort in adjusting the parameter values. In fact, the pattern was quite robust in that it was present in most of the combinations of parameter values which were tried during the calibration process. This indicates that the retail model is useful in simulating and thus possibly predicting changes in the structure of a retail system.

As for the relative sizes of centres within groups (Feature 2), these were captured well. In particular, the relationship between the size of Topsail and Kenmount was captured by the combination of parameter values which resulted from the calibration.

Finally, for the occurrence and timing of significant changes in centre sizes (Feature 3), which represent the finest level of detail examined in this thesis, the results were reasonably good. The final calibrations were largely successful at replicating the direction (i.e an increase or decrease) and the timing of the jumps in the individual trajectories. The main discrepancy was that instead of a rise in the trajectory of the Downtown all the simulations predicted a decline (Graph 7.32). This discrepancy will be analyzed and discussed in Section 8.5.

The following section presents the basic observations of the simulation results from the calibrations. Sections 8.2 to 8.5 provide interpretations in terms of the basic observations and Sections 8.6 and 8.7 provide a more general discussion of the basic observations in terms of retailers' decision making behaviour and the economic characteristics of retail centres. Section 8.8 illustrates how the retail model can be used as a planning tool to determine the effects of external constraints. And Section 8.9 presents the results of additional simulation runs, used to determine the equilibrium state of the system.

8.1 Basic Observations of the Calibration Simulations

An analysis of all the calibration runs can be summarized by five basic observations concerning the parameter values determined by the calibrations:

(1) Generally, the "best" combination of parameter values derived from the simulation runs was **g** = 0.0035, **b** = 0, **c** = 95.6, **m** = 1.05, **n** = 1.3, **y** = 1, **d** = 0, and **u** = 0.

(2) The absolute size of most retail centres was under-estimated. However, the pattern of relative sizes amongst centres was preserved for most simulation runs. (Section 8.2)

(3) Simultaneous simulation of the occurrence of a significant expansion of the Downtown and preservation of the pattern of relative sizes of the intermediate sized centres was not possible. Capturing the former conflicted with capturing the latter and vice-versa. (Section 8.3)

(4) With larger **n** values, the convergence of the trajectories of the intermediate sized centres (i.e the relative sizes) was captured more accurately. (Section 8.4)

(5) Attempts to simulate the occurrence of the significant expansion of the

Downtown resulted in the reverse behaviour, that is, a significant decline. (Section 8.5)

8.2 Under-estimation of Absolute Centre Sizes

Most of the simulations resulted in an under-estimation of the absolute centre sizes of all the retail centres during the calibration period. However, in some instances centre sizes were over-estimated. An example is provided by comparing the actual and simulated centre sizes for 1980 using the "best" set of parameter values. Table 8.1 shows the difference between actual centre sizes and the sizes given by the model. It can be observed that the simulated sizes were under-estimated for all the centres except Churchill Square, Elizabeth East and Elizabeth West for 1980.

Table 8.1 A Comparison of Actual Centre Sizes and Simulated Centre Sizes for 1980 in square feet (using the "best" combination of parameter values)

Retail Centre	Actual Size	Simulated Size	Difference	Ratio[1]
Large Sized Centre				
Downtown	1 264 930	575 696	689 234	0.45
Intermediate Sized Centres				
Kenmount	533 400	279 312	254 088	0.52
Topsail	518 481	343 871	174 610	0.66
Small Sized Centres				
Churchill	59 559	64 426	- 4 867	1.08
Torbay	75 955	72 754	3 201	0.95
Wedgewood	95 788	67 283	28 505	0.70
Elizabeth East	45 117	47 692	- 2 575	1.05
Elizabeth West	2 340	2 940	- 600	1.25

1. Ratio of Simulated to Actual Centre Size

The difference in the actual and simulated sizes is a result of problems associated with both the data and the calibration procedure. Two different sources of data were used to determine centre sizes and retail expenditures. Centre sizes were estimated using City Assessment Office records and retail expenditures were estimated using data published by the Financial Post. The use of two different data sources involved two different definitions of high-order retail. As a result there is a mis-matching of retail space to retail expenditure. In addition, unpublished data on retail expenditures (in 1966 and 1972) and the incompatibility of data resulting from changes in the classification of retail expenditure (especially between 1975 and 1977) introduced some inaccuracies to the data used (Graph 8.1). However, these problems associated with the data do not explain most of the difference between actual and simulated centre size.

The main explanation of the difference is associated with the calibration procedure. The corresponding values of the parameter **c** for **m** = 1.05, 1.1 and 1.15 were determined on the basis of the assumption that the system was at equilibrium (i.e. Total Revenue = Total Cost) in 1960. Parameter **c** is therefore the ratio of Total Cost to Total Floor space, which also represents the equilibrium condition of the St. John's retail system in 1960. Since **c** was not adjusted or changed during the calibration, the simulations are based on the assumption that the relationship between Total cost and Total Revenue remained unchanged. Therefore, under-estimation of centre sizes is a result of applying a higher **c** (ratio of cost to floor space) and over-estimation of centre size is a result of applying a lower **c**. This implies that in order to obtain more precise simulations of centre size, parameter **c** has to be computed using data for the entire period, or alternatively, **c** can be changed during the calibration to reflect the change in the ratio as it occurs in reality. In other words, the new value of **c** could be introduced during each iteration to reflect the equilibrium condition of the system for each year.

Having explained the difficulties in estimating centre sizes, it should be emphasized that in the current application of the model absolute centre size is not important. Since the focus of this study is on qualitative features as opposed to quantitative features, accuracy of the simulations in terms of absolute sizes is not a primary concern. An analysis of the simulations demonstrates that adjusting parameter **c** is not required for achieving qualitatively accurate results.

Simulations, using $\mathbf{c} = 95.6$ and $\mathbf{m} = 1.05$ with maximum sizes constraints and large **n** values, gave results which captured the pattern of relative centre sizes (Feature 1). An analysis of these simulation results indicates that, though the absolute sizes were under-estimated, the relative patterns of the St. John's system were captured accurately by the model. For example, in 1980 the pattern of relative centre sizes consisted of one very large centre (Downtown), two intermediate sized centres (i.e Topsail and Kenmount) and five small centres (i.e Churchill, Torbay, Wedgewood, Elizabeth East and Elizabeth West (Graph 7.1). Comparing Graph 7.1 and 7.32 shows that the pattern is captured by the retail model.

It should be emphasized that the actual membership of the retail centres within each group was preserved. In other words, the simulation results show the actual situation where the Downtown is the largest centre, Topsail and Kenmount are the intermediate sized centres and the remaining centres are small sized centres. This was also true for the other two patterns which characterize the system during the earlier part of the calibration period (Graph 7.1). The pattern between 1960 and 1969 consisted of one large centre and 7 small centres, and the pattern between 1969 and 1977 consisted of one large centre, one intermediate sized centre and five small centres. Graphs 7.3, 7.5 and 7.6 shows the effect of **n** on the pattern of relative sizes where a larger value of **n** improves the relative pattern of the centres in terms of the three size groups.

It is also important to emphasize that the use of the one set of parameter values throughout the calibration was sufficient to capture all three patterns of relative sizes. In addition, even though no changes in the centre sizes were made to reflect significant expansions as a result of the development of major shopping malls during the calibration, the model was able to capture the development of both Kenmount and Topsail from small centres into intermediate sized centres. This suggests that the developers' choice of location for the shopping malls coincided with the prime locations for high-order retailing as determined by the intrinsic dynamics of the system.

In summary, the robust results of the model, in terms of the pattern of relative centre sizes, suggest that the data and methods used in estimating centre sizes and retail expenditures are adequate to yield accurate results for qualitative analysis of the retail system.

8.3 Simultaneous Simulation of a Significant Expansion of the Downtown and Preservation of Relative Sizes of the Intermediate Sized Centres.

An analysis of Graph 7.1 shows that the size of the Downtown remained relatively unchanged until 1978 when it experienced a significant expansion. Kenmount also experienced two significant expansions in its size during 1967-1969 and 1978. And Topsail experienced a large expansion in 1978 which resulted in the convergence of the Topsail and Kenmount trajectories.

In most of the simulations with large values of **n**, the ability to capture the convergence of the Topsail and Kenmount trajectories was accompanied by an inability to capture the significant expansion of the Downtown. A comparison of Graphs 7.3, 7.5 and 7.6 illustrates the effect of **n** in capturing the convergence of the Topsail and Kenmount trajectories. Note that the trajectory of the Downtown for larger values of **n** resulted in a higher magnitude of decline in its size as opposed to an expansion.

In an attempt to improve the simultaneous simulation of both the expansion of the Downtown and the convergence of the intermediate centres, simulations using the modified growth function were carried out. Again the simulations showed that with a larger **n**, capturing the latter was associated with the loss of the former (Graphs 7.14 and 7.16). Sections 8.4 and 8.5 discuss the results of these simulations in terms of capturing the convergence of centres' trajectories and an expansion of the Downtown.

8.4 Convergence of the Trajectories of the Intermediate Centres

It has already been emphasized in Section 8.2 that the membership of the size groups was easily preserved. However, the relative sizes of the centres within each group show some deviations from the actual relative sizes. For example, Graph 7.1 shows the convergence of the Topsail and Kenmount trajectories in 1978, indicating a change of Topsail from a small centre to an intermediate sized centre. It was observed that this change in the status of Topsail was captured with a relatively large value of the interaction parameter: **n** = 1.3.

These results suggest that the St. John's system may not be a very high-order retail system, **n** = 1.3 is near the upper limit of the range of values corresponding to high order activity (White 1977,23). However, an analysis of the simulations which include the modified growth function indicated that with **u** = 0.3 the convergence of the intermediate sized centres was captured with a lower value of **n** (Graph 7.14 and 7.16).

8.5 Simulating the Occurrence of a Significant Expansion of the Downtown

Attempts were made to simulate the occurrence of the significant expansion of the Downtown using the modified growth function. With the introduction of the expansion threshold **u**, the simulation results showed significant jumps in the trajectory of the Downtown as well as in the trajectories of the other centres (Graphs 7.12 to 7.14). Since a larger value of **n** was essential to preserve the convergence of the intermediate sized centres' trajectories (Section 8.4), a very small value of **u**, close to 0, was tried to introduce the jumps in the trajectory of the Downtown. It was observed that though jumps were captured in the trajectory of the Downtown (Graphs 7.18, 7.20 and 7.21), these jumps occurred much earlier during the calibration period, in 1960 and 1966, instead of during the latter part of the calibration period in, 1978. Thus, the timing of the jumps simulated by the model, using a small value of **u**, did not correspond with the actual timing.

It was also observed that the decrease in the upper limit threshold **u**, with other parameters held constant, resulted in a smaller number of jumps in the trajectory of the Downtown, but increased jumps in the trajectories of the other centres. The timing of the occurrences of the jumps in the trajectories of the other centres corresponded closely to the actual timing of their occurrences (Graphs 7.18 and 7.19). For example the significant expansions in 1977 for Topsail and Kenmount were captured.

These results suggest that the expansion threshold is not the determinant factor in the expansion of the Downtown but is relevant in simulating the expansions of the intermediate sized centres. Having observed this effect of **u**, the objective of capturing the expansion of the Downtown had to be re-considered.

