THE IMPACT OF CLIMATE ON THE RETAIL COMMUNITIES OF VANCOUVER AND VICTORIA : A DOLLAR VALUE ASSESSMENT

by

ANGUS D'ARCY WHITMORE

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ABSTRACT

The effect of climate on the various components of the retail system is difficult to trace but its cumulative effect is shown by variations in the sales volume. Since unexpected climatic events are most likely to bring about changes in shopping patterns, mean climates were established for Vancouver and Victoria during the period 1961-1967 as a basis for this study. Variations from these mean climates were correlated with adjusted sales figures of selected retail categories over the seven-year period using a multiple, stepwise, linear regression model. Those climatic elements registering the greatest number of sales associations were wind, precipitation and cloud cover, while those elements associated with the greatest value of monthly sales variation were temperature and sunshine. The most sensitive retail categories for both centres were found to be jewellery stores, fuel dealers and motor vehicles, whereas the least sensitive were food other than groceries, general and variety stores. From the linear relationship between climate and retail sales deviations for both cities, the dollar value of a specific climatic variation from the normal was estimated for all significant climate-sales associations. A more accurate assessment of this climatic effect on the retail economy of a region will be realized only when the quality and quantity of available retail data are substantially improved. The study revealed a method for obtaining the value of a unit measure of climatic change to the retail economies of Vancouver and Victoria. A climatic index was devised to enable comparisons of the climatic effect on sales between categories and between cities.

Examiners : [redacted]

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CHAPTER I

INTRODUCTION

Climate, one of the earth's major resources, has an undeniable effect on many human activities, but a precise evaluation of this impact has tended to elude climatologists. This is partly due to the complex task of relating climate, composed of numerous variables, to the results of the equally complex process of human decision-making. As Lord Kelvin (1891, pp. 80-1) stated:

> When you cannot measure what you are speaking about, when you cannot express it in numbers, your knowledge is of meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of a science, whatever the matter may be.

When mathematical and economic techniques do exist to deal with such a problem,

> ... In too many instances, the lack of specific economic data is the chief cause of inability to apply these modern management tools. Climatological data are readily available; weather forecasts are given wide distribution. The processing of large amounts of data is no longer a bottleneck (McQuigg, 1965, p. 188).

In spite of the paucity of suitable economic data, there is still a need for further research into evaluating the effects of weather and climate on economic activities. This is stressed by various authorities, in particular the United States Department of Commerce (1964), the Australian Bureau of Meteorology (1965), McQuigg (1965), Sewell, Kates and Maunder (1965), Sewell (1966), Thompson (1966), and Maunder and Whitmore (1969).

One of the most recent and comprehensive summaries of research concerning the economic effects of weather and climate was produced by Maunder (1970). It became evident during the time that I assisted Dr. Maunder in the survey and compilation of information for his book, that while there were numerous published articles on weather-related events, few actually assessed in dollar terms the effect of weather variations on economic activities in a region.

Considerable attention was given to agroclimatological research, but most studies were restricted to showing the relationship between various weather elements, or combinations of elements, and productivity. Several studies, however, have assessed the effect of weather on a specific economic activity; for example, Lave (1963) investigated the raisin industry in California, Changnon and Neill (1968) concentrated on corn yields in central Illinois. One study by Maunder (1965) attempted to assess the value of weather in relation to the national agricultural income of New Zealand.

Extensive econoclimatic studies have been made of the aviation industry. Included among these are reports on the economic impact of weather information on aviation operations by Bollay and Associates, Inc. (1962), the cost of flight delays caused by adverse weather (Barry, 1965), and the assessment of fog dispersal at airports (Beckwith, 1966). In addition to the aviation-related studies, the technique of weather routing of ships is discussed by a number of authorities, including the reports of Cummins (1965), Spicer (1967) and Evans (1968).

Other sectors of the economy also are sensitive to weather. Utilities, such as gas, oil, electrical and water companies, are greatly influenced by variations in the weather, but only a few studies have attempted to assess this impact. McQuigg and Thompson (1966) deal with the natural gas distribution of Columbia, Missouri. Johnson, McQuigg and Rothrock (1969) studied temperature modification in relation to production cost of electrical power generation in the United States. Russo (1966) studied the effect of critical weather elements on the construction industry in an endeavour to determine the benefits and costs of weather information.

Assessment of the weather effect on retail trade has received only limited attention by climatologists, economists, and retailers, in spite of the importance of this sector of trade to a country's economy. Those studies which have attempted an assessment are concerned with a particular product or an individual retail outlet. Little is known about the effects of weather and climate on the retail economy of a region. If this information were available, retailers would be able to coordinate more closely their advertising and sales campaigns, and those involved with weather-sensitive products could operate more efficiently. This information would also be of value to those assessing the economics of weather forecasting and weather modification programmes. As Linden (1962, p. 16) stated in regard to retail trade:

> ... it is a fact that weather has a powerful effect on demand. With a little research and some imaginative application marketers can make it a profitable ally.

It was decided, therefore, to investigate weather effects on retail trade and to assess as accurately as possible the impact of weather on the retail economy of a region. Only eight of the few published studies on this topic were found to have a direct bearing on this research.

The most valuable study with respect to methodology was conducted by Steele (1950) into the effect of weather on daily department store sales in Des Moines, Iowa. He used five weather elements to describe the weather situation for a particular time period. After adjusting the retail sales to allow for the shifting date of Easter,Steele used multiple regression analysis to associate the adjusted sales with five weather elements. The overall results showed that 88 percent of the variance in stores sales was accounted for by the selected weather parameters and by the adjusted sales. Based on this, he proposed several interesting practical applications for his statistical study. The estimating equations could be used to forecast sales in advance by substituting the forecast weather into the equation, or they could be used to calculate daily sales potential using actual weather observations rather than forecasts. In addition, he recommended that the seasonally adjusted department stores sales published by the Federal Reserve Board in the United States should be corrected for the effect of weather in order to make the data more meaningful.

The literature also revealed that temperature was the element most often associated with the sales fluctuation of a specific commodity. Zeisel (1950) found a direct relationship between temperature and sales of cold beverages in Rhode Island. The first of two studies by Linden (1959a) investigated the influence of adverse weather on customer traffic in New York department stores. He found that the relationship between weekly weather and weekly sales demonstrated a parallel behaviour with a frequency much greater than could be attributed to chance alone. In his second study (1959b) he discovered that sales of a wide range of merchandise in New York department stores, particularly at seasonal turning points, were sensitive to temperature variations. Specifically, clothing, sportswear, and millinery sales were most weather sensitive, especially in September and October. In a later study Linden (1962) correlated the sales of women's winter coats in New York department stores with temperature and determined that the weather-sales relationship had a high correlation (sensitivity) in September, but later in the year the sensitivity decreased.

One of the tasks of the Dominion Bureau of Statistics, now called Statistics Canada, and the Federal Reserve Banks of the United States is the interpretation of monthly economic data. A major problem is to explain the sales variations that still occur, even after the sales have been adjusted to account for seasonable changes (see Appendix I for the seasonal adjustment technique). It is felt that weather may be one of the main factors contributing to these unexplained sales variations. An attempt to identify and measure these weather influences was undertaken by Petty (1963). Monthly sales data for Chicago department stores were compared to monthly temperature and precipitation figures. The analysis showed that retail sales volume was related to temperature and to a lesser extent to precipitation. Sales of apparel were especially sensitive to warmer than usual weather in the spring and cooler than usual weather in the fall. Petty suggested that, although these monthly sales data were found to be associated with weather variations, weekly or daily sales figures would make the relationship easier to detect.

The United States Bureau of the Census has done exploratory work into the analysis of the irregular movements that appear in monthly seasonally adjusted retail sales (Appendix I). Results of this analysis were published by Shor (1964). This work is of particular interest with respect to the methodology and results. Monthly estimates of the irregular movements were developed for total retail sales and for 28 business categories, such as department, grocery, and clothing stores, over an eight year period, May 1953 through April 1961. These estimates represented the residual fluctuations after the original data had been adjusted to eliminate the estimated seasonal and cyclical factors. National monthly averages of selected weather factors were calculated for the same period. Summary weather averages were derived for January in each of the eight years, similarly for February and all the other months. Simple and multiple regression analyses were used to correlate on a monthly basis these computed weather averages with the estimates of the irregular component of retail sales. This was done for total retail sales and separately by kind-of-business.

Department and apparel stores showed significant correlations with weather in a number of months, whereas gasoline stations and drug stores had several fall and winter months with high correlations. However, Shor reported that the correlation between weather and total retail sales could not be demonstrated to be statistically significant for most months of the year. Discussing the difficulties of using national retail data and national weather averages Shor stated:

> Our major problem may lie in the fact that our sales data are too broad to reflect the effect of weather with any precision. It is too broad in a geographic sense, in that we are using national averages, and also in that we are using sales data for months rather than for shorter periods. Most previous studies which effectively related retail sales to weather dealt with the individual metropolitan area, store, or even department, and were based primarily on daily or weekly sales data (Shor, 1964, p. 56).

It is interesting to note that Maunder and Whitmore (1968) in their preliminary study on the climate-sales relationship in Canada, encountered problems similar to those recognized by Shor. In general, the results published by Shor and those of Maunder and Whitmore

(1968) clearly illustrated the inability of the available sales data to reflect the effect of weather with any precision on a national level.

The review of the literature reveals substantial gaps in knowledge of the impact of weather on retail trade. While it was shown that temperature and precipitation had the most direct effect on retail activities, little mention was made of the effect of other elements, such as sunshine, wind, humidity, and cloud cover. Only a small group of retail activities, specifically, department, clothing, and drug stores, gasoline stations, and fuel dealers are recorded as being weather sensitive, and for these sensitivity was demonstrated to vary considerably in time and place. How sensitive are other retail outlets? Steele's dissertation on the effect of weather on daily department store sales comes closest to placing a value on weather in terms of retail sales. However, the question of precise evaluation remains unanswered, that is: how much is one inch of rainfall or one degree of temperature change worth in terms of sales of a particular commodity or in terms of the retail trade of a city or larger region?

The present study endeavours to answer some of the questions raised by previous research by assessing the impact of climate on the retail economy of two cities, Vancouver and Victoria. This embraces the identification of weather sensitive retail trade establishments and of climatic elements associated with significant sales variation, with the aim of assessing in dollar terms the effect of a specific climatic variation on retail sales volume, together with an assessment of the total climatic effect on the region. As a corollary, the possibility of predicting future sales on the basis of actual or forecast weather information is investigated.

CHAPTER II

THE RETAIL SYSTEM : CLIMATE AS AN INPUT

One of the essential features of a retail system is the transaction that takes place between the consumer and the retailer (Figure 1). This transaction is the result of numerous interacting economic, social, physical and psychological factors. The more important factors are illustrated in Fig. 1. Those influencing the consumer are divided into the following categories:

1) Economic - comprises such variables as personal disposable income, credit rating and savings.

2) Social - consists of such factors as social status, styles and customs, and individual preference.

3) Psychological - includes the mental capabilities of the consumer and his response to advertising and sales promotion.

4) Physical - includes a demographic description of the consumer, his geographic location, the transportation facilities and his physical requirements.

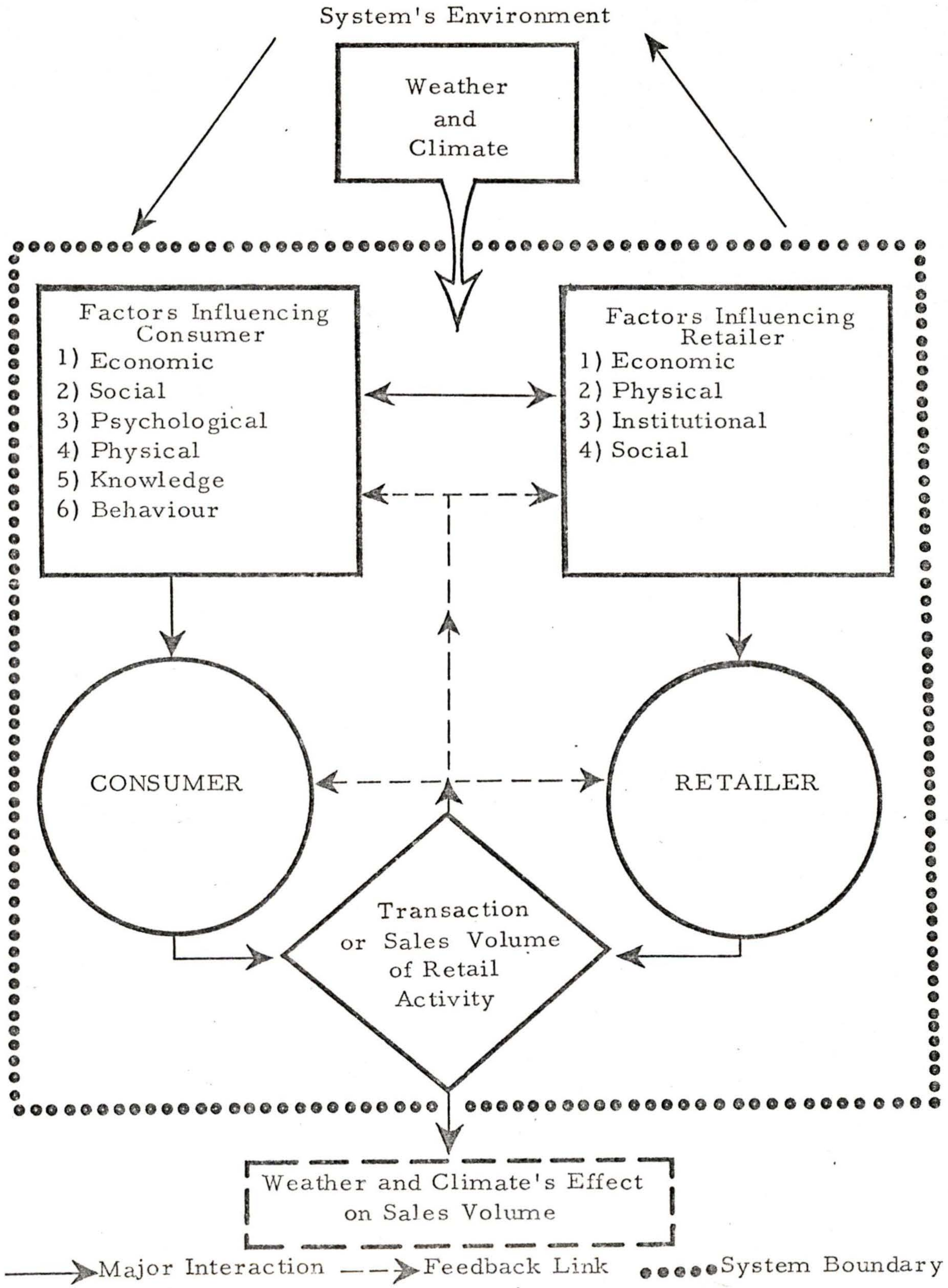
5) Knowledge - includes previous experience.

6) Behaviour - comprises the buying habits of the consumer.

It is apparent from the foregoing that there are a great number of variables influencing the consumer's decision to buy, postpone

FIGURE 1

A FLOW CHART OF A RETAIL SYSTEM



buying, or not to buy the merchandise. Similarly, there are many factors influencing the retailer's marketing techniques, including:

1) Economic - wholesale and transportation costs, operating costs, accounting and credit policies, research and marketing techniques in advertising and sales promotion, and competition with other firms.

2) Physical - location, size and function of the retail outlet, number of employees, transportation networks and communication media.

3) Institutional - the regulations and taxes of the municipal and provincial governments.

4) Social - the personal involvement of the retailer and salesman with the consumer.

Interactions also take place between these factors and groups of factors. Some of these interactions are direct and obvious, whereas others, which take place in different time periods and over considerable distances, are difficult to detect. However, analysis of such interactions is not deemed necessary to achieve the objectives of this research.

The link from the transaction to the components and factors is referred to as the feedback link. This link is a very important part of the retail system as shown by the following example. If information is given to consumers about a reduction in the price of an article, the demand for the article increases until the sale period is over or the supply depleted. The resulting sales volume provides the retailer with the feedback as to the degree of success of the merchandising campaign.

The system's environment, as designated by the problem solver, is composed of those factors which may place a demand on the system and yet are not essential to its operation. Weather and climate are part of this environment and as such influence the system in various ways. Weather may physically prevent or deter a consumer from shopping and/or a retailer from obtaining his supplies of merchandise. It may have a psychological effect on the consumer so that he alters his shopping habits. Extremely hot, humid weather may force him to seek relief in stores with air conditioning and after cooler weather returns he may continue to shop at these stores through force of habit. The merchandise itself may be weather sensitive, that is, certain articles are more desirable at specific seasons or during certain weather conditions. Although it is extremely difficult, if not impossible, to trace and evaluate directly the effects of climate through the system, it is possible to measure its total impact by analyzing the major interaction of this system, the transaction.

Preliminary studies indicate that the effect of weather and climate on sales depends a great deal on the normal climate of an area. Variations from the expected climatic conditions are likely to initiate an 'abnormal' response in the consumer and retailer, subsequently reflected in the transaction. Thus, before analysis can proceed with this study it is necessary to determine normal climates for the two cities under investigation, Vancouver and Victoria.

The climates within which the retail systems of Vancouver and Victoria operate are strongly influenced by the westerly circulation of air from the Pacific Ocean and, for the most part, the cities are protected from continental air masses by the Coast and Rocky Mountains. As a result, the two cities enjoy a mild, maritime climate characterized by cool, relatively dry summers and mild, wet winters. Both fall into Köppen's Csb (Mediterranean type) classification. Despite the overall similarities, distinct subclimates are discernible due to differences in location, topographic influences, and pressure systems (for a detailed account of the climatic controls in this region see Chapman, 1952; and Kendrew and Kerr, 1955). The main differences lie in temperature ranges, precipitation amounts and duration of sunshine (Table 1).

Vancouver has slightly cooler winter temperatures, with a mean January minimum of 33°F compared with 36°F at Victoria. Summers are warmer in Vancouver than Victoria, with mean July maxima of 72°F and 68°F, respectively. Similarly, the frost-free period in Vancouver is shorter than that of Victoria, being 213 days as against 275 days (Dept. of Transport 1967a and 1967b). The more

TABLE I

CLIMATIC NORMALS FÓR VANCOUVER AND VICTORIA

Month	City	Max. Temp.	Min. Temp.	Precip.	Snow	Wind Speed a.	Mean Hours of Bright Sun b.	Percentage of Possible Sunshine
Jan.	Van.	41.8	32.5	5.52	7.4	8.0	54.8	20
	Vic.	43.0	35.7	4.39	5.0	12.4	70.0	26
Feb.	Van.	45.5	33.2	4.74	4.4	8.1	87.7	32
	Vic.	45.9	36.8	3.22	2.3	11.8	96.7	34
Mar.	Van.	49.5	36.9	3.76	1.5	8.8	127.9	35
	Vic.	49.7	38.9	2.24	0.2	11.9	146.3	40
Apr.	Van.	55.7	40.8	2.30	0.01	8.5	182.5	45
	Vic.	55.9	42.7	1.21	0.0	11.5	210.5	52
May	Van.	62.9	47.1	1.92	0.01	8.0	250.9	54
	Vic.	61.4	46.8	0.90	0.0	11.7	275.0	59
Jun.	Van.	67.7	53.0	1.84	0.0	7.7	240.0	51
	Vic.	64.6	50.0	1.06	0.0	11.9	276.8	58
Jul.	Van.	72.3	55.3	1.04	0.0	7.5	302.6	62
	Vic.	68.0	52.2	0.57	0.0	11.4	337.0	69
Aug.	Van.	71.6	55.5	1.37	0.0	7.1	255.8	58
	Vic.	67.8	52.4	0.71	0.0	10.5	298.4	68
Sep.	Van.	65.2	50.4	2.13	0.0	7.0	189.9	50
	Vic.	64.8	50.4	1.25	0.0	8.7	208.4	55
Oct.	Van.	56.5	44.0	4.62	0.01	7.6	113.9	34
	Vic.	57.2	46.4	2.85	0.0	9.2	140.7	42
Nov.	Van.	48.6	37.6	5.44	1.0	7.9	70.1	26
	Vic.	48.8	41.0	3.92	0.7	11.3	80.9	39
Dec.	Van.	44.4	34.8	6.44	3.5	8.3	44.2	17
	Vic.	45.5	38.4	5.03	2.0	12.6	65.8	26

Note: All datawere compiled from the records published by the Meteorological Branch of the Department of Transport for the official recording stations at Vancouver and Victoria for the Standard Period 1931-1960, except for Vancouver where (a.) was 1938-1967 and (b.) 1947-1967.

extreme temperatures in Vancouver are a result of its mainland location where it is susceptible to outbreaks of continental air from the interior of British Columbia through the Fraser Canyon. However, Victoria, located on the southeastern tip of Vancouver Island, is subject to the moderating marine influence.

Situated on the windward side of the Coast Mountains, Vancouver experiences a steep gradient in annual precipitation. Values increase rapidly inland from approximately 40 inches at the Airport to 57 inches at City Hall and over 80 inches on the North Shore mountains (Wright, 1966). Victoria, on the other hand, is in the rainshadow of the San Juan Ridge and the Sooke Hills and has an average annual precipitation of only 26 inches. Hours of sunshine are correspondingly higher in Victoria, 2,200 hours compared with 1,920 hours in Vancouver.

The climate characteristics described here are the calculated normals for the standard 30 years period. The 30 year time span of these figures masks extremes and short term climatic fluctuations, although they are essential to depict the normal climates of Vancouver and Victoria.

CHAPTER III

METHODOLOGY

The previous chapters indicated that a statistical approach would be required to identify the climate-sensitive retail establishments, and to assess the climatic effect on these outlets. Before selecting a statistical technique, it was necessary to investigate the availability and quality of retail and climatic data for a specific region.

Retail Sales Data

Vancouver and Victoria were selected for this study primarily because both cities accounted for a large proportion of the total provincial retail sales, they had similar yet distinctive climates, and they were near enough to facilitate the gathering of the retail and climatic data. It was discovered that the retail information would be a restricting factor with respect to the scope and accuracy of this study. Retailers would not disclose their sales figures for research purposes even on a confidential basis, mainly a result of the competitiveness of our marketing system. As a result, the major source of retail information was the Dominion Bureau of Statistics.

The Bureau surveys all retail establishments in Canada through the decennial Census of Merchandising. Information on retail sales between census years is obtained by a monthly sample survey consisting of slightly less than ten percent of all retail trade establishments (Spoerri, 1968). Selection of the sample is by geographic area and it is based on the retail categories of the 1961 Census of Merchandising, which stratifies all outlets into sixteen major kind-of-business groupings. These sixteen categories are used throughout this study as the major retail groupings for Vancouver and Victoria (Table 2).

Major problems were encountered with the Bureau's published retail trade information. The main difficulty was the lack of monthly, seasonally adjusted retail sales data by kind-of-business for Vancouver and Victoria over a period of years (Appendix I). The 1961 Census provided sales information by retail trade groupings for each city, but this was restricted to annual totals. Monthly retail trade data by kind-of-business were available, but only in the form of provincial estimates and not for individual urban centres. Moreover, these monthly estimates were not adjusted for price changes, seasonal variation, number of shopping days and firms beginning or ceasing operations. Those estimates that were adjusted for the preceding variations on a monthly basis were available only as total sales for British Columbia and not by kind-of-business.

Comparison of total sales between one census period and another posed a problem. Every three or four years a revision occurred in the base for the seasonable adjustment of figures. This made a comparative study of retail trade for any length of time, such as a ten-year period impossible. Also, revisions by the Bureau to the

TABLE 2

RETAIL TRADE BY KIND-OF-BUSINESS COMPOSITION

1. Grocery and combination stores: grocery stores, without fresh meat; combination stores (grocery stores, with fresh meat).

2. Other food stores: bakery product stores; candy, nut stores; confectionary stores; dairy product stores; egg and poultry stores; food stores with other merchandise; delicatessen stores; other food stores.

3. Department stores: department stores; mail order offices or houses of department stores; non-department stores of department store firms.

4. General stores: general stores (more than one-third food).

5. Variety stores: variety stores.

6. Motor vehicle dealers: automobile dealers; automobile dealers, with wholesale car departments; automobile dealers, with farm implements.

7. Service stations and garages: service stations; garages.

8. Men's clothing stores: men's and boys' clothing and furnishings stores; men's and boys' furnishings stores; men's and boys' hat stores; custom tailors.

9. Women's clothing stores: women's ready-to-wear stores; lingerie and hosiery stores; accessories and other apparel stores.

10. Family clothing stores: family clothing and furnishings stores.

11. Shoe stores: men's shoe stores; women's shoe stores; children's and infants' shoe stores; family shoe stores.

12. Hardware stores: hardware stores; hardware and farm implement stores.

13. Furniture, television, radio and appliance stores: furniture and undertaker stores; furniture stores; household appliance stores; furniture, television, radio and appliance stores.

14. Fuel dealers: fuel dealers (other than oil); fuel oil dealers.

15. Drug stores: drug stores, without restaurant; drug stores with restaurant.

16. Jewellery stores: jewellery stores.

Note: For a more detailed definition of each category see Government of Canada 1961, Census of Canada Retail Trade D.B.S., Vol. VI, Part I, Catalogue No. 97508.

Standard Industrial Classification prior to 1961 placed a number of categories under wholesale which were formerly considered as retail trade. Such changes made actual comparisons between a number of categories for the census years 1951 to 1961 impossible. This made it necessary to limit the study to the period after January 1961.

The Dominion Bureau of Statistics was contacted about these problems. Officials of the Bureau were exceedingly cooperative and designed a computer programme to provide the monthly sales information for the sixteen retail categories, but only as total sales for British Columbia and not for the individual urban centres of Vancouver and Victoria. This programme was designed to overcome some of the irregular variations, such as calendar composition, the shifting date of Easter, and firms entering or leaving the business during the period January 1961 to December 1967, inclusive. The Easter adjustment, however, was applied only for department, variety, women's clothing, family clothing and shoe stores (Appendix I). The data were provided on the understanding that they would be used solely for this research project and not for publication.

Vancouver and Victoria Retail Sales

Since the retail data provided by the Bureau was only available for British Columbia, the problem was to determine the percentage of sales attributed to Vancouver and Victoria for each month of the study period, January 1961 and December 1967, inclusive. For

1961, the Census of Merchandising provided annual retail sales for each of the sixteen retail categories in both cities. These figures were expressed as percentages of the total British Columbia sales (Table 3). The Financial Post's Survey of Markets annual retail estimates were used in order to bridge the gap in the intercensal period. These figures were based on the 1961 Census distribution projected to 1965, taking into account the different rates of growth in the various provinces and cities with populations greater than 30, 000. The Vancouver and Victoria retail information was included, but only for total annual retail sales during 1962 and 1963, and for annual sales of six major retail categories during 1964 through 1967, compared to the sixteen supplied by the Dominion Bureau of Statistics. These six categories were grocery and combination, clothing, hardward, furniture, drugs and motor vehicles (The Financial Post Survey of Markets and Business Year Books 1964 to 1967).