Additional simulations which introduced the decline threshold **d** (with **u** = 0 to exclude the effect of the growth threshold) indicated that with **d** less than or equal to -0.5 (for **c** = 95.6 and **m** = 1.05 with **g** < 0.005), the simulations displayed both a significant expansion and a significant decline in the trajectory of the Downtown. At the same time the convergence of the intermediate sized centres' trajectories was also captured. This observation of a robust decline in the trajectory of the Downtown suggested that the actual increase in the Downtown trajectory may have resulted from an exogenous perturbation of the system.

Data for years after 1980 indicate a significant decline in the Downtown as a result of the closure of major retail facilities such as the Metropolitan(73 926 ft.^{2}), located in Atlantic Place and Ayre's(38 610 ft.^{2}), both in 1982-83, and the London(51 800 ft.^{2}) in 1983. The total effect of these closures was a decline of approximately 164 000 ft.^{2} by 1983, or thirteen percent of the size of the Downtown in 1980. In addition, most of the retail space in Atlantic Place(208 416 ft.^{2}) has been replaced by office space since 1980. This implies that the expansion of the Downtown, as a result of the development of Atlantic Place, was short lived.

Therefore, the decline which was produced by the model is in fact an accurate prediction of the behaviour of the Downtown, and the inability of the model to capture the expansion is not a reflection of a flaw of the model. Rather, the model's prediction of a decline reflects its ability to simulate accurately effects of the underlying dynamics of the retail system. Another observation which emphasizes the robustness of the retail model is the ability of the model to predict the decline without adjustments to the fixed cost parameter **b** and marginal cost parameters **c** and **m**.

8.6 Retailers' Decision Making Behaviour

Results of simulations with the threshold parameters set to zero suggest that the intrinsic dynamics of the retail system are more important than the decision making behaviour of retailers in terms of a delay in their response to profits. Alternatively, it may mean that the simple modification to the growth function may not have represented the behaviour of retailers.

An examination of the changes in high-order retail sales and retail space (Graphs 8.2 and 8.3) shows that there is correlation between the two trends, especially between 1960 to 1963 changes in retail expenditures and 1963 to 1965 changes in retail space, and also between 1964 to 1969 changes in retail expenditures and 1966 and 1971 changes in retail space. These observations indicate the existence of a time lag of two to three years in the response of retail space to retail sales before 1971. A divergence between the two trends was observed for the period after 1971, until 1978 when the two trends return to showing a time lag of two years. The divergence reflects a halt in changes in retail space followed by a very significant increase in retail space in 1978. This large increase in retail space appears to be a sudden, delayed response to the accumulated changes in retail expenditures of 1970 to 1975.

However, since the timing of the jumps in the retail trajectories was best captured when the threshold parameter was set at $y = 1$, it could be argued that there exists a lag of only one year between change in retail space and changes in retail expenditures. As discussed in Section 7.4, an inter-relationship between threshold parameter **y** and the critical values of **u** was observed. This observation implies that different combinations of **y** and **u** can yield similar results. For example, a large **y** and a small **u** has the equivalent effect of a small **y** and a large **u**. Additional applications of the retail model, using the modified growth function, will have to be undertaken to determine if the growth function is adequate and how the values of **u** and **y** can be calibrated to reflect the actual situation. Since the results using the 'best' combination of parameter values were adequate for the purposes of this study, it was not crucial to fine tune determination of these two parameter values.

8.7 Economic Characteristics of Retail Centres

Setting the fixed cost parameter **b** at zero for the calibration represents a situation where fixed costs are assumed to be the same for all centres. Since the simulation runs provided results which reflected the relative competitiveness of the retail centres without having to be provided data on fixed cost, this suggests that differences in cost levels are not a significant factor in determining the relative competitiveness of high order centres.

The interaction parameter **n** = 1.3 suggests that the St. John's retail system is not of a purely high-order type because theoretically high-order retail systems are associated with lower values of **n** between the range 0.5 and 1.3. However, the relatively high value of **n** may also be a result of the types of retail activity which were selected for this study. Without additional applications of the model to other situations it is difficult to determine why the value of **n** is higher than expected.

8.8 Illustrating the Use of the Retail Model as a Planning Tool

In general, analysis of the simulation results reveals the strengths of the model. One very important observation is that the model provides robust qualitative results which require minimal data. For example, as mentioned above, the model does not require data on the cost structure and retail sales of individual retail centres in order to determine the pattern of their relative sizes. Setting the fixed cost parameter $b = 0$ for all the centres reflects the fact that there is no need to differentiate the centres based on these factors. Another very important characteristic is that the simulations do not require any adjustment of parameter values during the calibration period in order to simulate the actual system behaviour. This suggests that the general system dynamics described by the model are more important than the local factors, such as the individual cost of each of the retail centres, in determining the development of the retail system. This point should be emphasized because it suggests that though the dynamic retail model is mathematically simple relative to the more complex models discussed in Section 1.1, it provides results which are not only robust but reasonably accurate. Thus, the model's strength is that it can be applied with minimal data requirements and at the same time provide very useful results.

The rest of this section provides examples of how the model can be applied in addressing specific planning questions. The first example is an evaluation of maximum size constraints on the individual retail centres; the second example is an evaluation of the effect on other centres of a maximum size constraint on a specific centre; the third example involves an evaluation of changes in retailers' decision making behaviour; and the fourth example concerns the combined effect of both constraints on maximum centre size and retailers' decision making behaviour.

A very common problem in planning is to determine a favourable balance of land uses in an urban area. One way of achieving this balance is to regulate the amount of space for specific types of land uses to conform to a development plan. Thus, to evaluate the effect of a proposed set of land use regulations which would restrict the possible scale of development of retail centres, the model is used to compare the situation where there are no constraints on maximum sizes (Graph 7.31) with a situation where specific maximum size constraints on retail centres exist (Graph 7.32). An analysis of the graphs indicates that the relative pattern of centre sizes changes from one with three intermediate sized centres to one with two intermediate sized centres. This suggests that the specific constraints imposed would favour the development of fewer intermediate sized centres than the system is capable of supporting. This implies that certain centres will be favoured over others with the introduction of the maximum size constraints.

Maximum size constraints on centres may take the form of building regulations and zoning-by laws which restrict the development of retail facilities. For example, Churchill Square is a centre which is very favourably located but because of the existing residential area surrounding it, it is restricted in its ability to expand its retail facilities. In reality, this constraint may be relaxed to allow expansion of retail facilities in existing retail space. Thus, to evaluate the effect, Graphs 7.32 and 7.31 can be used to illustrate the effect of the removal of the maximum size constraint for Churchill Square, because though maximum size constraints were imposed on all centres, only one, the constraint of Churchill Square, was in fact effective. Without the constraint, Churchill Square develops into an intermediate sized centre as opposed to remaining a small one. An analysis of the trajectories of the individual retail centres indicates that the Downtown is most adversely affected and Topsail and Kenmount are slightly affected when maximum size constraints are lifted on Churchill Square. This is an interesting observation because in 1990 the city approved the development of 84 874 ft.^{2} retail space at Churchill Square, and as already discussed in Section 8.5, the Downtown also declined after 1980.

Incorporated into the model is an assumption of entrepreneurs' response to changes in retail sales. For example, if prevailing economic conditions cause entrepreneurs to take fewer risks, then larger changes in retail sales are required to motivate them to expand or reduce retail space. To evaluate changes in entrepreneur decision making behaviour on the development of retail centres, a comparison of the situation where there are no external constraints (Graph 7.31) and a situation where only the modified growth function was applied (Graph 7.29) is made. The introduction of the modified growth function represents a change in retailers' decision making behaviour to a more conservative mode. The result of this change in their behaviour is the occurrence of fewer but more significant changes in the sizes of the individual retail centres, which suggests the occurrence of spurts of retail development activity in the city.

In reality, planners may also want to determine the combined effect of simultaneous changes in planning regulations and retailers' decision making behaviour. An example of how the model can also be used to evaluate the combined effect is to compare the situation of no constraints (Graph 7.31) to the situation where both maximum size constraints and changes in the decision making behaviour of retailers are present (Graph 7.30). Graph 7.30 reveals both a change in the pattern of relative sizes and the occurrence of fewer but more significant changes in centre sizes as described above.

Having demonstrated how the model can be used to evaluate the effects of changes in planning policies and the behaviour of entrepreneurs, we now proceed to illustrate how the model can be used to establish a base line for determining the effect of the changing spatial distribution of the population and retail expenditures.

8.9 Evaluating the Effects of Changes in the Spatial Distribution of Population and Retail Expenditures

The simulation results discussed so far represent the dynamics of the retail system at disequilibrium, since the spatial distribution of the populations and retail expenditures change for each iteration, and the system never catches up to these continually changing conditions. To evaluate the effects of the changing distribution of population and retail expenditures it is possible to compare the relative pattern of centre sizes for 1980 to the relative pattern corresponding to 1980 conditions when the system has reached equilibrium. The system equilibrium is determined by running the model until the pattern of relative centre sizes becomes stable, using the 1980 population and retail expenditures for each iteration. In this case, the simulations were carried out until the year 2000.

A set of four simulations was run for four different situations using 1980 spatial distribution of population and retail expenditures. The situations are: (i) there are no constraints (Graph 8.4), (ii) there are size constraints (Graph 8.5), (iii) there are growth constraints (Graph 8.6) and (iv) there are size and threshold constraints (Graph 8.7). The following are a few examples of the kinds of information which these simulations can provide to planners.

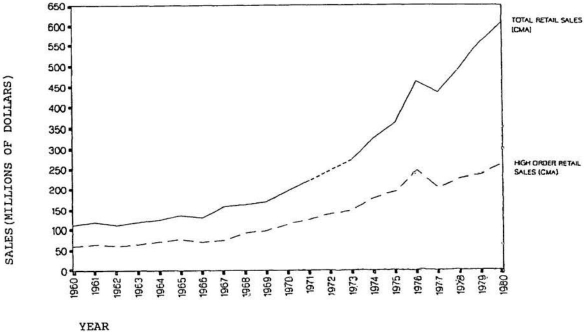
For example, planners could be interested in examining the situation where all planning regulations are relaxed to allow market forces to work on their own. The situation where no constraints are imposed on retail system development (Graph 8.4) indicates that under the influence of pure market forces, Churchill Square has the potential to develop into an intermediate sized centre and Topsail has the potential to develop into the largest centre.

Planners may also want to determine if introducing planning constraints will achieve the goal of maintaining the Downtown as the largest centre. The situation where limits on centre sizes are imposed (Graph 8.5) is compared to the situation with no constraints (Graph 8.4). The results of Graph 8.5 suggest that maximum size constraints will not maintain the Downtown as the largest centre without an increase in population and retail expenditure. In addition, a comparison of the situations where size and growth constraints are present (Graph 8.7) to the situation where only size constraints are present (Graphs 8.5) indicates that Churchill Square has to be constrained to a maximum centre size of half its potential size in order for the Downtown to have a size equal to that of Topsail. Thus, planning constraints are not only detrimental to the development of Churchill Square, but will not even benefit Downtown significantly.

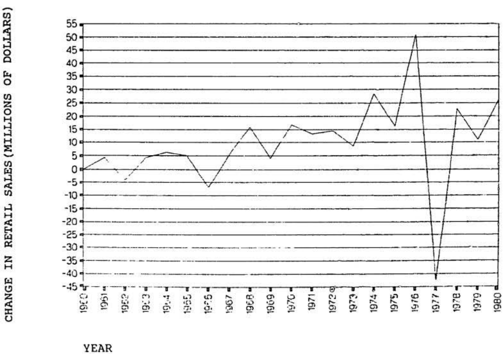
The simulations can also be used to determine the effect of changes in the decision making behaviour of retailers on the development of the retail system. A comparison of the situation where there are both constraints on centre sizes and growth thresholds (Graph 8.7) and the situation where there is a size constraint but no growth threshold (Graph 8.4) indicates smaller relative differences in the intermediate centre sizes when the growth threshold is introduced. This suggests that changes in entrepreneur decision making behaviour can have an effect on the relative sizes of the intermediate sized centres.

Finally, the model can also be used to determine the effect of changes in the spatial distribution of population and increasing retail expenditure. A comparison of the results of the simulations of the four different situations based on the patterns in 1980 and in 2000 (Graph 8.7) suggests that the pattern of relative centre sizes changes from one consisting of three different groups to one of two groups by size. This suggests that without changes in the spatial distribution of populations and, especially, without increase in retail expenditures, the system will not support a very large centre. Instead it will support intermediate sized centres and small centres. It is obvious that in the absence of increases in population and retail expenditures, the Downtown is extremely susceptible to rapid decline to the status of an intermediate centre even if planning constraints are in place to maintain its dominant position. A comparison of the results of all four simulations also suggests that the small centres can survive under economic conditions similar to those of 1980, and will survive even with the existing competition between the larger centres. This may suggest that the small centres may be quite different in nature and could reflect a different aspect of the retail system.

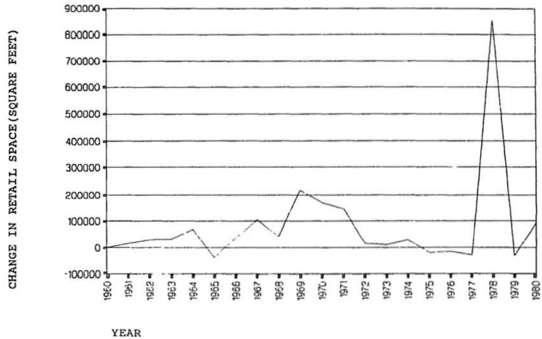
In conclusion, the examples above demonstrate clearly that based on minimal data requirements as well as the application of a simple calibration procedure the model can provide useful results which can be applied easily to address specific planning queries.



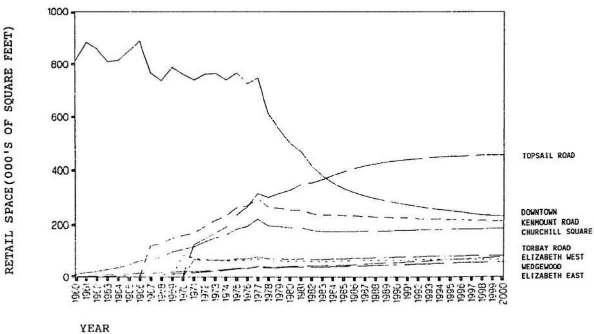
Graph 8.1 High Order Retail Sales for St. John's Metropolitan Area (1960-1980)



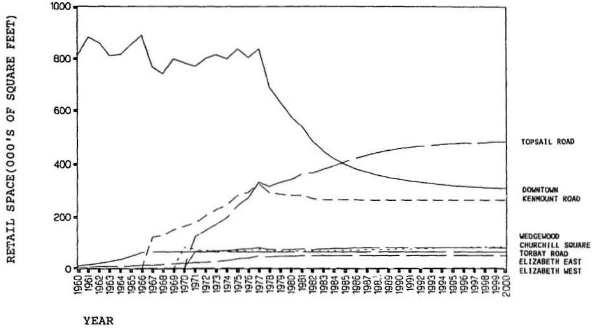
Graph 8.2 Annual Change in Total High Order Retail Sales for the St. John's Metropolitan Area (1960-1980)



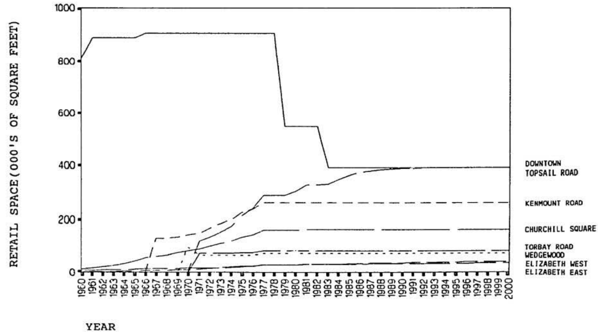
Graph 8.3 Annual Change in Total Retail Space for the St. John's Metropolitan Area (1961-1980)



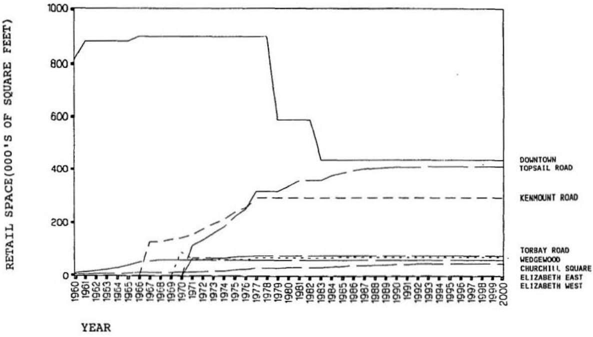
Graph 8.4 **Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;**
Growth Parameters: g=0.0035, y=1, u=0.0, d=0.0; No limits on centre sizes.



Graph 8.5 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3; Growth Parameters: g=0.0035, y=1, u=0.0, d=0.0; Limits on centre sizes.



Graph 8.6 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0035, y=1, u=0.0, d=-0.5; No limits on centre sizes.



Graph 8.7 Cost Parameters: b=0, c=95.6, m=1.05; Distance Exponent: n=1.3;
Growth Parameters: g=0.0035, y=1, u=0.0, d=-0.5; Limits on centre sizes.

Chapter 9

Summary and Conclusions

9.1 Summary

This study represents the first application of the dynamic retail model to a specific setting. It included four major steps: modification of the model to make it more appropriate for an actual application, collection of data required for input to the model and for evaluation of output, calibration of the model to simulate the qualitative features of the development of the retail system, and the interpretation of the simulation results in the context of planning issues.

The original formulation of the model assumed that retailers immediately adjusted retail space in response to every change of profit or loss. This assumption was not realistic. Therefore, three modifications were introduced: (1) constraints on maximum centre size, (2) a profit threshold which must be exceeded before retailers respond by expanding or reducing retail facilities, and (3) a time period for accumulating the profits or losses determining the magnitude of the change in centre size. Maximum centre sizes were introduced to allow the introduction of planning constraints on the development of centre sizes, while growth thresholds and accumulation periods were introduced to represent more realistically the decision making behaviour of retailers: a trend of profitability must be of sufficient magnitude and duration before the scale of retail facilities is adjusted.

The data used as input to the retail model were the spatial distribution of population by census tracts from published census data and estimated per capita high order retail expenditure from published market survey data on total retail expenditures. The data used to describe the actual development of the St. John's system, that is, the size of retail centres based on retail space occupied by high order retail facilities, were estimated from the city's property assessment records. This required tracing individual high order retail units which were operating at each major retail centre and summing the floor space of the units to compute the size of each retail centre for each year during the calibration period.

Since the input data used was not detailed enough to yield quantitatively accurate results, calibration in this study was restricted to simulating the qualitative features of retail system development. The parameter values used in the calibration were within the range of parameter values determined from general empirical studies of retail systems and from exploratory experiments using the dynamic retail model. The calibration procedure applied in this study basically involved a trial and error sensitivity analysis to obtain simulation results that best captured the qualitative features of the actual system behaviour. The first step was to assume that the system was initially at equilibrium by equating total revenue to total cost for the entire system, and to combine this assumption with an assumption that the St. John's retail system was operating at slight diseconomies of scale in order to derive values for the pair of cost parameters, c and m. The fixed cost parameter b was set at zero for all the simulations based of the assumption that all the centres were operating at similar levels of fixed costs. The growth parameter **g** was set at a level that avoided oscillatory behaviour in the system. The relative sizes of the retail centres are associated with their relative accessibility and this principle was used as the basis for determining the value of the interaction parameter **n**. The growth threshold parameters, **u** and **d**, were determined by how well the model results captured the occurrence of significant changes in the behaviour of the individual centre trajectories, and the accumulation period, **y**, was determined by evaluating how closely the model results tracked the timing of the actual occurrences of changes in the individual centre trajectories. The limit on the maximum size of each retail centre was set at the maximum size at which it had operated during the calibration period. The optimal set of parameter values was finally determined to be **c** = 95.6, **m** = 1.05, **b** = 0, **g** = 0.0035, **n** = 1.3, **u** = 0, **d** = 0.5, and **y** = 1.

The simulation results demonstrated that with minor modifications to the growth function, the model was able to give qualitatively accurate results in terms of three levels of detail. It was able to capture (1) the structure of the retail system in terms of groups of centres by size with one very large retail centre, two intermediate sized centres and five small sized centres; (2) the actual membership of retail centres for each group of retail centres by size with the Downtown as the largest retail centre, Topsail and Kenmount as the intermediate sized centres and the remaining ones as small centres; and (3) significant changes in the size of individual retail centres, for example, the expansion of the Topsail and Kenmount Road centres in the late 1970's. The observed growth of the Downtown as opposed to its simulated general decline was a very good example of a perturbation in the system which had a temporary influence on the development of the retail system. It should be emphasized that these qualitative features were captured without adjusting parameter values for individual retail centres. This suggests that the model is robust in its description of the dynamics of a retail system.

Comparisons of simulation results based on different scenarios provided examples of how the model results can yield useful planning information. More specifically, the comparisons showed how the model can be used to determine the effect of specific planning policies, changes in retailers' decision making behaviour, and changes in the retail environment in terms of the distribution of population and trends in retail expenditures.

9.2 Conclusions

The successful calibration of the dynamic retail model strongly suggests that the model is an appropriate tool for simulating the interactive process which gives rise to the structure of the retail system. The model in a sense explains how apparently unrelated events interact to give rise to the observed structure of the retail system. It demonstrates that though it is difficult to trace and determine the impact of individual determinant factors because of the complexity of the interactions and their interdependence, a non-linear dynamic model based on a relatively simple concept of spatial interaction and competition is sufficient to predict the overall outcome of all the complex interactions. Tracing the effect of individual determinants is difficult because of interdependence of the determinant factors, nor is it a useful or essential exercise because ultimately it is the balancing effect of all the determinant factors which gives rise to the structure of the retail system.

In terms of the issues associated with calibrating the model, minimum data is required to obtain qualitatively accurate results and there is no need for extensive fine tuning of parameter values in order to simulate the actual behaviour of a retail system. This suggests that the model is robust in terms of its description of the interaction amongst retail centres within a major retail system. It is expected that the model could provide quantitatively accurate results with the use of more accurate and detailed data.

The comparison of simulation results representing different situations demonstrates that it is a useful tool in monitoring and evaluating the development of a retail system. The results are relatively easy to interpret with respect to the impact of specific changes in the environment of the retail system as well as constraints on retail centre growth in terms of specific planning regulations. Furthermore, the effect of changes in retailers' decision making behaviour, or the economic characteristics of retail centres are easily evaluated because the model is basically a fusion of the theory of the firm and spatial interaction theory. One important observation in the comparison of the model results against actual system behaviour is that differences in the two may represent the occurrences of perturbations to the system as opposed to resulting from the dynamics of the retail system as described by the model. This is helpful in determining whether the effects of the perturbation are transitory or permanent. This is especially useful in terms of making planning decisions of whether it is necessary and feasible to counteract undesirable system development.