Wherever possible the 1961 census annual percentage figures for the sixteen retail categories in Vancouver and Victoria (Table 3) were compared with the 1951 Census of Merchandizing retail data and those of the Financial Post. It was found that the 1961 percentage totals in Table 3 varied less than six percent from the 1951 annual percentage calculated in both cities for the following categories; grocery, other food, department, general, motor vehicles, garage, fuel dealers and jewellery, while the other categories were not

TABLE 3

VANCOUVER AND VICTORIA RETAIL SALES, 1961

	Retail Category	Vancouver (Percent)	Victoria (Percent)
1.	Grocery and Combination	49.8	9.8
2.	Other food stores	54.9	12.2
3.	General stores	3.1	1.6
4.	Department stores	69.6	11.5
5.	Variety stores	40.3	9.7
6.	Motor vehicle dealers	52.8	9.1
7.	Garage	45.6	8.3
8.	Men's clothing	46.9	7.5
9.	Women's clothing	64.0	9.8
10.	Family clothing	54.6	9.3
11.	Shoe stores	55.8	10.5
12.	Hardware stores	30.0	8.9
13.	Furniture and appliances	50.5	10.9
14.	Fuel dealers	55.7	17.1
15.	Drug stores	57.5	9.8
16.	Jewellery stores	56.7	12.6

Note: These figures were calculated as percentages of total British Columbia retail sales, 1961 Census.

comparable because of reclassification by the Bureau. It was found that the Financial Post's 1962 to 1967 estimates varied approximately two percent from the 1961 total annual retail sales, and for the six retail categories varied less than two percent. Thus, the 1961 percentage census figures were accepted as the best available estimate of the annual percentage of sales by kind-of-business for Vancouver and Victoria during the 1961 to 1967 period.

In order to estimate the monthly retail sales figures during the study period, it was assumed that the monthly percentage retail sales for each category would be equivalent to the annual percentage of sales calculated for a particular business category. For example, Vancouver accounted for 69.6 percent of all British Columbia department store sales in 1961. Hence the monthly percentage of Vancouver department stores sales from January 1961 to December 1967, inclusive, was considered to be 69.6 (Table 3).

One of the problems associated with this assumption was that the resulting sales figures may not adequately reflect a local climatic variation at either centre. For example, suppose that Victoria department store sales in June are lower than the estimated eleven percent average, owing to local variations from normal climate, while total British Columbia sales are higher than average, the resulting Victoria sales figure may be erroneous. In spite of this possibility no other retail sales data are available and the above procedure provides the best available estimate for monthly sales.

Transformation of the Retail Sales Data

The Dominion Bureau of Statistics had eliminated seasonal and some irregular variations from the sales data before releasing it for this study (Appendix I). However, it was still not possible to directly compare sales for a particular month in one year with sales in the same month in another year because all retail categories for both cities over the seven-year period showed increasing sales. In order to be able to make monthly comparisons, this short term economic trend was assumed to be linear and, therefore, a least-squares criterion was applied to approximate the growth rate.

The least- squares criterion involves finding the unique straight line which has the property that the sum of the squares of the deviations from this line is a minimum (Blalock, 1960). Thus, the economic trend was a straight line fitted according to the least-squares criterion in the mathematical form:

$$Y = a + bT$$

where Y is the retail sales, T is the year, a is the Y intercept, and b is the slope of the line. In this way, any sales deviations from the trend associated with climatic fluctuations could be identified and evaluated.

A computer programme was designed to calculate the least-squares line and the deviations from the expected economic trend (Figure 2). These deviations were subsequently calculated for each month during the study period and for each retail category. The deviations were coded on computer cards and later correlated with selected climatic variables.

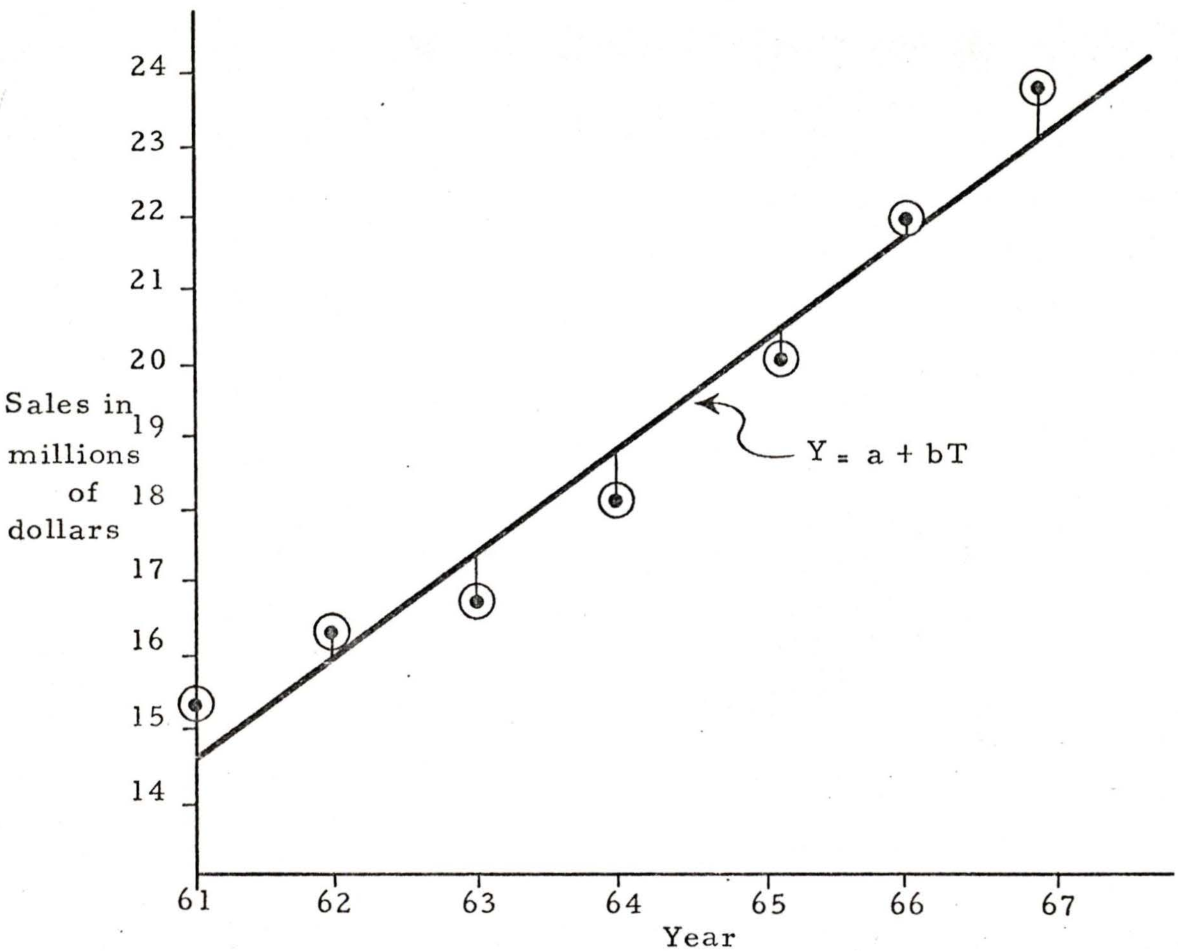
Climatic Data

All climatic data used for this analysis were taken from records published by the Meteorological Branch of the Department of Transport. The official recording stations at Vancouver International Airport and Gonzales Observatory, Victoria, were selected because of the quality, quantity, and uniformity of recorded data. In addition, the weather information available to the general public is based on the data collected and compiled at these centres.

The selection of the climatic elements was based on several considerations. Previous literature indicated that temperature, precipitation and sunshine influence sales (see Chapter I, pp. 4-8). Climatic elements recorded during the period 8:00 AM to 8:00 PM were considered of greatest value because the majority of retail sales are accounted for during this time. Finally, monthly long range weather forecasts, published only by the United States Weather Bureau, do not include more than temperature and precipitation. The long range forecasts would give added significance to this study if it were possible to determine the degree to which temperature and precipitation affected sales in Vancouver and

FIGURE 2

VANCOUVER GROCERY STORE SALES FOR OCTOBER, 1961 to 1967



Note: ⊙ denotes the actual monthly grocery store sales. Y = a + bT is the least-squares line. The deviations from the expected economic trend for October grocery store sales were:

1961	$670, 300
1962	202, 500
1963	-635, 800
1964	-668, 300
1965	-320, 300
1966	155, 600
1967	596, 200

Victoria. The possibility of using long range weather forecasts to estimate future retail sales would be opened.

Eleven climatic elements were selected for the period 1961 to 1967 (Table 4). In the subsequent statistical analysis the means for this period, called period means, were calculated for each element in both cities (Table 5 and 6). The period means were used to represent the normal climate for each centre, rather than the standard thirty-year normals, because they were more representative of the average climate for the seven-year period.

Statistical Analysis

An examination of various statistical methods indicated that linear regression analysis would be an appropriate technique for a study in which retail figures were to be related with climatic variations (Blalock, 1960; Croxton, Cowden and Klein, 1967; Croxton, Cowden and Bolch, 1969; Draper and Smith, 1967; Ferguson, 1959; and Ralston and Wilf, 1960; in addition to the literature described in Chapter I). Any examination of climate involves consideration of many variables, for example, temperature, precipitation, sunshine, and wind speed. The multiple regression procedure, which attempts to estimate the value of a dependent variable from a set of independent variables, allows a number of elements to be considered. As a means of testing the null hypothesis of no linear relationship between climatic fluctuations and retail sales variations a multiple linear regression model of the

TABLE 4

SELECTED CLIMATIC ELEMENTS

Element	Symbol
1. mean temperature recorded at 1000 hours	- T. 10
2. mean temperature recorded at 1600 hours	- T. 16
3. mean percentage of cloud cover at 1000 hours	- C. 10
4. mean percentage of cloud cover at 1600 hours	- C. 16
5. mean maximum temperature	- TMAX
6. mean minimum temperature	- TMIN
7. total precipitation (rain + snow)	- PPT.
8. total snowfall	- SNOW
9. mean hourly wind speed	- WIND
10. mean percentage of bright sunshine at 1100 hours	- S. 11
11. mean percentage of bright sunshine at 1300 hours	- S. 13

TABLE 5

PERIOD MEANS FOR VANCOUVER

MONTH		T.10	T.16	C.10	C.16	TMAX	TMIN	PPT.	SNOW	WIND	S.11	S.13
JAN.	$\overline{X}$	37.8	40.4	83.1	81.4	42.6	32.9	6.67	9.53	7.7	18.6	25.3
	SD	3.0	2.9	8.1	8.9	2.6	2.9	2.54	7.15	2.2	8.5	8.1
FEB.	$\overline{X}$	41.9	45.0	82.5	77.3	47.3	35.6	4.93	0.36	7.6	31.4	39.0
	SD	1.8	1.7	7.1	7.1	1.7	2.6	3.21	0.46	1.5	12.0	12.8
MAR.	$\overline{X}$	43.6	47.0	75.3	73.3	49.3	35.3	3.48	4.20	8.0	46.1	52.9
	SD	1.2	1.5	10.4	9.3	1.5	2.6	0.93	7.48	1.3	14.8	12.3
APR.	$\overline{X}$	48.9	52.4	78.4	74.7	54.8	40.5	2.15	0.01	7.8	48.7	53.7
	SD	1.5	1.4	5.9	9.3	1.5	2.0	0.86	0.04	1.0	9.0	8.7
MAY	$\overline{X}$	54.6	58.7	71.4	62.4	61.0	45.2	2.01	0.0	7.1	62.0	66.7
	SD	1.4	2.0	9.8	9.0	1.9	1.8	0.82	0.0	1.1	15.4	10.7
JUNE	$\overline{X}$	60.5	65.0	65.7	59.7	67.5	51.5	1.25	0.0	7.0	65.0	69.9
	SD	2.2	2.3	14.9	15.1	2.3	1.9	0.72	0.0	1.0	15.3	14.4
JULY	$\overline{X}$	63.7	68.9	61.4	50.4	71.1	54.3	1.70	0.0	7.4	65.0	70.3
	SD	1.8	2.5	12.1	10.4	2.7	1.5	1.07	0.0	1.2	13.0	10.4
AUG.	$\overline{X}$	65.2	69.6	59.1	53.1	71.9	55.2	1.65	0.0	6.4	68.1	73.6
	SD	2.5	2.9	1.6	1.2	3.0	1.2	1.10	0.0	1.0	12.8	12.3
SEP.	$\overline{X}$	60.0	63.5	65.3	61.4	65.8	50.0	2.35	0.0	6.1	62.4	68.1
	SD	2.1	2.3	5.5	6.5	2.6	2.0	1.29	0.0	1.4	8.9	10.4
OCT.	$\overline{X}$	52.3	54.3	78.0	76.6	57.2	44.1	5.57	0.0	7.1	36.7	42.7
	SD	1.3	1.2	5.9	9.0	1.5	2.3	2.86	0.0	1.1	6.9	5.4
NOV.	$\overline{X}$	44.3	46.1	84.3	81.0	48.9	37.5	5.96	0.46	7.7	28.9	31.6
	SD	1.9	1.5	6.7	7.3	1.6	2.1	0.99	0.72	2.0	10.0	7.1
DEC.	$\overline{X}$	39.1	40.8	86.3	85.3	43.6	34.2	7.43	9.94	8.0	20.9	24.0
	SD	3.0	3.1	2.4	3.5	2.7	3.3	1.65	12.36	1.0	5.1	5.9

Note: The above figures are the computed $\overline{X}$ and S. D. for each climatic element in each month for the period January 1961 to December 1967, inclusive.

TABLE 6

PERIOD MEANS FOR VICTORIA

MONTH		T.10	T.16	C.10	C.16	TMAX	TMIN	PPT.	SNOW	WIND	S.11	S.13
JAN.	$\overline{X}$	40.6	41.7	80.6	79.3	44.4	37.1	4.93	2.01	11.5	32.1	31.3
	SD	2.2	2.2	6.4	7.5	2.2	2.2	2.01	3.48	1.5	10.6	9.3
FEB.	$\overline{X}$	43.3	45.2	78.4	75.0	47.7	38.8	3.07	0.87	11.0	39.3	45.4
	SD	1.5	1.7	7.5	8.3	1.7	2.3	1.79	2.09	1.1	11.8	11.4
MAR.	$\overline{X}$	44.3	46.8	73.3	71.4	49.5	38.8	1.51	2.61	11.3	53.6	59.1
	SD	1.3	1.6	9.1	10.0	1.6	1.2	0.80	4.34	1.6	13.1	10.1
APR.	$\overline{X}$	48.7	51.0	72.6	70.9	54.1	42.3	1.33	0.03	10.7	54.6	60.9
	SD	1.3	1.1	8.5	7.0	1.5	1.1	0.31	0.05	1.5	12.5	11.6
MAY	$\overline{X}$	53.5	55.6	57.1	61.0	59.2	45.7	0.90	0.0	11.6	69.3	72.4
	SD	1.7	2.0	18.8	9.1	1.9	1.1	0.41	0.0	0.8	14.0	11.4
JUNE	$\overline{X}$	57.4	60.1	56.7	55.4	63.9	49.9	0.61	0.0	11.3	72.1	71.9
	SD	1.3	1.6	12.7	12.5	1.7	1.1	0.31	0.0	0.9	11.8	13.0
JULY	$\overline{X}$	59.7	62.6	52.1	44.1	66.9	52.4	0.69	0.0	10.1	72.9	72.3
	SD	1.8	1.8	11.1	11.0	2.0	1.3	0.50	0.0	2.1	11.5	11.0
AUG.	$\overline{X}$	60.6	63.0	52.0	47.3	67.5	52.8	0.82	0.0	9.6	76.4	78.1
	SD	1.5	1.7	13.4	11.7	2.3	0.8	0.62	0.0	1.1	10.9	12.4
SEP.	$\overline{X}$	58.0	60.0	53.7	52.7	64.4	50.9	1.27	0.0	8.3	73.9	76.4
	SD	1.6	1.9	5.3	4.2	2.1	1.4	0.60	0.0	1.1	7.8	5.7
OCT.	$\overline{X}$	51.8	53.3	73.6	69.9	56.8	46.8	3.27	0.0	9.5	45.9	50.9
	SD	0.8	1.0	5.9	9.3	1.3	1.3	2.33	0.0	0.8	9.9	12.0
NOV.	$\overline{X}$	45.3	46.1	80.1	77.6	49.0	41.6	3.75	0.39	10.6	33.9	35.0
	SD	1.7	1.5	6.1	7.0	1.6	1.9	1.78	0.90	1.3	8.4	9.0
DEC.	$\overline{X}$	41.3	42.1	82.7	82.9	44.9	38.1	4.46	3.37	11.3	25.7	27.9
	SD	2.4	2.5	4.0	3.3	2.1	2.7	0.95	5.29	1.1	6.4	8.0

Note: The above figures are the computed $\overline{X}$ and S. D. for each climatic element in each month for the period January 1961 to December 1967, inclusive.

following form was adopted:

$$\hat{Y} = a_0 + a_1X_1 + a_2X_2 + \ldots + a_nX_n$$

where $\hat{Y}$ is the dependent variable; X_1, X_2, ..., X_n are the independent variables; a_0 is the constant or Y intercept; and a_1, a_2, ..., a_n are the coefficients or weights. The multiple regression solution yields a least-squares optimal value of these coefficients for a particular set of predictors.

Application of Multiple Regression Analysis

The University of Victoria's computing facilities were used for this research. The BMD02R Stepwise Regression programme was selected from a variety of computer programmes. A detailed account of the computational procedure for this programme is presented in Dixon (1967), while the actual mathematics of stepwise multiple linear regression is discussed in detail by Draper and Smith (1967) and Efroymsen (1960). The BMD02R computes a sequence of multiple linear regression equations in a stepwise manner. These equations are obtained by adding one variable at a time and the following intermediate equations are calculated (Efroymsen, 1960, p. 192).

$$\text{i)}\quad Y = a_0 + a_1X_1$$

$$\text{ii)}\quad Y = a'_0 + a'_1X_1 + a'_2X_2$$

$$\text{iii)}\quad Y = a''_0 + a''_1X_1 + a''_2X_2 + a''_3X_3$$

$$\vdots$$

The added variable is the one which makes the greatest improvement in the 'goodness of fit' of the regression line or provides the greatest decrease in the residual sum of squares (Efroymsen, 1960). It is the variable that has the highest partial correlation with the dependent variable partialled on the independent variables that have already been added. Efroymsen (1960, p. 192) commented on this stepwise regression procedure:

> ... An important property of the stepwise procedure is based on the facts that (a) a variable may be indicated to be significant in any early stage and thus enter the equation, and (b) after several other variables are added to the regression equation, the initial variable may be indicated to be insignificant. The insignificant variable will be removed from the regression equation before adding an additional variable. Therefore, only significant variables are included in the final regression.

In this analysis the dependent variables were the transformed monthly retail data for the sixteen retail categories in Vancouver and Victoria, and the independent variables were the eleven climatic variables for both cities over the same period. In each regression equation Y represented the monthly sales deviations for one retail category, while X_1 represented T. 10, X_2 - T. 16, X_3 - C. 10, X_4 - C. 16, X_5 - TMAX, X_6 - TMIN, X_7 - PPT., X_8 - SNOW, X_9 - WIND, X_{10} - S. 11, X_{11} - S. 13. Because there were seven observations, the number of independent variables in the final regression equation was restricted to five (N-2 degrees of freedom). The decision to accept or reject the null hypothesis was based on whether or not the calculated

F-ratio for each regression equation was significant at or beyond the five percent level.

In order to determine the most efficient set of predicators, the selection involved a possible two-stage operation. The first analysis (Run A) arbitrarily selected, in order, the four climatic variables carrying the highest partial correlations with monthly sales deviations.

The output from Run A was inspected to identify the most significant F-ratio from among the four calculated. In other words, that step in the analysis which revealed the strongest climate-sales association was deemed to be the most efficient expression of the underlying relationships. For 91 percent (348/384) of the total associations evaluated, Run A yielded an optimum set of predictors. For the remaining 9 percent (36/384) a second run (Run B) was considered necessary to permit the exclusion of a predictor which had, during subsequent steps in the analysis, become non-significant. The purpose for Run B was to insure that there was no predictor, previously excluded, which would contribute significantly to the relationship. Hence, during Run B the non-significant variable was forced out of the equation and replaced, arbitrarily, by that remaining variable with the highest partial correlation. Of the 36 associations to which Run B was applied, 18 produced a more significant predictor set than was achieved by Run A (Appendix II).

Evaluating the Effect of Climate on Retail Sales

Fluctuations in climate were measured in terms of a specific climatic variation defined as: a variation of one standard deviation about the average or normal. This was the semi-range, or one-half a standard deviation above and one-half a standard deviation below the normal. For example, above normal weather will occur when conditions are equal to or greater than one-half a standard deviation above the average for a particular climatic element. Similarly, below normal conditions are recorded if a departure of one-half a standard deviation below the climatic average occurs.

To evaluate the effect of a significant climatic element on individual retail categories, the coefficient a_i in the regression equation was multiplied by this specific climatic variation, $a_i (\overline{X}_i \pm {}^1/2SD_i)$. This calculation enabled a dollar estimate of one climatic element on sales when all other climatic elements or variables were considered to be normal.

To compare this climatic effect between individual retail categories and between Vancouver and Victoria a climatic index was constructed. The index was the calculated effect on sales attributed to a variation of one-half a standard deviation in one climatic element, expressed as a percentage of the average monthly sales (Appendix II). These average monthly sales were the actual sales figures for each retail category obtained from the Dominion Bureau of Statistics and not the average transformed sales as computed in this study. Normal for the index was zero, while a positive or negative number indicated either a positive or negative association between weather and sales.

In addition to this individual assessment, the combined economic effect of all significant climatic variables on a particular retail category was calculated, in order to determine the feasibility of predicting future sales. This combined effect was evaluated by using the following multiple regression equations:

$$\text{i)}\quad \hat{Y}_A = a_0 + a_1(\overline{X}_1 + {}^1/2SD_1) + a_2(\overline{X}_2 + {}^1/2SD_2) + a_3(\overline{X}_3 + {}^1/2SD_3) + a_4(\overline{X}_4 + {}^1/2SD_4)$$

$$\text{ii)}\quad \hat{Y}_B = a_0 + a_1(\overline{X}_1 - {}^1/2SD_1) + a_2(\overline{X}_2 - {}^1/2SD_2) + a_3(\overline{X}_3 - {}^1/2SD_3) + a_4(\overline{X}_4 - {}^1/2SD_4)$$

where $\hat{Y}_A$ represents the sales deviation associated with above normal weather, and $\hat{Y}_B$ the sales associated with below normal weather; $\overline{X}_1$, $\overline{X}_2$, $\overline{X}_3$ and $\overline{X}_4$ are the means for each significant climatic element; a_0 is the constant, and a_1, a_2, a_3, a_4, are the coefficients determined by the stepwise regression programme. Thus, the total effect of above or below normal climate on retail sales would be the sum of the effect of each of the individual climatic elements when all other variables are assumed to be normal.

In applying this procedure, it should be noted that certain combinations of climatic elements will produce a climatic effect which does not reflect a typical departure from the climatic normal. For example, it is unlikely that precipitation and sunshine would both be above normal in the same month and it is impossible for cloud cover and sunshine to be above normal during the same period. Nevertheless, this procedure does provide a method of predicting future retail sales in Vancouver and Victoria, given the appropriate climatic information.

CHAPTER IV

IDENTIFICATION AND EVALUATION : A DOLLAR VALUE ASSESSMENT

Identification of the climate-sensitive retail categories was a prerequisite to the evaluation of the climatic effect. Analysis of the computer output for each city revealed the frequency with which a retail category was significantly associated with a particular climatic element. These associations were tabulated and ranked according to the number of monthly climatic associations (Table 7). From this table the sensitivity of a specific retail category to climatic fluctuation was determined by calculating the proportion of the year an individual category was significantly associated with one or more climatic elements.

The sensitivity of the categories varied from a high of fifty percent of the year for fuel dealers and jewellery stores in both cities to a low of eight percent for general, shoe, and variety stores in Vancouver, and eight percent for food other than groceries in Victoria. In many retail categories sensitivity was greater in one city than the other. For example, in Vancouver the association with climatic variations for furniture stores greatly exceeded the comparable figure in Victoria, 42 percent versus 17 percent. On the other hand, Victoria recorded more frequent associations in the case of shoe, department and drug stores; 58, 42 and 33 percent, respectively; compared with Vancouver's 8, 17 and 8 percent. Climatic fluctuations in Victoria

TABLE 7

MONTHLY CLIMATIC ASSOCIATIONS WITH RETAIL CATEGORIES

Rank	Category	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	Fuel dealers	X0		X0	X			X0		X0		0	X0
2	Jewellery	X0	X				0	X0		X0	X0	X	0
3	Motor vehicle		0		X0	X0		0	X0	X	X		
4	Hardware	X		X			0	0		X	X0	X	0
5	Garage		X	X0			0	X0		0		X	
6	Men's clothing				X	0	X0			X0		X	0
7	Shoes	0		0	0	X	0			0	0		0
8	Department		0					X0	0	X0	0		
9	Furniture	0	X			X		X0		X		X	
10	Grocery			0				0			X0	X0	X
11	Drug		0	0						0	0	X	
12	Family clothing		0			X		0		X0			
13	Women's clothing				0		X	0		X			0
14	General			0				0				X0	
15	Other food					X		X0					
16	Variety		0	0						X			

Note: Vancouver X - Victoria 0

All retail categories associated with climate in the above months were significant at the five percent level. Retail categories were ranked according to the number of monthly climatic associations.

were associated with sales variations in 63 months, amounting to 33 percent of the study period, while Vancouver had 50 months in which a climate-sales relationship existed, or 26 percent of the period. The fall sales, September through November in Vancouver and the summer sales, June through August, in Victoria showed the closest associations with climate.

The frequency with which a specific climatic element was associated with sales variations was also tabulated and ranked according to the percentage of the total possible climate-sales associations (Table 8). WIND ranked first with 26percent of the sales associations for both cities, whereas TMAX ranked last with 14. 8 percent. Later evaluation of the effect of these elements on sales showed that wind had relatively little quantitative effect on sales, whereas TMAX had considerably more effect. Nevertheless, these results indicatedthe importance of including a number of climatic elements in addition to temperature and precipitation in the analysis.

An assessment in dollar terms was made for all significant climate-sales associations in Vancouver and Victoria. The assessment was accomplished by using the calculated dollar value of a specific climatic variation on the expected sales for each retail category. Since the adjusted sales figures used were expressed in thousands of dollars, the calculated deviations must be multiplied by one thousand in order to give the dollar assessment. Consider,for example, the October grocery store sales in Vancouver which were associated

TABLE 8

FREQUENCY OF CLIMATIC ASSOCIATIONS WITH RETAIL SALES

Climatic Variable	Number of Associations				Percentage of Total Climate-sales Associations	Combined Rank
	Vancouver		Victoria			
	Number	Rank	Number	Rank		
WIND	53	1	47	1	26.0	1
PPT.	43	3	42	4	23.2	2
C.16	39	9	47	2	22.4	3
TMIN	40	6	46	3	22.4	4
SNOW	23	2	20	5	22.4	5
S.13	42	5	38	7	20.8	6
C.10	40	7	39	6	20.6	7
T.16	42	4	35	9	20.0	8
T.10	39	10	36	8	19.5	9
S.11	40	8	31	10	18.5	10
TMAX	28	11	29	11	14.8	11

Note: All associations were significant at least to the five percent level. Ranking was done according to the percentage of the total possible number of climate-sales associations.

with S.11 and T.16(Appendix II, Table II-1). The mean and standard deviation for S.11 were 36.7 and 6.9 percent, and for T.16 they were 54.3 and 1.2 degrees (Table 2). It was assumed that if T.16 remained normal the effect of a month with the mean percent of bright sunshine at eleven o'clock (S.11) one-half standard deviation below normal (36.7 - 3.46 = 33.25%)would be to deviate the grocery sales from the trend line by 828,280 dollars (-240.08 · -3.45). Conversely, a month with the amount of bright sunshine increased by one-half a standard deviation would be associated with a sales decrease below the trend line of 828,280 dollars (-240.08 · 3.45). On the other hand, if S.11 were assumed to be normal and the mean temperature at eleven o'clock (T.11) is increased by one-half a standard deviation (54.9°F) the economic effect on grocery store sales would be to decrease them from the trend line by 36,980 dollars (-61.64 · 0.6). For a decrease of one-half a standard deviation in temperature (53.7°F) the effect would be to increase sales by 36,980 dollars (-61.64 · -0.6) from the expected sales trend. Thus, the climatic effect of one standard deviation about the average on October grocery store sales in Vancouver for S.11 was -1,656,560 dollars (∓ 828,280) assuming T.16 normal; and -73,960 dollars (∓ 36,980) for T.16 assuming S.11 was normal. The negative sign in front of the climatic effect indicates a negative association between climate and sales.