The model is not merely a black-box because it is based on a known set of hypotheses which describes the process giving rise to structure. Like all models, it is applicable only within a certain domain; therefore, if the nature of the process changes, the model has to be modified or even re-built altogether, depending on the magnitude of the changes. But if the model is able to capture the actual development of the retail system and make accurate predictions then our confidence in the set of hypotheses is increased. On the other hand, failure of the model to make reasonable predictions may suggest that we have missed an essential element in our understanding of the dynamics of retail system development.

In conclusion, this thesis demonstrates that the dynamic retail model is applicable to the St. John's metropolitan system of major retail centres. In spite of the simplicity of the model, qualitatively accurate replication of actual system development was achieved, and the model proved to be adequate for making reasonable predictions of retail system behaviour. Thus, the model shows potential as a planning tool for monitoring, analyzing and forecasting the development of a retail system. In a broader perspective, the results of this thesis support the argument that it is not always necessary to model all the details of a spatial process in order to develop a model which can be used to predict system structure, at least in the case of retail systems.

BIBLIOGRAPHY

Abraham, Ralph H. and Christopher D. Shaw. 1984. *Dynamics - The Geometry of Behaviour, Part 1: Periodic Behaviour.* The Visual Mathematics Library, Vol.1. Santa Cruz, California: Aerial Press Inc.

Allen, Peter. 1983. Self-Organization and Evolution in Urban Systems." In *Cities and Regions as Nonlinear Decision Systems*, ed. Robert W. Crosby, pp. 29-62. Colorado: Westview Press.

Allen, Peter and Guy Engelen. 1983. *Evolution of the Population Distribution of the United States and Changing Economic and Demographic Structure - Modelling the Evolution of Spatial Structure of the United States.* Draft Final Report, prepared for Purdue University and The Department of Transportation of The United States.

Allen, Peter and M. Sanglier. 1981. Urban Evolution Self-Organization and Decision Making. *Environment and Planning A* 13:167-83.

Amrhein, Carl G. and Ross D. Mackinnon. 1988. A Micro-Simulation Model of a Spatial Labour Market. *Annals of the Association of American Geographers* 78(1):112-131.

Ayeni, 'Bola. 1979. *Concepts and Techniques in Urban Analysis.* New York: St. Martin's Press.

Beaumont, J. R., M. Clarke and A. G. Wilson. 1981. The Dynamics of Urban Spatial Structure: Some Exploratory Results using Difference Equations and Bifurcation Theory. *Environment and Planning A* 13:1473-83.

Berry, Brian J. L. 1967. *Geography of Market Centres and Retail Distribution.* Englewood Cliffs: Prentice Hall.

Berry, Brian J. L. and H. Gardiner Barnum. 1962. Aggregate Relations and Elemental Component of Central Place Systems. *Journal of Regional Science* 4(1):35-68.

Berry, Brian J. L. and William L. Garrison. 1958. Recent Developments of Central Place Theory. *Papers and Proceedings of the Regional Science Association* 4:107-20.

Clarke, M. and S. Openshaw. 1987. The AGW Spatial Interaction Workstation. *Environment and Planning A* 19:1261-68.

Community Resources Services Limited. 1985. *Hibernia Demographic Impacts-Background Report*. St. John's, Newfoundland.

Couclelis, Helen. 1988. Of Mice and Men: What Rodent Populations Can Teach Us About Complex Spatial Dynamics. *Environment and Planning A* 20:99-109.

Crosby, Robert W. 1983. *Cities and Regions as Nonlinear Decision Systems*. Boulder, Colorado: Westview Press.

Cullen, Ian. 1984. *Applied Urban Analysis - A Critique and Synthesis*. New York: Methuen.

Davies, R. L. and D. S. Rogers. 1984. *Store Location and Store Assessment Research*. Suffolk: John Wiley & Sons.

Davies, Ross and Peter Hall. 1978. *Issues in Urban Society*. Middlesex, England: Penguin.

Dawson, John. 1980. *Retail Geography*. New York: John Wiley & Sons.

DeLCan De Leuw Cather. 1982. *Newfoundland and Labrador Retail Development Study 1982*. Technical Report undertaken for the Department of Municipal Affairs, Provincial Planning Office, Newfoundland.

De Leuw Cather and Company. 1974. *A Transportation Plan for the City of St. John's, Newfoundland 1971*.

Dendrinos, Dimitrois S. and Henry Mullaly. 1985. *Urban Evolution - Studies in the Mathematical Ecology of Cities*. Oxford: Oxford University Press.

————. 1981. Evolutionary Patterns of Urban Population. *Geographical Analysis* 13(4):328-44.

————. 1981. Fast and Slow Equations: The Development Patterns of Urban Settings. *Environment and Planning A* 13:819-27.

Department of Municipal Affairs and Housing Provincial Planning Office. 1977. *St. John's Metropolitan Area Municipal Plan.* St. John's Urban Region, Newfoundland.

Fenco (Nfld.) Ltd. 1980. *St. John's Urban Regional Development Plan.*

Forrester, J. 1969. *Urban Dynamics.* Cambridge, Mass.: The M.I.T. Press.

Fotheringham, A. Stewart and M. E. O'Kelly. 1989. *Spatial Interaction Models - Formulations and Applications.* Dordrecht: Kluwer Academic Publishers.

Fotheringham, A. Stewart and Daniel C. Knudsen. 1986. Modelling Discontinuous Change in Retailing Systems: Extensions of the Harris-Wilson Framework with Results from a Simulated Urban Retailing System. *Geographical Analysis* 18(4):295-312.

Francis J. O'Leary (Chairman). 1978. *Report of the St. John's Housing Corporation 1944-1978.* St. John's Housing Corporation.

Guy, C. M. 1987. Recent Advances in Spatial Interaction Modelling: An Application to the Forecasting of Shopping Travel. *Environment and Planning A* 19:173-86.

Hagerstrand, T. 1953. *Innovation Diffusion as a Spatial Process.* Translated by A. Pred. Chicago: Chicago University Press, 1967.

Haynes, Kingsley E. and A. Steward Fotheringham. 1984. *Gravity and Spatial Interaction.* Beverly Hills, California: Sage Publications.

Huggett, Richard. 1980. *Systems Analysis in Geography.* Oxford: Clarendon Press.

Isard, Walter. 1956. *Location and Space-Economy - A General Theory Relating to Industrial Location, Market Areas, Land Use, Trade, and Urban Structure.* Cambridge, Massachusetts: The M.I.T. Press.

Levins, Richard. 1968. On Theories and Models. In *Evolution in Changing Environments - Some Theoretical Explorations.* Princeton: Princeton University Press.

Lombardo, S. T. and G. A. Rabino. 1985. Calibration Procedures and Problems of Stability in Nonlinear Dynamic Spatial Interaction Modelling. *Environment and Planning A* 18:341-50.

Meadows, Donella H. and Jenny M. Robinson. 1985. *The Electronic Oracle-Computer Models and Social Decisions.* Chichester: John Wiley & Sons.

Nicolis, G. and Ilya Prigogine. 1977. *Self-Organization in Nonequilibruim Systems - From Dissipative Structures to Order Through Fluctuations.* New York: Wiley Interscience.

Pearson, R. E. 1969. *Atlas of St. John's.* Memorial University of Newfoundland, Department of Geography, St. John's, Newfoundland.

Pumain, D., T. Saint-Julien and L. Sanders. 1987. Application of a Dynamic Urban Model. *Geographical Analysis* 19(2):152-66.

————. 1984. Dynamics of Spatial Structure in French Urban Agglomerations. *Papers of the Regional Science Association* 55:71-82.

St. John's Metropolitan Area Board. 1966. *St. John's Metropolitan Area Municipal Plan.*

Sanglier, M. and P. M. Allen. 1989. Evolutionary Models of Urban Systems: An Application to the Belgian Provinces. *Environment and Planning A* 21:477-98.

Scarlett, M. J. 1985. *The Newfoundland Economy: A Spatial Analysis.* Memorial University of Newfoundland, Department of Geography, St. John's, Newfoundland.

Shrimpton, M. 1979. *Change in the City of St. John's and the Remainder of the St. John's CMA., 1971-76: A Summary.* City of St. John's Planning Office, St. John's, Newfoundland.

————. 1979. *Change in the St. John's Downtown Residential Area, 1971-1976.* City Planning Office, St. John's, Newfoundland.

Swartzman, Gordon L. and Stephen P. Kalyzmy. 1987. *Ecological Simulation Primer.* Biological Resource Management. New York: Macmillan.

Unwin, David. 1981. *Introductory Spatial Analysis.* London: Muthuen.

Urban Land Institute. 1969. *Dollars and Cents of Shopping Centres 1969.* Washington D.C.

White, Roger, W. 1984. System Dynamics and Evolution: Intermittent Chaotic Behaviour in a Hierarchical System. *Revue d'Economic Regionale et Urbaine,* 5:823-838.

————. 1984. Principles of Simulation in Human Geography. In *Spatial Statistics and Models,* eds. Gary L. Gaile and Cort J. Willmott, pp. 389-416. Dordrecht: D. Reidel Publishing Company.

————. 1983. *Chaotic Behaviour and Self-Organization of the Urban Retail System.* Brussels Working Papers on Spatial Analysis, Series A: Human Systems, No.3. Universite Libre de Bruxelles.

————. 1978. The Simulation of Central Place Dynamics: Two -Sector Systems and the Rank-Size Distribution. Geographical Analysis 10(2): 201-208.

————. 1977. Dynamic Central Place Theory: Results of a Simulation Approach. *Geographical Analysis* 9:226-43.

————. 1976. A Generalization of the Utility Approach To the Problem of Spatial Interaction. *Geographical Analysis* 8:39-46.

————. 1975. Simulating the Dynamics of Central Place Systems. *Proceeding of the Association of American Geographers* 7:279-82.

————. 1974. Sketches of A Dynamic Central Place Theory. *Economic Geography* 50(3):219-27.

Wilson, Alan G. 1984. Making Urban Models More Realistic: Some Strategies for Future Research. *Environment and Planning A* 16:1419-32.

————. 1981. *Catastrophe Theory and Bifurcation-Applications to Urban and Regional Systems.* London: Croom Helm.

———. 1980. Aspects of Catastrophe Theory and Bifurcation Theory in Regional Science. *Papers of the Regional Science Association* 44:109-118.

———. 1980. *The Evolution of Urban Spatial Structure: The Evolution of Theory.* School of Geography, University of Leeds.

———. 1974. *Urban and Regional Models in Geography and Planning.* London: John Wiley and Sons.

Wilson, Alan G. and R. J. Bennett. 1985. *Mathematical Methods in Human Geography and Planning.* Chichester: John Wiley & Sons.

———. 1972. Patterns and Processes in Urban and Regional Systems. *London Papers in Regional Science*, Vol. 3. London: Pion.

Wilson, Alan G. and Michael J. Kirby. 1980. *Mathematics for Geographers and Planners.* New York: Oxford University Press.

Woodcock, A. and Monte Davis. 1978. *Catastrophe Theory.* New York: Avon Books.

Appendix I

Sizes of Retail Units and
Year of Opening and Closing Operations

Note: Retail unit size refers to the floor space which is used for retailing (i.e. space used for other purposes, such as, office, storage and parking are excluded). In the case where the year of opening and closing operations is the same, it indicates that the retail unit operated during that year.