In Victoria the October grocery store sales were more strongly associated with TMAX. The mean and standard deviation for TMAX were 56.8 and 1.3 degrees respectively (Table 3). The effect of an increase in mean maximum temperature by one-half a standard deviation (57.45^{o}F) would be to decrease sales from the expected trend by 48,880 dollars (-75.20 · 0.65), whereas a temperature decrease of one-half a standard deviation would increase sales by 48,880 dollars. The total for one standard deviation is -97,760 dollars.

In Appendix II, Tables II-1 (Vancouver) and II-2 (Victoria) summarize the monthly dollar assessment for each significant climatic variable that was associated with a particular retail category, with the assumption that the contributions of the remaining climatic variables in the regression equation were normal. In order to compare these dollar assessments the climatic index was used.

Climatic Index

The index was the climatic effect expressed as a percentage of the average monthly sales. It ranged from -21.1 to 17.4 percent for Vancouver sales, and from -15.8 to 16.9 percent for Victoria sales (Appendix II). This indicated that the magnitude of the climatic effect on sales variations was greater in Vancouver, even though Victoria had a greater total number of climate-sales associations. The mean percentage of average monthly sales variations was calculated and ranked for each climatic element (Table 9). The four temperature variables in both cities were associated with larger average sales

TABLE 9

MEAN PERCENTAGE OF AVERAGE MONTHLY SALES
ASSOCIATED WITH A CLIMATIC ELEMENT

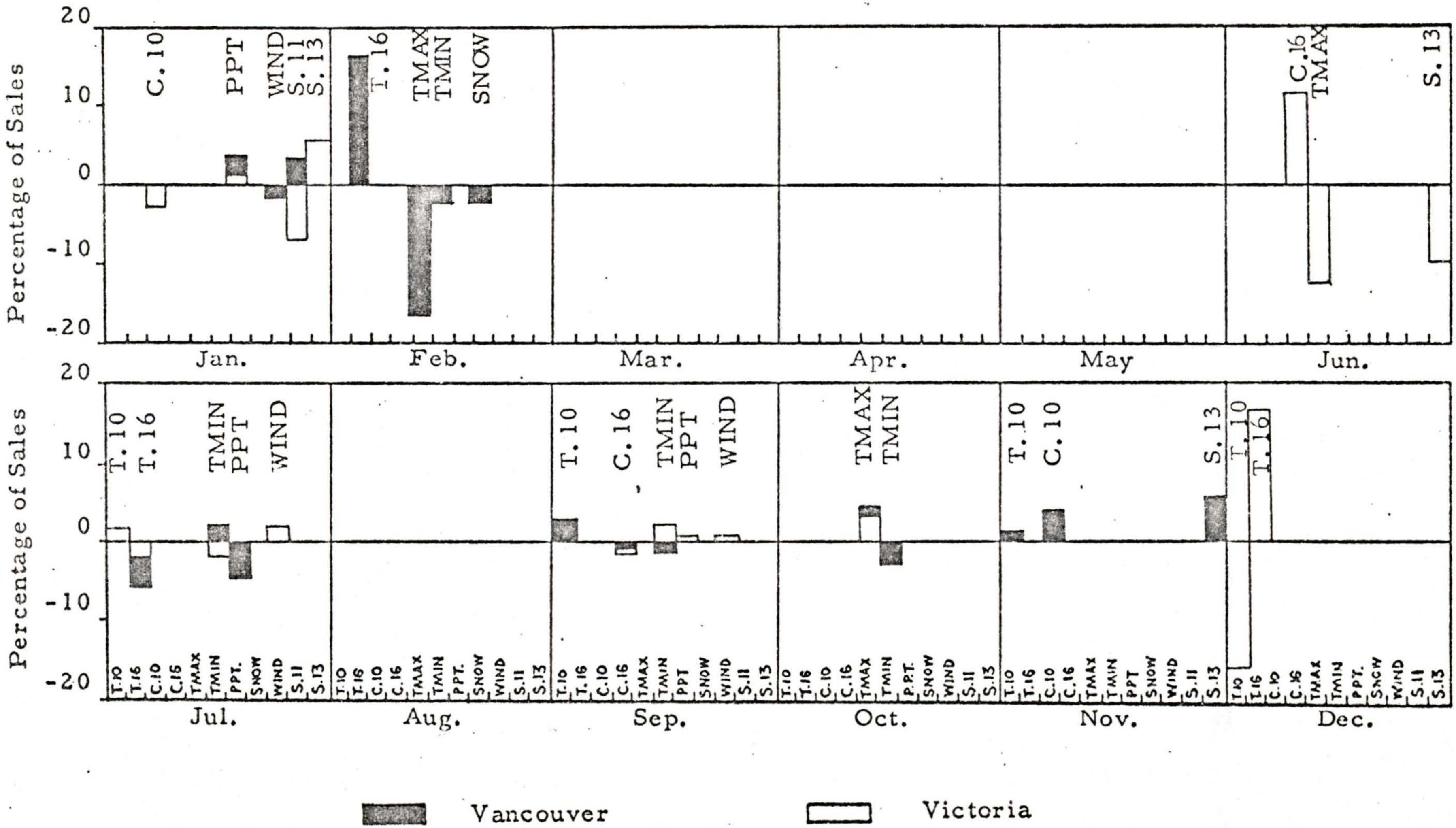
Climatic	Vancouver		Victoria	
Element	Mean Percentage	Rank	Mean Percentage	Rank
T. 10	6.4	1	4.1	4
TMAX	5.4	2	3.8	5
T. 16	4.0	3	5.7	1
C. 10	3.4	4	2.6	9
TMIN	3.2	5	4.2	3
S. 13	3.1	6	2.8	7
S. 11	2.8	7	5.3	2
C. 16	2.6	8	2.9	6
PPT.	2.5	9	1.4	11
SNOW	2.0	10	2.7	8
WIND	1.9	11	1.7	10

variations than any other climatic elements. The climatic element with the least dollar impact on Vancouver sales was wind speed, but in Victoria it was precipitation, preceded by wind. Even though wind speed had the greatest number of retail associations in both centres, the overall dollar effect was relatively small. In only two months was wind speed in Vancouver associated with a sales variation of greater than four percent of the total average monthly sales, and this was with fuel and family clothing. Victoria had only three months in which wind speed was associated with a monthly sales variation of greater than four percent, specifically in the hardware, drug, and family clothing categories. Morning cloud cover and afternoon sunshine appeared to have a slightly greater impact on sales in Vancouver than a sunny morning and cloudy afternoon, whereas the reverse was true in Victoria.

The climatic index allows the comparison of the assessed climatic effect, not only between retail categories, but also between cities. One of the interesting results of the evaluation was the significant relationship between climate and jewellery sales in both Vancouver and Victoria (Figure 3). In January, July, September and October, climate was associated with substantial sales variations in both cities, although few climatic elements were commonly significant. One element that was associated with approximately the same variation in jewellery sales in both centres was afternoon mean temperature, T. 16. In Vancouver, it was associated with a February sales variation

FIGURE 3

CLIMATIC EFFECT ON JEWELLERY SALES IN VANCOUVER AND VICTORIA



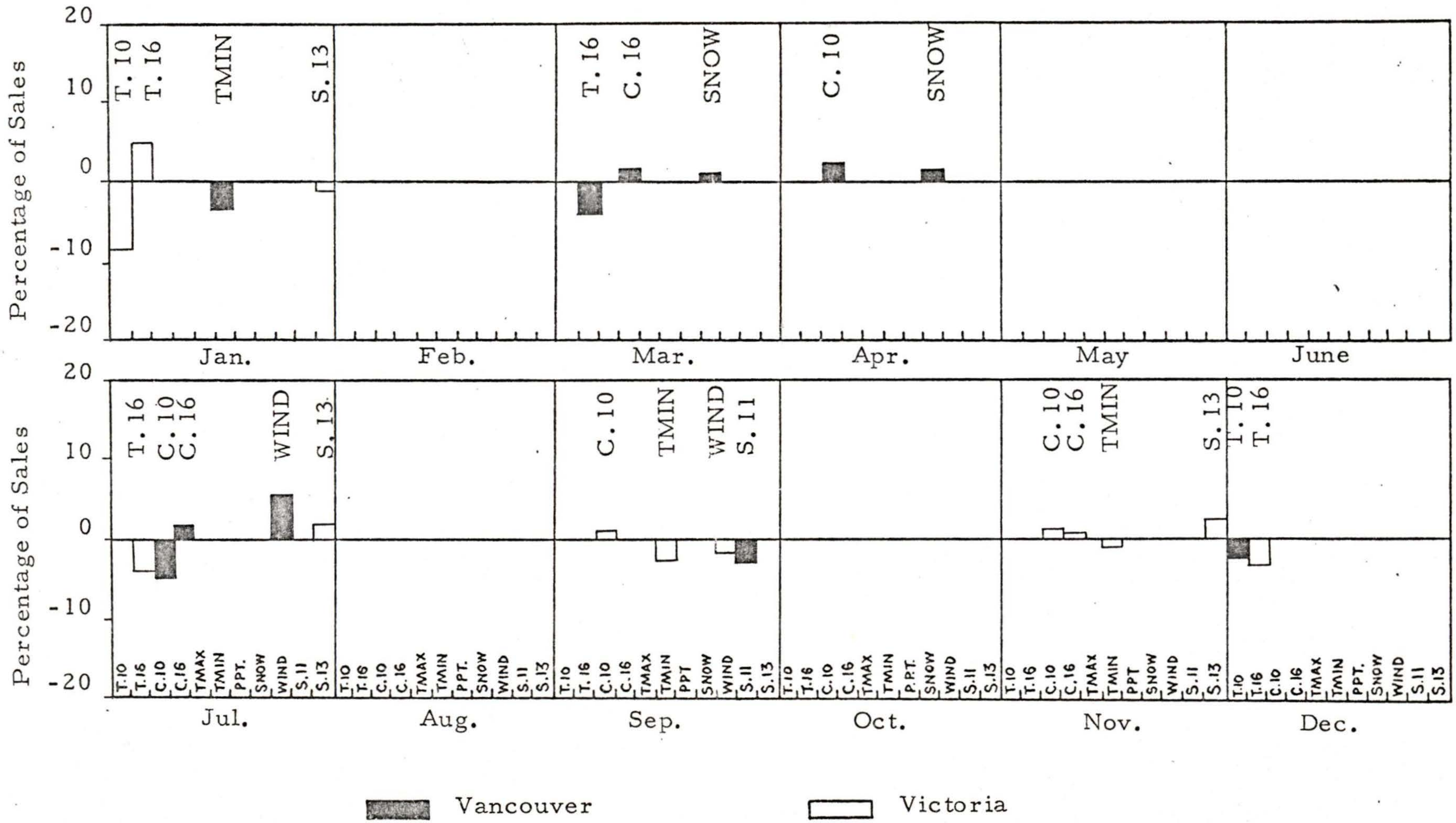
of 16.7 percent, whereas in Victoria T.16 was associated with a December sales variation of 16.9 percent. It was also apparent that warmer conditions had an appreciable effect on jewellery sales in Victoria in June, and in both cities during the fall season. From this study it is impossible to give a definite reason for this significant relationship, but it appears that further climatic research in this retail area would be extremely useful.

Fuel sales in both cities, as would be expected, were negatively correlated with temperature and sunshine, and positively correlated with cloud cover and snowfall (Figure 4). Thus, cool, cloudy, snowy conditions were accompanied by increased home heating costs. Interestingly enough, increased fuel sales in both cities were associated with increased cloud cover and wind speed, and decreased temperature in July. A possible explanation might be that people often have their tanks filled during July in preparation for the cooler fall months. The seasonal adjustment process used by the Dominion Bureau of Statistics has apparently accounted for some but not all of the sales variation during that month.

Another pattern emerged with the effect of climate on motor vehicle sales. It appeared that sales were positively associated with cloudy mornings and sunny afternoons in Vancouver during May and August, and in Victoria during February and May. Sales were also positively associated with warmer than average conditions during April

FIGURE 4

CLIMATIC EFFECT ON FUEL SALES IN VANCOUVER AND VICTORIA



and August in Victoria, and September and October in Vancouver (Figure 5). Thus, it seemed that pleasant afternoons were conducive to automobile sales, indicating possibly, people's preference to peruse car lots when the weather is nice.

The greater number of climate-shoe sales associations in Victoria than in Vancouver might well be attributed to the climate to which people are accustomed and for which they are prepared. Since shoe sales in Victoria were positively associated with rain, snow and wind in December and January, any abnormal amount of precipitation during these months would be reflected in increased sales of appropriate footwear (Figure 6). No significant climatic effect was observed for Vancouver. An explanation might be that people in Vancouver are more accustomed to the heavier precipitation and are better prepared for its occurrence. Temperature and sunshine also influence shoe sales in Victoria during the spring and fall, possibly reflecting an earlier change in seasonal footwear than in Vancouver.

Department store sales in Victoria during July, August and September are negatively associated with T. 10 and positively with C. 16. Victoria's tourist industry may contribute in part to this association. When it is cool in the morning and cloudy during the afternoon, tourists may spend more time shopping in the large department stores than sightseeing.

Drug sales in Victoria are closely associated with climatic

FIGURE 5

CLIMATIC EFFECT ON MOTOR VEHICLE SALES IN VANCOUVER AND VICTORIA

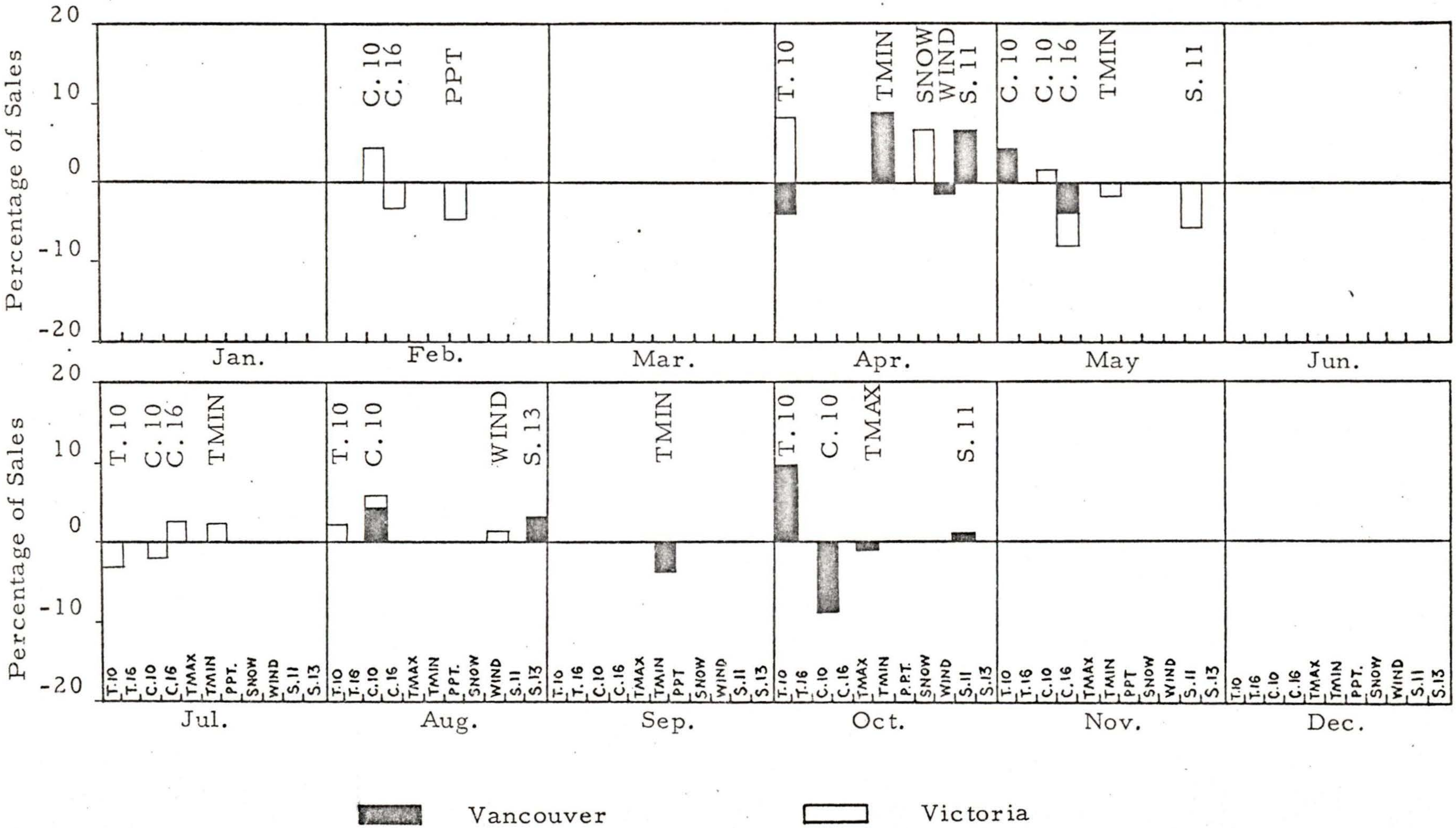
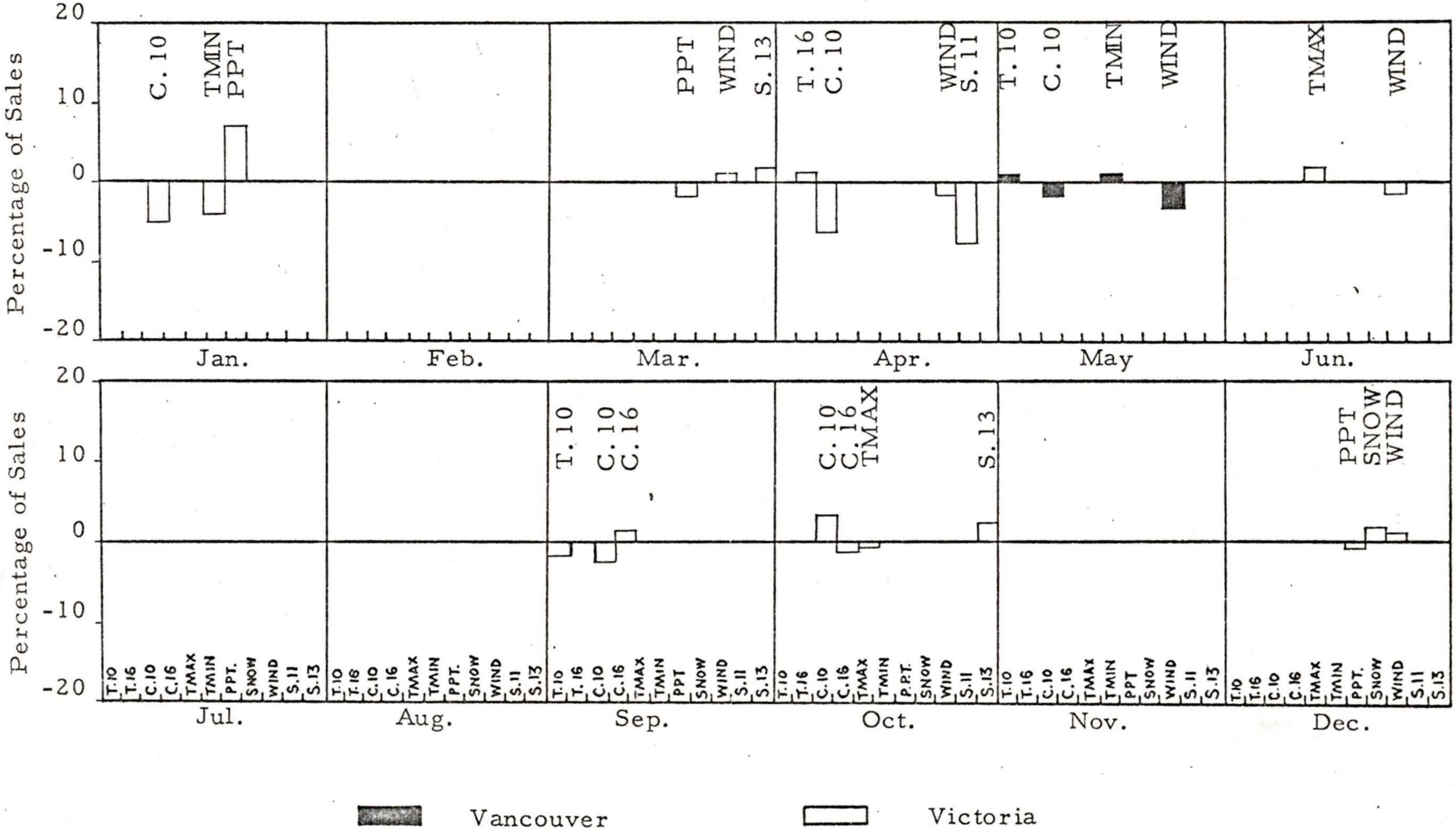


FIGURE 6

CLIMATIC EFFECT ON SHOE SALES IN VANCOUVER AND VICTORIA



fluctuations in the early spring and fall. Increased drug sales could be attributed to the large proportion of elderly people living in Victoria who are particularly susceptible to illness and discomforts, and especially so at the turn of the seasons. Vancouver showed little correlation.

On the other hand, Vancouver's furniture and appliance stores were influenced considerably more by climate than those in Victoria. Specifically, during February and May furniture and appliance sales in Vancouver were negatively associated with cloud and precipitation, while in July, September and November they were positively associated with temperature and negatively with precipitation. Increased sales during these months may be the result of Vancouver's retail hinterland being extended during good weather, perhaps to include even Victoria.

In summary, the climatic index revealed the percentage change in sales that was associated with a specific climatic variation. The indices enabled a comparison of this climatic effect on average monthly sales between retail categories and between centres. One climatic pattern that appeared to emerge was the significant effect fall temperatures had on average monthly retail sales in Vancouver. Average summer sales in Victoria were more influenced by variations in climate than sales in Vancouver, particularly important were temperature, cloud cover and wind speed. Spring and winter sales in both cities were affected by climate to approximately the same extent. In spite of the similarites in the climate of both centres, it was apparent from the indices that the same retail category in each city was often significantly associated with different climatic elements and at different times of the year. This emphasizes the importance of limiting the scale of econoclimatic studies of this type to individual cities rather than to a larger region, such as a county or province.

The Predicted Impact of Climate on September Retail Sales

The assessment of the total effect of climate on the retail communities of Vancouver and Victoria involved using the two estimating equation developed earlier (Chapter III):

$$\hat{Y}_A = a_0 + a_1(\overline{X}_1 + 1/2SD_1) + a_2(\overline{X}_2 + 1/2SD_2) + a_3(\overline{X}_3 + 1/2SD_3) + a_4(\overline{X}_4 + 1/2SD_4)$$

$$\hat{Y}_B = a_0 + a_1(\overline{X}_1 - 1/2SD_1) + a_2(\overline{X}_2 - 1/2SD_2) \pm a_3(\overline{X}_3 - 1/2SD_3) + a_4(\overline{X}_4 - 1/2SD_4).$$

Steele (1950) suggested a practical application for such regression equations; the prediction of future sales and the associated advantages to the retailer. In the present study it was possible to evaluable the impact of climate on the retail economies of both cities, and to illustrate the value of this regression model by substituting into the above equation a hypothetical weather forecast for the month of September. This month was selected because thirteen of the sixteen retail categories in both centres were sensitive to climate, five categories being common to both cities (department stores, men's and family clothing stores, fuel dealers, and jewellery stores).

September's long range weather forecast for the southwest coast of British Columbia was postulated to be above normal for temperature and sunshine, and below normal for precipitation and wind. In other words, September was to be drier, warmer, and sunnier than normal with less wind and cloud, an 'Indian' summer. In this example it was assumed that the above and below normal climatic conditions in the forecast were the equivalent of one-half a standard deviation. However, any degree of forecast or actual variation could be utilized in other applications.

The combined effect of climate on each of the sensitive retail outlets was then calculated through the use of the estimating equations, using the necessary coefficients from Appendix II, Tables II-1 and II-2, the period means, Tables 5 and 6, and the climatic information from the hypothetical long range forecast. The results are shown in Table 10.

Temperature and sunshine were the most important climatic elements for both centres, with T. 10 and TMIN being more important than T. 16 and TMAX. Afternoon sunshine, S. 13, was more important in Vancouver, while morning sun, S. 11, was associated with greater sales variation in Victoria.

Department store sales in Vancouver were associated with a large 28 percent decrease from the average monthly sales, which amounted to 5, 407, 640 dollars below the expected trend. Victoria experienced hardly any decrease from the trend in department store

TABLE 10

THE PREDICTED IMPACT OF SEPTEMBER'S CLIMATE ON RETAIL SALES

	Vancouver		Victoria	
Retail Category	Climatic Effect Dollars	Climatic Index Percent	Climatic Effect Dollars	Climatic Index Percent
Department stores	-5,407,640*	-28.29	- 980*	-0.03
Variety stores	34,050*	3.00		
Motor vehicles	- 528,290	- 3.34		
Garage			- 3,370*	-0.26
Men's clothing	91,370	9.14	- 2,990*	-1.86
Women's clothing	- 36,710*	- 1.95		
Family clothing	- 24,340*	- 2.67	2,260*	1.45
Shoe stores			7,050*	4.70
Hardware stores	2,540*	0.37		
Furniture stores	- 52,000*	- 2.32		
Fuel dealers	- 39,830*	- 3.01	- 8,860*	-2.18
Drug stores			9,140	1.87
Jewellery stores	19,930	1.92	9,000	3.91
Total retail sales	-5,940,920	-13.16	-11,250	0.18

Note: All climatic associations were significant at the 0.05 level except where indicated by an asterisk when the level was 0.01.

sales, only 0.03 percent or 980 dollars below the expected. Clothing was another category that was influenced by September's climate. In Vancouver there was an increase in men's clothing sales, but a decrease from the expected sales in women's and family clothing. Victoria experienced a decrease from the trend in sales of men's clothing, but an increase in family clothing sales. Fuel sales were down from the average in both centres by three percent and two percent respectively, which amounted to a decrease in sales of 48,690 dollars. On the other hand, the combined jewellery sales for both cities were above the expected trend by 28,930 dollars.

The total effect of a drier, warmer, and sunnier September on retail sales in Vancouver was a decrease from the expected trend by 5,940,920 dollars or 13 percent below the average estimates sales. Victoria, on the other hand, was associated with an increase in sales above the trend of 11,250 dollars, which amounted to less than 0.2 percent of the average September sales. The net impact of climate on the retail economy for this region was to decrease sales below the September estimate by 5,929,670 dollars or about 11.5 percent. Of this amount Vancouver department stores accounted for 90 percent of the variation. Since this evaluation involved a hypothetical weather forecast, a possible reason for the significant climate-sales association would be purely speculative and is beyond the scope of this study. Nevertheless, careful consideration must be given to the interpretation of this climatic effect on a regional basis especially when one retail category dominates the total climatic effect. This example does, however, illustrate the practical application of this regression model. It also shows that Vancouver retail sales in September, particularly department store sales, are much more significantly associated with climate than those of Victoria. Further research in this area would provide valuable information as to the causes and effects of such climate-sales relationships.