Churchill Square	Size(ft^2)	Open	Close
1 Slumber Shop	681	1979	1980
15-17 Taylors Furniture	1563	1960	1962
15-17 Gourley Gowns Salon	1563	1963	1980
23 Contemporary Woman	625	1977	1980
23 Bison Brewing	625	1972	1972
23 Parker & Monroe	625	1965	1970
29 La Boutique	600	1970	1977
31 Cranes Jewellery	600	1971	1980
35-37 Liquor Store	2811	1963	1980
35-37 Arcade	2811	1960	1971
Giant Mart	37218	1963	1979
Giant Mart	34468	1980	1980
Auntie Crae's	2750	1980	1980
<u>Rowan Street</u>			
15 Flamingo Restaurant	1515	1963	1967
19 Int'l Com. Drugs Ltd.	1400	1978	1980
21 Margaret Dunn Cosmetics	1026	1979	1980
21 Mr. Music	1026	1977	1978
25 Macy's Ltd.	5904	1961	1980
33 Liquor Store	1110	1960	1980
59 Elizabeth Drugs	4755	1960	1980
55 Big Ben's	1866	1972	1980
55 Bowring Brothers	1866	1960	1970
13 The Circle Lounge	2541	1972	1973
13 Park Club Lounge	2541	1964	1969
15 Radio Shack	1515	1972	1973
21 Imperial Optical	750	1964	1973
17 Milts Steak House	957	1967	1973

Wedgewood	Size(ft^2)	Open	Close
K-Mart	93288	1970	1980
Schooner Lounge	2500	1972	1980

Elizabeth Avenue East	Size(ft^2)	Open	Close
Canadian Tire	21100	1973	1980
People's Choice Drugs	3789	1974	1980
61 Torbay Drugs	3500	1963	1978
69 Parkdale Pharmacy	4495	1960	1980
81 Dunns Pharmacy	1190	1960	1975
Elizabeth Store	1190	1960	1969

Elizabeth Avenue West	Size(ft^2)	Open	Close
392-94 Queen's Plate	600	1979	1979
394 Astor Beauty Salon	600	1962	1980
Elizabeth Drug Ltd.	1740	1966	1980
Kenmount Drug	1740	1960	1965
A & W Restaurant	1000	1968	1971

Torbay	Size(ft^2)	Open	Close
Zellers	56885	1971	1980
Brewers	1200	1977	1980
Shoppers Drug Mart	7038	1980	1980
China House	2172	1978	1988
Shop Musico	2172	1975	1976
Fabric City	900	1975	1976
Tic Toc Deli	975	1977	1980
George & Son	660	1980	1980
Expert Olympic Shoe	645	1971	1979
Bata Shoe Store	1025	1971	1979
E & W Take Out	900	1974	1980
Peters Pizza	900	1980	1980
Four Ace Lounge	900	1977	1980
C P Lounge	900	1973	1976
Four Ace Lounge	900	1971	1972
Parker & Monroe	900	1971	1980
Tooton's	405	1983	1980
Jeans & Things	580	1972	1980
Imperial Optical Ltd.	1200	1977	1980
Brewers Retail	1200	1973	1976
Musicians Warehouse	1800	1976	1976
Mr Home Movie,T Shirt,June	1800	1976	1977
The Fix It Shop	45	1977	1987
Radio Shack	1800	1976	1980
Elizabeth Drugs	3600	1971	1976
Arcade	3600	1971	1977
Royal Stores	1950	1971	1974
Dossies Delicatessen	975	1971	1975
Nfld. Shop,Underworld,Korner	350	1971	1974
Nfld. Shoppe, Korner	350	1975	1980
Pet, Mexican Food, Jeweller	350	1980	1981
Time Shoppe	350	1980	1988

Kenmount Road	Size(ft^2)	Open	Close
30 Haynes Furniture Mart	10000	1980	1980
<u>Atlantic Shopping Centre</u>			
Pizza Delight	928	1977	1980
80 Canadian Tire	52164	1964	1980
58 O'Regan & O'Brien	1075	1977	1978
58 Crawford Music Ltd.	5025	1977	1977
58 Consumer Distributing	10389	1974	1980
58 Baine (Furn. & App.)	11997	1967	1980
58 Kenmount Home Centre	11997	1968	1970
A & W Drive In	1092	1967	1980
Simpsons Sears	10000	1967	1977
90 Nfld. Liquor	10000	1967	1980
120 Hollmart Family Rest.	3620	1980	1980
75 Kenmount Rest.	3502	1967	1980
75 Kenmount Lounge	3502	1967	1980
79 Color Your World	4500	1978	1980
151 Tim Hortons Ltd.	1571	1978	1980
161-63 Masonary Supply	47715	1970	1980
161 Stokes Bldg. Supply	10767	1970	1980
<u>Freshwater Street</u>			
290 Palm Springs SPA Ltd.	2189	1976	1980
290 New Dawn	780	1978	1980
318 Mr. Jim's Pizza	2683	1978	1980
320 Weight Watchers	840	1978	1980
338 Barney's	2240	1972	1980
340 The Pop Shoppe	8050	1976	1980
329 Italia Pizzeria	1524	1973	1979
329 Barney's Chicken	1524	1967	1976
<u>Avalon Mall</u>			
Beer Store	1035	1967	1979
Parker & Monroe	2095	1967	1979
Holland Nurseries	500	1967	1979
The Royal Stores	11900	1967	1975
The Band Box Ltd.	300	1967	1968
Macy's Ltd. (book)	2667	1967	1979
Fabric Centre	2000	1967	1979
Agnew Surpass Shoe	2750	1967	1979
London, NY & Paris	8922	1978	1979
Eastern Reitmans	6000	1967	1969
La Boutique	750	1967	1969
Woolcraft	500	1967	1979

Kenmount Road	Size(ft^2)	Open	Close
<u>Avalon Mall (cont'd)</u>			
Chez Margo	500	1967	1978
The Korner	600	1967	1967
Global Gifts Ltd.	600	1967	1967
Dairy Queen	700	1967	1971
West End T.V.	1100	1967	1977
Trans Canada Drugs	750	1967	1971
Imperial Optical Co.	750	1967	1971
Strand Lounge	2000	1967	1971
Ayre's Ltd.	39600	1978	1979
Brick Shirt House	500	1978	1979
Carden Ltd.	625	1977	1977
The Craftsman Bazaar	625	1978	1979
Arcades Ladies Shoppe	3000	1978	1979
Medival Inns	531	1978	1979
Dalmy's Ltd.	2188	1978	1979
Carlton Cards	1861	1978	1979
Dalmy's Ltd.	3000	1969	1971
Fred Lewis Shoe	1333	1968	1979
Mary's Sewing Centre	110	1971	1971
Trip Point	110	1970	1970
Mary Browns	600	1971	1971
Tip Top Tailors	3250	1968	1979
Singer Co. of Canada	2000	1968	1979
Shirley Price	110	1969	1969
Tiara	110	1969	1972
Ship or Shore	110	1969	1970
Sobey's Ltd. (rest.)	600	1969	1969
Art Studio 7C	600	1969	1969
Nortells	3000	1969	1977
Dairy Queen	700	1969	1977
Hilltop Dairies	1400	1969	1977
West End TV Ltd.	1100	1969	1970
The Royal Stores (furn.)	1200	1969	1975
Birks	4500	1969	1979
Laura Secord	600	1969	1979
Tootons	600	1969	1979
Sobey's Ltd. (rest.)	600	1969	1969
Expert Olympics Shoe Clinic	575	1968	1979
Trans Canada Drug	4696	1969	1976
Strand Lounge	7000	1969	1979
Ayre's Ltd.	39600	1969	1979
Woolco	145240	1969	1979
Uniform Shop	750	1970	1970
K Marsal	110	1970	1977
Gordon Kearney	55	1970	1977
Gomar Ent. (Mary's Sewing)	110	1970	1977

Kenmount Road	Size(ft²)	Open	Close
Avalon Mall (cont'd)			
Twin Point	110	1970	1970
Golden Skillet	600	1970	1970
A E Hickman Co. Ltd. (Furniture)	1200	1970	1979
A E Hickman Co. Ltd.	600	1970	1979
Imperial Optical	750	1970	1976
Ayres	750	1972	1975
Trip Inn	110	1971	1977
Trip Inn	110	1971	1975
Jeans & Things	110	1976	1979
Mary Browns	110	1972	1977
The Nfld. Shoppe	110	1975	1975
Grafton Fraser	3902	1978	1979
Chaussures Lewis Shoes	2544	1978	1979
Thrifty's	2453	1978	1979
Fred's Ltd.	3000	1978	1979
Suzy Shier	2671	1978	1979
Elegant Lady Lingeries	2000	1978	1978
Pennington Stores Ltd.	2995	1978	1979
P J's	1867	1978	1978
Terris Fashions Ltd.	2481	1978	1978
Dalliards	3511	1978	1979
Rhodi Serv. Ltd.	1359	1978	1979
G Richards Kingsize	4080	1978	1979
Brody's Town's Country	2481	1978	1979
Bata	1876	1978	1979
Big Steel Man	6931	1978	1979
Bowring Brothers	5753	1978	1979
Leisure World	2594	1978	1979
Dalmy's Canada	4707	1978	1979
Maher Shoe	1657	1978	1979
P B Allan	1157	1978	1979
Trip Inn Boutique	500	1978	1979
The Time Machine	500	1979	1979
World of Time	500	1978	1978
Ethel Barrett Chili	847	1978	1979
Reitman's Ltd.	2393	1978	1979
Imperial Optical	814	1978	1979
Radio Shack	2328	1978	1979
Trans Canada Drug	5567	1978	1979
Cavay - Grandma Lees	350	1978	1979
Fast Food Ltd. A & W	376	1978	1979
Orange Julius	350	1978	1979
C K Hols	1100	1978	1979
Medival Inn	974	1978	1979
Barney's Chicken Bar	931	1978	1979

Kenmount Road	Size(ft^2)	Open	Close
Avalon Mall (cont'd)			
Mother's Ltd.	427	1978	1979
Ri~e Bowl	724	1978	1979
Collegiate shirts	870	1979	1979
Puff & Stuff	870	1978	1978
Adam & Eve	1733	1978	1979

Topsail Road	Size(ft^2)	Open	Close
Village Mall			
Dalmy's Canada	3444	1978	1980
Fredelle Shoe Store	987	1978	1980
Laura Secord	556	1978	1980
The Green Thumb	1517	1978	1979
Sound City	987	1978	1979
Readmore Book Store	2313	1978	1980
Birks	2949	1978	1980
Bowing Brothers	3445	1978	1980
Lewis Shoes	2117	1978	1980
Suzy Shier	2460	1978	1980
Eastern Reitman's Ltd.	4013	1978	1980
Bar-B-Q Villa	400	1978	1980
Sandwich Shoppe	221	1978	1980
Newfie Bullet	1617	1978	1980
Dairy Queen	350	1978	1978
Italian Pizzeria	350	1978	1978
A & W	643	1978	1980
Donut Hut	197	1978	1979
The Hot shoppe	457	1979	1980
Greek Donair	457	1978	1978
Char-Broil	221	1979	1980
Dairy Delight	224	1979	1980
Keller's Krispy Chicken	449	1978	1979
Rice Bowl	702	1978	1980
Village Fish & Chips	453	1980	1980
Mothers	453	1978	1979
Orange Julius	350	1979	1979
Strand Lounge	5608	1978	1980
Fred's	8246	1978	1979
Town & Country Maps	2542	1978	1980
Reitmans Ltd.	2529	1978	1980
Jeans & Things	1579	1978	1980
House of Spectacles	393	1978	1980
Dylex Diversified	4387	1978	1980
Tip Top	4663	1978	1980
Thrifty's Riding & Sports	2240	1978	1980
Maher Shoes Ltd.	1640	1978	1980
Charm Diamond Centre	1500	1980	1980
Shaino's His & Hers	1500	1978	1979
Lindo Ltd.	1753	1978	1980
Agnew Surpass Shoe Store	1653	1978	1980
Harrison Draperies	3480	1978	1980
Country Kitchen	1162	1978	1979
Radio Shack	1225	1978	1980
Kinney Shoes	1960	1978	1980
Marks & Spencer	9128	1978	1980