In summary, this study not only identified the climate sensitive retail categories in Vancouver and Victoria and the climatic elements which were associated with sales variations, but also showed when the climate-sale associations were significant. In addition, it revealed differences between the two cities in the effect of climate on sales. These differences might be attributed to a number of factors, two being the normal climate and the tourist industry. Specifically, Victoria experiences a milder climate than Vancouver and so climatic extremes may have a greater effect on Victoria sales. Climatic variations are also associated to a greater extent with summer sales in Victoria than Vancouver, possibly reflecting the importance of Victoria's major tourist industry. Future researchers in this field should profit by focusing on some of these major differences in climatic sensitivity and timing as well as on regional assessments. The effect of climatic fluctuations on retail sales can be estimated by use of multiple, linear regression analysis developed for any particular retail outlet, in any region and for any time of year. The procedure involves substituting into the equations the appropriate coefficients developed for the particular situation, and the necessary weather data, either actual or forecast. The result is a quantitative measure which gives the direction and the amount of retail sales deviation from the estimated sales trend.

CHAPTER V

SUMMARY AND CONCLUSIONS

An accurate assessment of the impact of climate on many economic activities has yet to be determined. This results from the complexity of the relationships involved and the lack of suitable economic data. While considerable attention has been devoted to identifying and analyzing the effects of weather on agriculture, communication, construction and transportation, little has been done to evaluate in dollar terms the effect of weather on the retail economy of a region, despite the potential financial rewards to retailers.

Previous research in the retail field revealed that temperature and precipitation do influence sales, particularly in the beverage industry, department stores, drug stores, and fuel dealers. In order to assess the climate-sales relationship, statistical studies indicated that a multiple regression analysis was the most appropriate technique for analyzing the many variables involved. Steele (1950) suggested that these regression equations could be used to predict department stores sales, given the required coefficients and climatic data.

The purpose of this study was to identify and evaluate in dollar terms the impact of climate on the retail communities of Vancouver and Victoria. An examination of the retail system revealed its complexity. In order to quantitatively evaluate the effect of climate on this system, the deviations in sales volume associated with a specific climatic variation had to be determined.

Problems were immediately encountered when retail sales information was requested from various establishments. The only available data was from the Dominion Bureau of Statistics and even the Bureau would release only monthly, seasonally adjusted British Columbia retail sales data for 1961 through 1967. The proportion of retail sales by kind-of-business for Vancouver and Victoria was calculated from the 1961 census retail information (Table 3). In order to isolate the irregular sales variations due to climatic conditions, the economic trend was identified in the seasonally adjusted sales data using the least-squares method. The transformed retail data were expressed as deviations from the economic trend and were correlated with the climatic data.

Eleven climatic elements were chosen from the available data collected and compiled at the official weather offices for both cities (Table 4). Monthly means for each climatic element were determined for the seven-year period of study. These period means were used to depict the normal climate, rather than the standard thirty-year normals, because the longer averages tend to hide short term fluctuations that might affect the study period.

A stepwise multiple linear regression programme was employed for the study. This enabled only the most significant climatic variables to be selected from the eleven original elements, and these were used in the final regression equation. The linearity of the relationship between deviations of retail sales from the economic trend and fluctuations of climatic elements from the normal was tested by the significance of the calculated F-ratio. The null hypothesis was rejected at the 95 percent significance level. With more precise economic data the relationship between climate and retail sales might have been more accurately determined. These relationships were examined and the climatic effect evaluated in dollar terms for all significant correlations (Appendix II).

The degree of climatic sensitivity of all retail categories was evaluated, using the number of significant monthly associations. It varied from a high of fifty percent of the year for jewellery stores and fueldealers in both cities to a low of eight percent for general, shoe, and variety stores in Vancouver and eight percent for food stores other than groceries in Victoria.

In order to compare the dollar assessment between categories and between cities a climatic index was devised. The index was found to be useful in determining which climatic elements were associated with the greatest sales variation, and in evaluating the influence of climate on a retail category. Temperature variables were associated with the highest average monthly sales variations (Table 9). Generally, fall temperatures were associated with the greatest sales variation in Vancouver and summer temperatures were more significant in

Victoria. Wind speed had the lowest average dollar effect even though it had the greatest number of sales associations. The amount of sunshine or cloud cover also had an appreciable effect on sales. Morning cloud cover and afternoon sunshine were most significant in Vancouver, whereas the reverse appeared to be true in Victoria. The effect of precipitation on sales was not as marked as expected. It had a slightly greater average effect on sales in Vancouver, whereas snow had a more marked effect on sales in Victoria.

The index also substantiated that fluctuations from the normal climate were significantly associated with monthly sales variations of fuel and motor vehicle dealers, and garages; jewellery, hardward, shoe, men's clothing, furniture, department, and grocery stores in Vancouver and Victoria from January 1961 to December 1967. However, it was apparent from the index that the same retail category in each city was associated with different climatic elements during different months. This indicated that a separate analysis would be required for each city if the total overall climatic effect on the retail economy of a region were desired.

The potential use of the model was illustrated by determining the total effect of a climate on the retail communities of Vancouver and Victoria using a hypothetical September weather forecast. It was calculated that a drier, warmer, and sunnier than normal September would result in a decrease of approximately 11.5 percent in the average September retail sales for the region. Because of the extreme difficulties in obtaining economic data it was impossible in this study to test the accuracy of the regression model on prediction of actual Vancouver and Victoria sales. Nevertheless, it was demonstrated that, given actual or forecast climatic data, predictions of the potential retail sales in these two cities were feasible. As Steele (1950) pointed out, this anticipation of sales is valuable from the point of view of store management and merchandising. The relationship found to exist could also be useful in monthly marketing strategy. In addition, the climatic index would be beneficial to retailers in enabling comparisons of the effect of climate on retail sales between retail categories and between regions.

Finally, it may be concluded that this study identified a significant linear relationship between deviations of certain retail sales and particular climatic elements in Vancouver and Victoria during the period 1961 to 1967. As a result, a dollar evaluation of the impact of a specific climatic variation on sensitive retail categories was estimated, revealing the value of a unit measure of precipitation or temperature change on the retail communities of Vancouver and Victoria. A few suggestions were also advanced in an attempt to explain some of the significant associations, but further research is necessary before a complete understanding of the climate-sales relationships is possible.

Problems and Prospects for Econoclimatic Research

Provincial and national evaluation of the impact of climate on the retail economy is severely hampered by the paucity of economic data for individual outlets or even retail categories. If provincial or national retail data are used the problems of reducing the numerous climatic variations found in a province or nation to meaningful climatic averages and establishing suitable climatic indices may prove insurmountable. The use of monthly data will always present the problem of hiding weekly or daily variations, but until daily or weekly economic data are available it will be impossible to do a regional evaluation for periods shorter than one month. Long term analysis, however, may reveal that the linear relationship found in this study no longer holds true for the climate-sales relationship.

Although climate does have an important effect on sales, there are many other factors that influence the human decision-making process. Statistical analysis is not the complete answer to the question 'What is weather worth?'. A warning was issued by Kuh (1965, p. 368) who stated:

> ... the dangers of substituting too much computer brawn for analysis should not be minimized. We may become overmechanized dinosaurs who ultimately will become extinct in an impenetrable underbrush of magnetic tape.

A solution to the problem may be in a systems approach in which statistical evaluation is only one part. There is no question as to the value of continued research in the field of quantitative methods and model building, but there are equal if not more important tasks for research in the areas of measurement and description before the question 'What are the impacts of weather and climate on economic activities?' is answered.

REFERENCES

Angle, E. W. 1966 Keys for Business Forecasting. Federal Reserve Bank of Richmond, Richmond, Virgina, 23213, 24 pp.

Australian Bureau of Meteorology 1965 What is Weather Worth? Papers presented to the Productivity Conference, Melbourne, Australia, 31 Aug. - 4 Sept., pp. 1-16.

Barry, W. S. 1965 Airline Management. George Allen and Unwin Ltd., London, 352 pp.

Blalock, H. M. Jr. 1960 Social Statistics. McGraw-Hill, New York, 465 pp.

Bollay, E. and Associates Ltd. 1962 Economic Impact of Weather Information on Aviation Operations. Final report to the Federal Aviation Agency, Washington, D. C.

Beckwith, W. B. 1966 Impacts of weather on the airline industry: the value of fog dispersal programs. In: Sewell, W. R. D., ed., 1966: Human Dimensions of Weather Modification, University of Chicago, Dept. of Geography, Research Paper No. 105, pp. 195-207.

Changnon, S. A. and Neill, J. C. 1968 A mesoscale study of corn-weather response on cash grain farms. Journ. App. Met., 7 : pp. 94-104.

Chapman, J. D. 1952 The Climate of British Columbia. Paper presented to 5th B. C. Natural Resources Conference, 27 February, 47 pp.

Croxton, F. E. and Cowden, D. J. 1955 Applied General Statistics. Prentice-Hall, Englewood Cliffs, N. J., chaps. 21 and 26.

Croxton, F. E. Cowden, D. J. and Bolch, B. W. 1969 Practical Business Statistics, 4th ed., Prentice-Hall, Englewood Cliffs, N. J. 444 pp.

Croxton, F.E. Cowden, D.J., and Klein, S. 1967 Applied General Statistics, 3rd ed., Prentice-Hall, Englewood Cliffs, N.J. 754 pp.

Cummins, W.E. 1967 Practical results of weather routing. Marine Observer, 37, pp. 23-26.

Dept. of Transport Meteorological Branch 1961-1967 Monthly Record, Meteorological Observations in Canada. January 1961 to December 1967 inclusive, Toronto, Ontario.

Dept. of Transport Meteorological Branch 1967a Annual Meteorological Summary 1967, Vancouver. Ottawa, Canada.

Dept. of Transport Meteorological Branch 1967b Annual Meteorological Summary 1967, Victoria. Ottawa, Canada.

Dixon, W.J. (Editor) 1967 BMD Biomedical Computer Programs. 2nd ed., Publications in Automatic Computation No. 2, University of California, U. of C. Press, Berkeley and Los Angeles, pp. 237-257d.

Draper, N.R. and Smith, H. 1967 Applied Regression Analysis. Wiley and Sons, New York, pp. 71-73; 104-125; and 178-194.

Efroymsen, M.A. 1960 Multiple regression analysis. In: Ralston, A. and Wilf, H.S. 1960: Mathematical Methods for Digital Computers, Part V, Wiley and Sons, New York, pp. 191-203.

Evans, S.H. 1968 Weather routing of ships. Weather, 23, pp. 2-8.

Ferguson, G.A. 1959 Statistical Analysis in Psychology and Education. McGraw-Hill, New York, 347 pp.

Financial Post, The | 1964-1967 | Survey of Markets and Business Year Books. 1964-65, 1965-66, 1966-67, MacLean and Hunter Publishing Co., Toronto.

Government of Canada | 1961 | Census of Canada Retail Trade. Dominion Bureau of Statistics, Vol.VI, Part I, Cat. No. 97508.

Government of Canada | 1968 | Retail Trade December 1967. Dominion Bureau of Statistics, Vol. 39, No. 12, Cat. No. 63005, p. 1.

Hocking, R. R. and Leslie, R. N. | 1967 | Selection of the best subset in regression analysis. Technometrics, Vol. 9, No. 4, Nov., pp. 531-40.

Johnson, S. R. McQuigg, J. D. and Rothrock, T. P. | 1969 | Temperature modification and costs of electric power generation. Journ. App. Met., 8, pp. 919-26.

Kelvin, Lord | 1891 | Popular Lectures and Addresses. 2nd ed., Macmillan and Co., London, I, pp. 80-1.

Kendrew, W. G. and Kerr, D. P. | 1955 | The Climate of British Columbia and the Yukon Territory. Dept. of Transport, Meteorological Branch, Queen's Printer, Ottawa, Canada.

Kuh, E. | 1965 | Econometric models : is a new age dawning? Amer. Econ. Review, Vol. 55A, pp. 362-68.

LaMotte, L. R. and Hocking, R. R. | 1970 | Computational efficiency in the selection of regression variables. Technometrics, Vol. 12, No. 1, Feb., pp. 83-93.

Lave, L. B. | 1963 | The value of better weather information to the raisin industry. Econometrica, 31, (1-2): pp. 151-64.

Linden, F. | 1959a | Weather in business. The Conference Board Business Record, 16, pp. 90-4, 101.

Linden, F. 1959b Merchandising with the weather. The Conference Board Business Record, 16, pp. 144-49.

Linden, F. 1962 Merchandising weather. The Conference Board Business Record, 19, pp. 15-16.

McQuigg, J. D. 1965 Foreseeing the future - forecasts and decisions. Meteorological Monographs, Vol. 6, pp. 181-88.

McQuigg, J. D. and Thompson, R. G. 1965 Economic value of improved methods of translating weather information into operation terms. Monthly Weather Review, 94, pp. 83-7.

Maunder, W. J. 1965 The effect of climatic variations on some aspects of agricultural production in New Zealand, and an assessment of their significance on the national agricultural income. Unpublished Ph. D. thesis, University of Otago, New Zealand.

Maunder, W. J. 1966 An agroclimatological model. Science Record, 16, pp. 78-80.

Maunder, W. J. 1968 An Econoclimatic Model for Canada : Problems and Prospects. Paper presented at the conference and workshop on Applied Climatology of the American Meteorological Society, Ashville, N. C. Oct.

Maunder, W. J. 1970 The Value of Weather. Methuen and Co., London, 388 pp.

Maunder, W. J. and Whitmore, A. D. 1968 Research was done on an econoclimatic model for Canada and a paper was presented by Maunder, W. J., 1968 at the conference and workshop on Applied Climatology of the American Met. Soc., Ashville, N.C., Oct.

Maunder, W. J. and Whitmore, A. D. 1969 The value of weather : challenge of assessment. Australian Geographer, 11, pp. 22-28.

Petty, M. T. 1963 Weather and consumer sales. Bull. Amer. Meteor. Soc., 44, Feb., pp. 68-71.

Ralston, A. and Wilf, H. S. 1960 Mathematical Methods for Digital Computers, Wiley and Sons, New York.

Russo, J. A. 1966 The economic impact of weather on the construction industry of the United States. Bull. Amer. Meteor. Soc., 47, pp. 967-72.