Topsail Road	Size(ft^2)	Open	Close
<u>Village Mall (cont'd)</u>			
Jack Fraser	1998	1978	1980
Bata Shoes	1890	1978	1980
Coles Book Stores	2280	1978	1980
Peoples Jewellers	2146	1978	1980
Scholar Choice	2417	1980	1980
Kearney's	2417	1978	1979
Sussex Sales	1821	1979	1980
The Locker Retail Sales	1821	1978	1978
Drug Fair	8125	1978	1979
City Furniture Co.	2558	1978	1979
D'Allards	3433	1980	1980
St. Clair Paint & Wallpaper	1725	1980	1980
Leisure World	1725	1978	1979
Circle & Sound	1725	1980	1980
Sam The Record Man	1725	1978	1979
Athletes World	1825	1978	1980
Kids Place - Reitmans	1860	1978	1980
Nortell's Ltd.	2490	1980	1980
Gregory's Ltd.	2490	1978	1979
Parker and Monroe	606	1978	1980
Boutique Bleu Fashion	1147	1978	1980
V & M Ltd. Accentor Hobby	1208	1978	1979
Tooton's Ltd.	1015	1978	1980
Carlton's Card	1540	1978	1980
O. B. Allan	1021	1978	1979
Imperial Optical Co.	429	1978	1980
London, NY & Paris	16855	1978	1980
Toppy's	1056	1978	1980
Avalon Jewellers	1524	1978	1979
<u>Others</u>			
Mother Natures Ltd.		1978	1978
Hosiery Hut		1978	1979
The Bath Boutique		1978	1979
Craftman Bazaar		1978	1979
Thompson's Place		1978	1979
Flowers Unlimited Co.		1978	1980
Olympic Shoe Clinic		1978	1979
Scotch Wool		1978	1980
Magic Eve Cosmetics		1978	1980
Cassander 2000		1978	1980
Total of Others	7300	1978	1980
Consumers Distributing	3700	1978	1979
Woolco Stores	133120	1978	1980
Simpson Sears	129174	1978	1980

Topsail Road	Size(ft^2)	Open	Close
462 Color Your World	1425	1980	1980
462 William Hamlyn	2150	1977	1980
470 K Mart Dept. Store	93288	1971	1980
Orient Gardens Rest.	2500	1971	1980
Drive In Restaurant	1000	1971	1976
T Mcmurgo Co.	1920	1977	1978
A & W	1000	1971	1976
474 Liquor Store	2500	1977	1980
502 Tim Horton Donuts	1896	1977	1980
506 Hollmart Family Rest.	3552	1978	1980
584 Liquor Store	2500	1971	1975
Pizza shop	1500	1971	1971
658 Brewers Association	1100	1975	1980
662 Mr Jim's Pizza	2318	1980	1980
666 Pop Shoppe	735	1978	1980
666 Flower World Ltd.	1632	1980	1980
666 Furniture & Co.	750	1980	1980
670 Barney's Ltd.	1365	1973	1980
531 Mr. Submarine	1600	1980	1980
Brookfield Drugs Ltd.	1600	1976	1980
Admiral Sub Sandwiches	1232	1971	1975
665 A-1 Take Out	1040	1971	1980
665 P.T. Pizza	782	1980	1980
Mr Pizza	782	1975	1979
675 Pink Poodle Rest.	6888	1971	1980
691 Mar'c Take Out	1000	1974	1977
691 Charlies Lunch	1000	1971	1973

Water Street		Size(ft^2)	Open	Close
88	Maurice Men's Wear Ltd.	2700	1970	1980
96	Stardust Lounge	2500	1978	1980
96	Concord Room	3400	1970	1980
96	The Big 'E' Ltd. - (Furniture)	8925	1974	1977
96	Bell Club Ltd. Tavern	5000	1964	1968
104	Liquor Store	1000	1960	1966
106	Gordon Murphy	842	1962	1962
106	Jardines Rest.	842	1960	1961
108	Mary's Snack Bar	660	1964	1964
108	Atlantic Textile	3150	1975	1975
108	Jardine Bros. Ltd.	660	1961	1962
110	Jardine Bros. Ltd.	660	1962	1962
112	Jim's Tavern	1680	1974	1980
112	Jardine Bros. Ltd.	2724	1962	1962
114	Tavern (John White)	2406	1960	1973
124	AfterWard 1977 Ltd.	2025	1977	1980
124	The Gallery (Photo Studio)	1575	1973	1974
124	G Oakley Restaurant	1575	1968	1969
126	H & B Take Out	2800	1978	1980
126	Harry's Take Out	966	1975	1977
126	Repair Centre (sales & serv.)	966	1972	1971
126	Music Centre	966	1971	1971
128	Sandwich Shoppe Ltd.	745	1980	1980
130a	Gem Studios	745	1972	1972
130a	Macy's Ltd.	745	1964	1966
134	The Book Corner	1680	1974	1977
134	Woodstock Sales (Stny.)	1680	1960	1972
136	Royal Stores Ltd.	5060	1960	1976
136	MacNeill's Music Co.	4631	1974	1976
136	Century Importers (Ftware)	1940	1972	1973
136	Royal Stores	8979	1967	1976
138	Royal Stores Ltd.	8979	1960	1964
140	Lunch Box	1000	1960	1965
140	Seaview Rest.	1000	1966	1967
142	Charm Jewellery	4500	1960	1979
144	The Uniform Shop	2995	1977	1978
144	Lyman Calvert Tuxedo (rentals)	2995	1974	1974
144	Hudson Bay Co.	2995	1960	1976
156	General Home Furnishing	3774	1976	1976
156	Pizza Delight	3774	1977	1978
156	Fashion Floor Center	6300	1975	1975
156	Original Tuxedo Rental	1575	1973	1973

Water Street		Size(ft^2)	Open	Close
156	Variety Sales	1575	1971	1972
156	Flowers & Cakes	1575	1960	1962
158	Electrolux Canada Ltd.	504	1960	1973
160	Electrolux Canada Ltd.	420	1960	1973
164	Night Cap Lounge	3100	1979	1980
166	Hiberia Woodstove	1200	1980	1980
166	Sandwich Shoppe	982	1978	1979
166	Capitol Stationery	1200	1974	1978
166	Color Sound Electric	2400	1970	1970
168	Scandinavian Shop	1000	1975	1980
168	Hary Hon Tailor	1000	1965	1967
168	A.M. Duffy (stationery)	1000	1960	1964
172	Taster's Delight	2408	1979	1980
174	World of Time	806	1980	1980
174	The Music Centre	3000	1973	1979
174	Marty's Lunch	3000	1960	1963
176	Kitchen Queen	1700	1972	1980
176	C. H. Noseworthy Ltd.	1700	1971	1971
176	City Credit Jewellers	1700	1964	1964
176	Nfld. Credit Jewellers	1700	1960	1963
186	Capital Cocktail Lounge	3840	1962	1977
186	The Fashion Centre	1460	1960	1961
188	Sooters Studio	1620	1980	1980
188	MacNeill's Records	4800	1979	1979
188	The Lighthouse	1800	1972	1978
196	Footware Supplies	4800	1973	1978
196	Modern Home Supplies Ltd.	1983	1960	1972
198	Furniture Discount	2000	1964	1965
204	Pioneer Take-Out	1738	1978	1978
204	Marty's Restaurant	3300	1964	1974
204	Catering Service	3300	1963	1963
206	Gray & Goodland Ltd. (stny.)	1800	1960	1972
208	El Tico Ltd. Tavern	1800	1964	1980
208	Pillar Lounge & Dining	1800	1976	1978
208	Cabot Dining Room	1800	1975	1975
208	Avalon Caterers (Rest.)	1200	1965	1972
208	Vogue Gallery	1200	1960	1963
210-14	T McMurdo & Co. Ltd.	4442	1960	1972
216	Cabot 4 Lounge	8400	1975	1975
216	Ernest Clouston Ltd.	1400	1972	1973
216	Embassy Dining Room	1800	1973	1974
218	Louis Swersky & Co Ltd	4205	1960	1972
220	Clouston Ltd. (furn.)	4205	1962	1972
220	Macy's Ltd.	4205	1961	1961
220	Louis Swersky & Co. Ltd	4205	1960	1972

Water Street		$Size(ft^2)$	Open	Close
222	Chas. Hutton & Son (music)	1800	1960	1980
240	A. E. Hickman Co. - Elect	1377	1962	1962
246	Ultra Sound Ltd.	5400	1976	1980
246	Cabot Optical Ltd.	5400	1971	1974
246	Empire shoe Rebuilders	2700	1965	1969
246	Fashion Flair	1170	1964	1964
246	City Sewing Shop	1170	1964	1964
248	Fireside 1978 Ltd.	6000	1974	1980
248	W. G. Pippy Hardware	1200	1960	1975
250	Mr. Submarine	1620	1979	1980
250	Ho Ho Restaurant	1620	1971	1978
250	Foto Electronix Sales	3000	1970	1970
254	Shelly's Restaurant	5100	1968	1980
254	House of Wax	5100	1966	1966
254	Bowring Bros. Ltd.	5100	1960	1964
256	Edwin Murray Ltd.	5400	1960	1980
256	Porthole	5400	1960	1961
258	Edwin Murray Ltd.	5400	1970	1980
258	Roper & Son (Jeweller)	5400	1960	1964
262-64	Direct Way Ltd. (Retail)	1560	1973	1978
262-64	R. E. Innes & Co.	1560	1960	1970
266-68	R. E. Innes & Co.	2847	1960	1970
270	Neyle Soper Hardware Ltd.	2000	1960	1980
272	Neyle Soper Hardware Ltd.	3000	1960	1980
274	Neyle Soper Hardware Ltd.	1276	1960	1966
276	Cabot Optical Ltd.	3000	1975	1980
276	City & Guild	5220	1974	1974
276	Fraser Clouster (restaurant)	1200	1960	1973
278	Roy O'Brien-Music Store	780	1960	1980
280	Royal Show Repair	450	1976	1980
282	The In Thing	2900	1980	1980
282	Downtown Restaurant	2900	1962	1976
284	Mitchell Fur	3600	1978	1980
284	Filter Queen (electrical)	3600	1968	1969
286	Nonia	903	1972	1980
288	Neyle Soper Hardware Ltd.	2795	1960	1970
290	Diamond Jewellery	6000	1962	1980
294	Nfld. Optical Co.	3795	1967	1980

Water Street		Size(ft^2)	Open	Close
294	W. J. Brennan (fridge sales)	3795	1972	1974
294	Bowring Brothers	3795	1970	1970
294	Geo Langmead Co. Ltd.	3795	1960	1966
294	Funtime Amusement	1800	1979	1980
296	Footware Supplies	2900	1979	1980
296	Irene	2900	1960	1978
296	Koch Shoes	2900	1960	1961
300	Footware Supplies	1900	1979	1980
300	Irene	1900	1960	1978
302	Capital Lounge	2760	1960	1980
304	Gourmet Kitchen	2700	1978	1980
304	Winsome Restaurant	2700	1974	1977
304	Hwy. Snack Bar	2700	1973	1973
304	Patricias Snack Bar	2700	1971	1972
304	House of Flowers	2700	1960	1969
306	Melendy's Sales	4860	1968	1980
308	Hudson's Bay Co.	4623	1978	1980
308	Resik Exporters Ltd.	4623	1976	1977
308	Liquor Store	4623	1968	1974
308	P.J. Grouchy Ltd.	4623	1963	1967
308	Julius Schwatz	4623	1960	1962
310	E & W Restaurant	3000	1969	1980
310	Joseph Lee Restaurant	3000	1968	1968
310	R. J. Grouchy Ltd.	3000	1964	1966
310	White Lilly (rest.)	3000	1960	1963
312	Wilansky & Sons Ltd.	7200	1960	1980
318	Avalon Jewellers	3600	1964	1980
318	Simon Levits & Sons Ltd	3600	1960	1963
320	Kelly's Stereo Mart	9008	1978	1980
324	Laracys Reme Shop	2600	1960	1980
326	Sports Craft Ltd.	3600	1970	1980
326	Wm L. Chafe & Sons Ltd.	3600	1968	1969
330	Wm L. Chafe & Sons Ltd.	2900	1970	1980
332	Mario Hairstylist	3150	1967	1980
332	Daniel & French Pastry	3150	1961	1961
332	GUS Winter Ltd.	3150	1960	1960
334	Mantrap	4800	1974	1980
334	M Connor Ltd - Pet Shop	1800	1960	1973
334	M Connors - Druggist	3600	1960	1969
	Osmond Furniture (10 Adelaide St.)	1500	1972	1980
336	Macneill's Music	3840	1976	1976
336	M Connors Ltd.	3000	1970	1973
336	Avalon Credit Jewellers	3000	1960	1963
338	Quality Woodstoves Ltd.	8500	1980	1980
338	Lewis Ferman & Co.	3000	1960	1977
340	Silver's Jewellery	2448	1960	1980

Water Street		Size(ft²)	Open	Close
342	Silver's Jewellery	3600	1960	1980
348	Sports Unlimited	7125	1978	1980
350	Capri Ltd.	7680	1980	1980
362	Trask Foundry Ltd. (Stove)	2400	1960	1980
364	Trask Foundry Ltd.	3000	1980	1980
366	The Uniform Shop	1200	1975	1976
368	Lucky's Chop Suey House	1610	1970	1980
370	W. B. Thomas	1200	1960	1961
370	Leon Alexander	1200	1962	1963
370	W. J. Jones (Tobacconist)	1200	1964	1976
372	Peter Boulos (Watchmaker)	1440	1968	1979
372	H. F. Fanning & Sons	750	1971	1972
372	Towns Cafe	750	1966	1966
372	Tom's Rest	750	1961	1965
372	Deluxe Cafe	750	1960	1960
374	F Fanning & Sons (Statny)	750	1960	1972
376	London Cafe	960	1960	1972
386	Standard Bedding Co. Ltd.	1200	1966	1980
386	Kenneth Ruby Ltd (Hrdw)	1200	1960	1965
390	Char Broil	2100	1975	1975
390	Robert Carter (Second Hand)	2100	1960	1966
392	Esquire Lounge	2460	1961	1980
394	Town & Country Rest	3100	1960	1980
398	Leon Alexander (Retail)	3500	1960	1968
402	Orchid Grill	1200	1960	1980
404	Albert J. Tob(retailer)	660	1968	1971
408	Rideouts Elect. Ser.	2000	1960	1968
410	Jackman Furniture & App	2400	1972	1977
414	Capitol shoe Hospital	2000	1960	1961
418	Wm. Noseworthy (Hardware)	1200	1960	1978
426	Radio Shack	6000	1974	1980
426	Canam Ltd.	4800	1972	1973
430	Liquor Store	15376	1966	1980
436	Wild Side Boutique	960	1973	1973
440	Nfld. Handcrafted Leather	1080	1975	1975
440	Jack Fizgerald (novelty)	1080	1972	1974
446	Riveria Lounge	2268	1973	1980
448	Riveria Tavern	2000	1960	1969
450	Ron's Take-Out	1200	1974	1974

Water Street		Size(ft^2)	Open	Close
454	Capitol Shoe Hospital	600	1962	1963
456	Station Grill (rest.)	600	1960	1960
458	Pothole Tavern	600	1960	1961
468	T.V. Radio Service Ltd.	1920	1966	1970
472	E & S Barbour Ltd. (Hardware)	1200	1960	1971
476	Ashley Electric Ltd.	3760	1960	1961
478	Tony's Tailor	1080	1978	1980
484	Lanternlite	1020	1967	1980
484	Joseph Lee (Rest.)	969	1960	1966
488	Peter O'Mara	1500	1960	1980
524	Callahan's Co.	1600	1960	1979
524	Tempo Photo (Commercial Photo)	507	1973	1978
524	J. E. Campton Ltd.	507	1962	1963
528	Healey's Pharmacy	500	1966	1967
556	W J Murphy Ltd.	720	1960	1977
562	Gallery Mason	1200	1974	1977
566	Mamzelles	1050	1964	1964
586	Copperfield's Take out	2100	1979	1980
586	Gord's Take out	2100	1977	1978
586	Mom's Take-out	2100	1974	1975
586	Marty's Ltd.	1500	1976	1973
732	Superior Optical Ltd.	1440	1973	1980
736	Edward Drug Store	1800	1960	1980
99	Albert E. Furey (Yamaha)	2250	1973	1977
99	Harris & Hiscock Ltd. (Hardware)	1560	1967	1977
123-25	National Office Equip	5100	1970	1980
153	Royal Stores Ltd.	3000	1970	1971
153	Tandy Leather	3000	1972	1979
157	Royal Stores	3000	1971	1972
159	Martin Royal Store (Hardware)	1920	1960	1966
161	Kings Head Lounge	6720	1978	1980
161	Waterfront Club	6720	1970	1977
163	Butler Brothers Ltd. (Stationery)	3000	1960	1962
165	Happy Gardens	2890	1973	1980
165	Marty's Ltd. (rest.)	1800	1966	1972
165	Jardine Brothers (Hrdw)	1800	1960	1961
165	Parker & Monroe	1800	1962	1965
169	Harris & Hiscock (Hrdw)	7962	1960	1980
171	Model Shop (dry gds.)	4200	1960	1968
173	The Model Shop	7500	1960	1979
175	London, NY & Paris	2100	1975	1980
175	Sherwin Williams (retail)	3570	1960	1974

Water Street	Size(ft^2)	Open	Close
177-79 London NY & Paris	4800	1960	1973
179 London NY & Paris	51780	1960	1980
187 Martha's Company Ltd.	3760	1978	1980
187 Sergios Place	3760	1974	1977
187 Sea Breeze Lounge	3760	1975	1977
187 Atlantic Films & Elect	2100	1967	1980
187 Shamrock Ent. Rest.	2100	1973	1973
187 Fogo-A-Go-Go-Ltd.	2100	1971	1973
187 The Musical Clock (Flm. & Cam.)	2100	1960	1966
193 Parker & Monroe	2549	1960	1980
195 Parker & Monroe	2549	1960	1980
197 R H Trapnell Ltd.	3150	1960	1980
199 Oceans of Notions	1680	1973	1973
199 Music Centre	16 0	1971	1972
199 W H Ewing & Son	1680	1960	1970
201 Funland	1045	1977	1980
201 Arcade Stores	5000	1968	1975
201 Mid Town Goods (Dry Goods)	5000	1962	1967
201 If Perlan & Co.	5000	1960	1961
203 Arcade Stores	4500	1960	1973
209 S Milley Ltd (Dry Good)	4200	1960	1973
211 Sally Shops (Dry Goods)	4200	1960	1972
213 Sweet Shop Ltd. (rest.)	4200	1960	1968
215 Metropolitan Stores	73926	1978	1980
<u>Atlantic Place</u>			
Dalmy's Canada	19002	1978	1980
Thrifty's Riding Shop	17430	1978	1980
Tiptop Tailors	17860	1978	1980
Fredells'	4842	1978	1980
Eastern Reitman's	18721	1978	1980
Eastern Reitman's	9226	1978	1980
Pennington Stores	21194	1978	1980
People's Jewellers	16537	1978	1980
Sally's Shop Ltd.	10293	1978	1980
Lewis shoes 1976 Ltd.	16040	1978	1980
Artistic Hairstyle	3440	1978	1979
Shirley K Maternity	9008	1978	1978
The Last Word	9849	1978	1979
Rhodi Services Ltd.	3766	1978	1980
Atlantic Fur Ltd.	4288	1979	1980
Dairy Queen	1000	1979	1980
Avalon Lounge	36742	1978	1980
Readmore	9551	1978	1979
Rhodi Services Ltd.	7254	1978	1980
Optical Centre	4221	1978	1980

Water Street	Size(ft^2)	Open	Close
215 Ayres Ltd.	4500	1964	1970
225 Ayres Ltd.	14000	1960	1970
239 Leon Green	1500	1960	1961
239 Jack Bell	1500	1962	1963
243 Nfld. Liquor Commission	15050	1975	1980
243 Dicks & Co.	800	1960	1980
245 Dicks & Co.	770	1960	1980
Ayre's Ltd.	7800	1960	1980
Ayre's Ltd.	4500	1960	1980
249 Ayre's Ltd.	1800	1960	1980
249 Ayre's Ltd.	14800	1960	1980
251 Ayre's Ltd.	2000	1960	1980
Ayre's Ltd.	5630	1960	1980
Ayre's Ltd.	2080	1960	1980
Bowring Brothers	84000	1960	1980
Bowring Brothers	3900	1960	1980
Bowring Brothers	3900	1960	1980
Signal hill Restaurant	4800	1974	1980
283 Agnew Surpass Shop	8400	1960	1980
295 House of Spectacles	3366	1975	1980
295 Jeans & Things	2880	1973	1974
295 Modern Clothing Store	1920	1960	1972
295 City Radio & Music (Electrical)	1920	1960	1975
297 City Radio & Music Co.	6240	1960	1972
299 City Radio & Music Co.	1500	1960	1975
301 Marty's Ltd.	5400	1960	1980
303 Thompsons Jewellers	8400	1960	1980
D1-1 Speakeasy & Co. Ltd.	16809	1980	1980
E1-1 Children's World	5087	1980	1980
F1-1 Chez Margot/Marco Cutt	3471	1980	1980
I1-2 Mary Janes Too	7323	1980	1980
I1-4 Gatsby Ltd.	2495	1980	1980
J-K-1-2 Russell's Ltd.	40916	1980	1980
D2-1 Living Rooms	14877	1980	1980
D2-2 Coffee Time	2093	1980	1980
I2-3 Atlantic Arts	4366	1980	1980
I2-4 Chique Ltd.	8930	1980	1980
309 Tooton's Ltd.	6000	1960	1980
315 Issac Levitz	6000	1968	1976
317 Popular Clothing	6800	1960	1980
319 Lee's Furniture	4800	1967	1970
319 Spring Garden Restaurant	3400	1973	1980
319 Foremost Furniture & App. Ltd.	3400	1965	1966
319 Margaret Golick Footwear	3400	1964	1964

Water Street		Size(ft^2)	Open	Close
323	Sally shop Ltd.	3500	1960	1962
325	Lee's Ltd. (dry good)	3600	1966	1980
325	Sheffman Bros	3600	1960	1965
327	G.E. Oil & Imp Co. Ltd.	8900	1966	1973
335	The Big Six Ltd. (dry good)	3750	1960	1973
337	The Big Six Ltd. (dry good)	3000	1961	1973
321	Sally shops Ltd.	5000	1960	1980
339	The Big Six Ltd. (dry good)	3600	1966	1973
339	Jeans and Things	5560	1975	1978
341	Premier Garment Co. Ltd	4200	1960	1974
343	Robert A Templeton	660	1960	1974
345	The Arcade Store	32000	1962	1980
349	The Arcade Store	7000	1960	1980
349	The Arcade Store	13000	1960	1980
351	Woolworth	154600	1960	1980
352-55	F.W. Woolworth Co. Ltd.	86000	1960	1980
357	Mrs. Lee Swartz	5000	1960	1964
359	Mrs Lee Swartz	5000	1960	1964
359a	Mrs Lee Swartz	5000	1960	1964
361	Parker & Monroe	9500	1960	1980
363	Parker & Monroe	7400	1966	1980
365-67	Emporium Furniture Ltd	32000	1980	1980
643	Park View Lounge	1360	1971	1980
643	Taverns Park Inn	1360	1960	1970
659	Elect App. Serv.	1000	1961	1962
703	West End TV Ltd.	300	1971	1973
705	West End TV Ltd.	1080	1960	1973
707	West End T.V.	1000	1960	1961
713	Canadian Westinghouse Ltd.	2400	1964	1973
719	West End Tavern	1500	1964	1980
803	London NY & Paris	21000	1967	1980
807	McLoughlan Supplies Ltd.	4200	1967	1973
Starboard Restaurant		15219	1969	1973
The Light-Restaurant		31900	1974	1974

Appendix II

Retail Expenditures by Census Tracts (1960-1980)
for St. John's CMA

High-Order Retail Expenditures By Census Tracts 1960-1981 (millions of dollars)

CT	1960	1961	1962	1963	1964
1.00	2.99	3.37	3.10	3.23	3.47
2.00	10.38	11.70	10.76	11.22	12.04
3.00	3.51	3.71	3.64	4.02	4.56
4.00	4.35	4.60	4.50	4.98	5.65
5.01	7.03	8.31	7.53	7.74	8.19
5.02	9.37	11.08	10.04	10.32	10.92
6.00	17.88	19.76	17.42	17.40	17.88
7.00	14.19	12.90	11.71	12.05	12.78
8.00	7.18	6.68	6.01	6.13	6.43
9.00	2.87	2.18	1.93	1.94	2.01
10.00	8.69	6.58	6.02	6.25	6.67
11.00	8.49	10.26	9.38	9.72	10.38
12.00	8.87	10.66	9.73	10.07	10.73
13.00	4.74	6.07	5.48	5.61	5.91
14.00	8.07	8.32	7.85	8.40	9.23
15.01	2.15	2.27	2.22	2.46	2.79
15.02	2.53	2.67	2.61	2.89	3.28
15.03	2.98	3.15	3.08	3.41	3.86
16.00	5.71	6.03	5.91	6.54	7.41
100.01	2.09	2.20	2.16	2.39	2.71
100.02	2.32	2.45	2.40	2.66	3.01
170.00	3.13	3.31	3.24	3.58	4.06
171.00	3.44	3.63	3.56	3.94	4.46
172.00	2.86	3.02	2.96	3.27	3.71
200.01	1.16	1.22	1.20	1.33	1.50
200.02	4.15	4.38	4.30	4.75	5.39
201.00	1.52	1.61	1.58	1.74	1.98
202.00	2.82	2.98	2.92	3.23	3.66
300.00	2.17	2.30	2.25	2.49	2.82
301.01	.00	.00	.00	.00	.00
301.02	.00	.00	.00	.00	.00
302.00	.00	.00	.00	.00	.00
303.00	.00	.00	.00	.00	.00

High-Order Retail Expenditures By Census Tracts 1960-1981 (millions of dollars) cont'd

CT	1965	1966	1967	1968	1969
1.00	3.63	3.21	3.27	3.68	3.63
2.00	12.61	11.15	11.37	12.76	12.61
3.00	5.02	4.66	5.18	6.27	6.62
4.00	6.22	5.77	6.41	7.76	8.20
5.01	8.46	7.37	7.45	8.30	8.14
5.02	11.27	9.83	9.93	11.06	10.84
6.00	17.90	15.12	14.67	15.68	14.77
7.00	13.21	11.54	11.24	12.06	11.40
8.00	6.59	5.70	5.49	5.83	5.45
9.00	2.03	1.73	1.67	1.77	1.66
10.00	6.95	6.12	5.93	6.33	5.96
11.00	10.81	9.51	9.36	10.16	9.72
12.00	11.16	9.80	9.59	10.34	9.83
13.00	6.08	5.28	5.17	5.57	5.30
14.00	9.90	8.95	8.99	9.95	9.70
15.01	3.07	2.85	3.16	3.83	4.04
15.02	3.61	3.35	3.72	4.51	4.76
15.03	4.26	3.95	4.39	5.31	5.61
16.00	8.17	7.57	8.41	10.19	10.76
100.01	2.98	2.77	3.07	3.72	3.93
100.02	3.32	3.08	3.42	4.14	4.38
170.00	4.48	4.15	4.61	5.59	5.90
171.00	4.92	4.55	5.07	6.13	6.48
172.00	4.09	3.79	4.22	5.10	5.39
200.01	1.66	1.54	1.71	2.07	2.18
200.02	5.94	5.50	6.12	7.41	7.82
201.00	2.18	2.02	2.25	2.72	2.87
202.00	4.04	3.74	4.16	5.04	5.32
300.00	3.11	2.88	3.21	3.88	4.10
301.01	.00	.00	1.14	2.48	3.58
301.02	.00	.00	.75	1.63	2.35
302.00	.00	.00	.57	1.24	1.79
303.00	.00	.00	.60	1.31	1.89

High-Order Retail Expenditures By Census Tracts 1960-1981 (millions of dollars) cont'd

CT	1970	1971	1972	1973	1974
1.00	4.09	4.40	4.51	4.46	4.99
2.00	14.18	15.28	15.42	15.00	16.49
3.00	7.90	8.97	10.07	10.81	13.03
4.00	9.78	11.11	11.09	10.67	11.59
5.01	9.08	9.72	9.52	8.98	9.54
5.02	12.11	12.95	12.84	12.25	13.20
6.00	15.84	16.28	15.81	14.78	15.56
7.00	12.28	12.67	12.31	11.50	12.11
8.00	5.79	5.90	5.73	5.35	5.62
9.00	1.76	1.80	1.77	1.69	1.81
10.00	6.38	6.55	6.44	6.10	6.51
11.00	10.59	11.06	10.92	10.39	11.16
12.00	10.64	11.03	10.95	10.47	11.30
13.00	5.73	5.95	5.98	5.79	6.34
14.00	10.77	11.46	11.40	10.93	11.83
15.01	4.82	5.48	6.93	8.13	10.51
15.02	5.68	6.45	8.07	9.42	12.11
15.03	6.69	7.60	7.35	6.83	7.15
16.00	12.83	14.58	14.83	14.55	16.12
100.01	4.69	5.33	5.97	6.41	7.71
100.02	5.22	5.93	6.65	7.13	8.59
170.00	7.04	7.99	9.01	9.70	11.72
171.00	7.73	8.78	8.94	8.78	9.74
172.00	6.43	7.30	9.29	10.95	14.20
200.01	2.60	2.96	3.16	3.25	3.78
200.02	9.33	10.60	11.33	11.66	13.54
201.00	3.43	3.89	4.04	4.05	4.58
202.00	6.34	7.21	7.76	8.03	9.37
300.00	4.89	5.55	5.88	6.00	6.90
301.01	5.22	6.84	7.34	7.57	8.81
301.02	3.43	4.49	4.82	4.97	5.78
302.00	2.61	3.43	3.62	3.68	4.23
303.00	2.76	3.62	3.77	3.78	4.28

High-Order Retail Expenditures By Census Tracts 1960-1981 (millions of dollars) cont'd

CT	1975	1976	1977	1978	1979
1.00	4.74	5.37	4.04	4.14	3.94
2.00	15.41	17.18	12.61	12.62	11.74
3.00	13.28	16.05	12.47	13.19	12.96
4.00	10.71	11.78	9.37	10.12	10.14
5.01	8.61	9.24	6.74	6.70	6.19
5.02	12.08	13.18	9.64	9.61	8.90
6.00	13.88	14.72	10.51	10.21	9.21
7.00	10.81	11.46	8.15	7.87	7.05
8.00	5.01	5.30	4.02	4.15	3.99
9.00	1.64	1.78	1.31	1.31	1.23
10.00	5.90	6.37	4.64	4.61	4.25
11.00	10.17	11.05	8.02	7.94	7.29
12.00	10.36	11.32	8.22	8.14	7.48
13.00	5.89	6.54	4.75	4.71	4.33
14.00	10.89	11.94	8.73	8.70	8.06
15.01	11.32	14.34	10.93	11.36	10.97
15.02	13.01	16.42	12.67	13.31	12.99
15.03	6.33	6.66	5.14	5.41	5.28
16.00	15.19	17.07	12.85	13.18	12.58
100.01	7.85	9.49	7.44	7.94	7.87
100.02	8.74	10.56	8.23	8.74	8.61
170.00	11.96	14.49	10.88	11.14	10.61
171.00	9.20	10.35	7.73	7.88	7.46
172.00	15.33	19.45	16.31	18.43	19.18
200.01	3.72	4.37	3.65	4.11	4.27
200.02	13.34	15.65	11.99	12.52	12.14
201.00	4.40	5.04	3.85	4.01	3.88
202.00	9.28	10.94	8.53	9.04	8.90
300.00	6.75	7.86	6.09	6.41	6.28
301.01	8.70	10.23	7.68	7.86	7.48
301.02	5.71	6.71	5.19	5.47	5.35
302.00	4.12	4.79	3.80	4.10	4.10
303.00	4.12	4.73	3.61	3.74	3.61

High-Order Retail Expenditures By Census Tracts 1960-1981 (millions of dollars) cont'd

CT	1980	1981
1.00	3.95	3.60
2.00	11.47	10.21
3.00	13.37	12.54
4.00	10.63	10.14
5.01	6.00	5.30
5.02	8.66	7.67
6.00	8.69	7.46
7.00	6.61	5.63
8.00	4.03	3.71
9.00	1.20	1.07
10.00	4.11	3.63
11.00	7.03	6.18
12.00	7.22	6.35
13.00	4.19	3.68
14.00	7.84	6.95
15.01	11.12	10.28
15.02	13.32	12.43
15.03	5.42	5.06
16.00	12.61	11.51
100.01	8.18	7.73
100.02	8.90	8.37
170.00	10.61	9.68
171.00	7.42	6.73
172.00	20.80	20.43
200.01	4.62	4.53
200.02	12.37	11.48
201.00	3.94	3.64
202.00	9.20	8.65
300.00	6.45	6.03
301.01	7.47	6.81
301.02	5.50	5.14
302.00	4.29	4.08
303.00	3.67	3.39

Source: Author's Calculations, Statistics Canada and Financial Post Survey of Canadian Markets

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