Sewell, W. R. D. (Editor) 1966 Human Dimensions of Weather Modification. University of Chicago, Dept. of Geography Research Paper No. 105, 423 pp.

Sewell, W. R. D., Kates, R. W. and Maunder, W. J. 1968 Measuring the economic impact of weather and weather modification: a review of techniques of analysis. In: Sewell, W. R. D. et al 1968: Human Dimensions of the Atmosphere. National Science Foundation, Washington, D. C., pp. 103-12.

Sewell, W. R. D., et al 1968 Human Dimensions of the Atmosphere. National Science Foundation, Washington, D. C., 174 pp.

Shiskin, J. 1957 Electronic Computers and Business Indicators. Occasional Paper No. 57, National Bureau of Economic Research, New York.

Shiskin, J. and Eisenpress, H. 1958 Seasonal Adjustments by Electronic Computer Methods. Technical Paper No. 12, National Bureau of Economic Research, New York.

Shiskin, J., Young, A. H. and Musgrave, J. C. 1965 Variant of the Census Method II Seasonal Adjustment Program. Bureau of the Census Technical Paper No. 15, Superintendent of Documents, Government Printing Office, Washington, D. C.

Shor, M. 1964 Exploratory work in measurement of the effect of weather factors on retail sales. Proc. Amer. Stat. Assoc., 1963, Business and Economic Section, pp. 54-8.

Spicer, H. 1967 Mobil's experience with commercial weather routing. Marine Observer, 37, pp. 30-3.

Spoerri, A. 1968 Personal communication with Current Business Indicators and Time Series Data Bank Section, D. B. S., Ottawa.

Sprent, P. 1969 Models of Regression and Related Topics. Methuen and Co., London, 173 pp.

Steele, A. T. 1950 Weather as a determinant of marketing strategy: a department store case study. Unpublished Ph. D. thesis, Aug., State University of Iowa, Iowa.

Thompson, J.C. 1966 The potential economic and associated values of World Weather Watch. World Weather Watch Planning Report, No. 4, 35 pp.

U.S. Dept. of Commerce Weather Bureau 1964 The National Research Effort on Improved Weather Description and Prediction for Social and Economic Purposes. Prepared by the U.S. Dept. of Commerce, Weather Bureau, for the Federal Council for Science and Technology, Interdepartmental Committee on Atmospheric Sciences, 84 pp.

Wright J. B. 1966 Precipitation Patterns over Vancouver City and Lower Fraser Valley. Report No. TEC 623, Meteorological Branch, Toronto, Canada.

Zeisel, H. 1950 How temperature affects sales. Printers Ink, 233, pp. 40-42.

APPENDIX I

SEASONAL ADJUSTMENT OF RETAIL SALES

A compiled statistical series, such as the retail sales data, is termed an original series whose movement in time is made up of four components: trend, cyclical, seasonal, and irregular variations (Figure I-1). Variations that occur in approximately the same calendar order each year reflect seasonal changes, perhaps in social custom, business practices and climate, all tending to obscure the true trend of the series. They may be removed from the series by a process of seasonal adjustment. Such seasonally adjusted data would allow a retailer to plan for future expansion on the basis of past overall progress in which the increased spending, resulting, for example, from the introduction of new spring fashions, back-to-school sales, and Christmas, would be removed.

In this study, where the objective was to isolate and analyse the irregular variations caused by weather variations, the removal of the seasonal variation from the retail sales data was a prerequisite. To adjust for this variation the original series was divided by the seasonal component (Figure I-2):

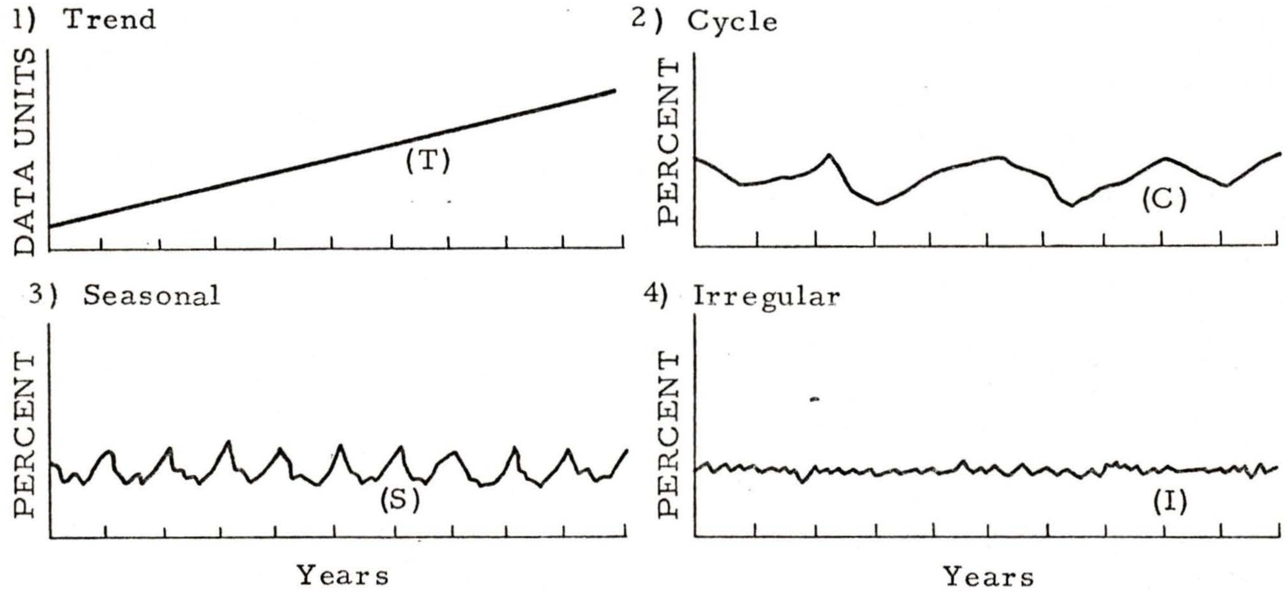
$$O/S = T \cdot C \cdot I$$

The Census Method II used by the Dominion Bureau of Statistics to calculate the seasonal adjustment factor in the retail sales data is a refinement of the common ratio-to-moving average method and was

FIGURE I-1

MAJOR COMPONENTS OF A TIME SERIES

A Typical Time Series in Influenced by Four Types of Movement:



Note: 1) Trend - long-term growth or decline occurring within the series.

2) Cycle - alternating upswings and downswings of varying length and intensity.

3) Seasonal - more or less regular movements within a year.

4) Irregular - random movements and those which reflect unusual events.

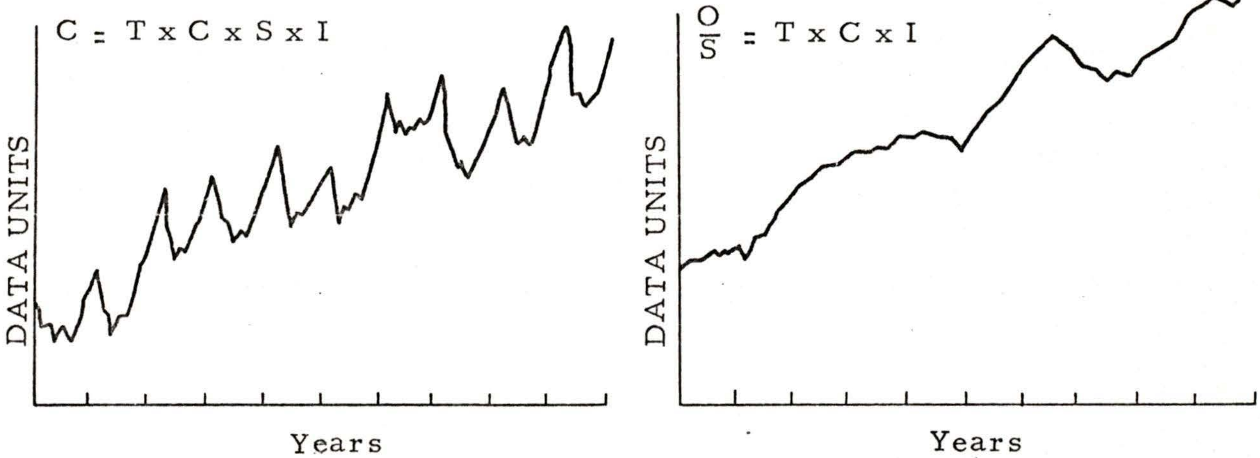
Source: after Angle, 1966.

FIGURE I-2

SEASONAL ADJUSTMENT

1) Original

2) Seasonally adjusted



Source: after Angle, 1966.

developed at the Bureau of the Census in Washington, D.C. (Shisken, 1957; Shisken and Eisenpress, 1958).

Some of the irregular factors affecting the time series may also be identified, and these were removed by the Dominion Bureau of Statistics; for example, irregularities caused by variations in the number of working or trading days in a month as a result of holidays or number of Sundays. The X-II varient of the Census Method II seasonal adjustment programme includes an option for trading day adjustments and was used by the Bureau to adjust five of the sixteen categories mentioned in Chapter III (Shisken, Young and Musgrave, 1965).

APPENDIX II

Table II-1 (Vancouver)and Table II-2 (Victoria)summarize the dollar evaluation for each significant climatic variable that was associated with a particular retail category. In 91 percent of the total climate-sales associations the optimum set of predictors was selected from Run A. For the remaining 9 percent, the most significant predictor set was selected from Run B and designated by the letter "B". All associations were significant at or beyond the five percent level.

TABLE II-1

CLIMATIC EFFECT ON RETAIL SALES
IN VANCOUVER

Category and Month	Regressor	Constant	Coefficients of Regression	Standard Error of Regression Coefficient	F ratio to Remove	Average Monthly Sales	Climatic Effect on Sales	Climatic Index
	X	a_o	a_i	Sa_i	F	Thousands of dollars	$a_i(\bar{X}_i \pm \frac{1}{2} SD_i)$ Dollars	I
Grocery Stores								
Oct.	S. 11	15299.19	- 240.08	71.87	11.6	18,194	-1,656,550	-4.6
	T. 16		- 61.64	12.49	24.35		- 73,970	-0.2
Nov.	C. 16	- 7366.75	- 81.18	13.15	38.11	19,042	- 543,910	-1.4
	TMAX		285.03	58.10	24.07		456,050	1.2
Dec.	WIND	- 849.69	483.67	56.07	74.41	19,077	435.300	1.1
	SNOW		- 47.09	6.30	55.91		- 583,920	-1.5
	PPT.		- 340.28	46.51	53.53		- 544,450	-1.4
Other Food Stores								
Mar.	PPT.	231.82	384.76	64.42	35.67	3,495	357,830	5.1
	C. 10		- 20.86	5.74	13.17		- 216,940	-3.1
Jul.	S. 11	- 841.88	7.90	0.72	121.51	3,499	101,910	1.5
	WIND		44.29	7.86	31.62		53,150	0.8
General Stores								
Nov.	TMIN	- 96.90	2.58	0.56	21.50	147	5,420	1.8

TABLE II-1 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Department Stores								
Jul.	C.10	1862.51	- 30.32	5.50	30.38	19,027	- 366,870	-1.0
Sep.	T.10	21511.54	-1043.72	53.61	379.00	19,113	2,191,810	-5.7
	S.13		76.22	4.71	261.26		792,690	2.1
	TMIN		685.63	49.82	189.41		1,371,260	3.6
	S.11		25.98	4.69	30.71		228,620	0.6
Variety Stores								
Sep.	PPT.	1996.99	- 59.00	2.53	541.55	1,132	- 76,110	-3.4
	T.10		- 113.95	4.69	590.37		- 239,300	10.6
	TMIN		89.00	4.52	387.84		178,000	7.9
	S.13		7.73	0.44	310.48		80,390	3.6
Motor Vehicles								
Apr. B.	S.11	-33689.28	241.87	4.28	3198.76	15,543	2,176,830	7.0
	TMIN		1358.81	32.98	1697.75		2,717,620	8.7
	T.10		- 639.79	25.30	639.34		- 959,690	-3.1
	WIND		- 241.98	26.87	81.09		- 241,980	-0.8
May B.	TMIN	13710.06	- 297.10	75.13	15.64	15,612	- 534,780	-1.7
	C.10		118.45	18.67	40.24		1,160,810	3.7
	C.16		- 139.89	23.17	36.46		-1,259,010	-4.0
Aug.	C.10	-10849.13	98.51	16.87	34.09	16,179	1,566,310	4.8
	S.13		68.28	21.80	9.81		839,840	2.6
Sep.	TMIN	27633.40	- 552.19	101.35	29.68	15,809	-1,104,380	-3.5
Oct.	S.11	-74126.60	26.23	7.10	13.65	15,989	180,990	0.6
	TMAX		- 215.38	79.80	7.28		- 323,070	-1.0

TABLE II-1 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Motor Vehicles (contd.)								
Oct.	C. 10		- 460.84	17.91	662.40		-2,718,960	-8.5
	T. 10		2322.36	133.21	303.94		3,019,070	9.4
Garages								
Feb.	S. 13	-1013.29	19.77	2.37	69.54	6,755	253,060	1.9
	PPT.		49.13	9.43	27.12		157,710	1.2
Mar.	WIND	-1157.74	- 83.93	8.24	103.69	6,880	- 109,110	-0.8
	T. 16		44.48	4.34	105.11		66,720	0.5
	C. 16		- 15.93	1.56	103.87		- 148,150	-1.1
	C. 10		12.03	1.24	93.93		125,110	0.9
Jul.	C. 10	756.67	- 12.32	1.15	113.97	7,015	- 149,070	-1.1
Nov.	PPT.	-1600.56	- 239.06	7.20	1102.44	7,169	- 236,670	-1.7
	SNOW		231.82	7.23	1027.24		164,590	1.1
	TMAX		52.77	2.47	456.31		84,430	0.6
	WIND		44.07	2.89	232.44		88,140	0.6
Men's Clothing Stores								
Apr.	C. 10	1180.98	- 11.14	1.62	47.13	991	- 65,730	-3.3
	S. 13		- 5.72	1.09	27.56		- 49,760	-2.5
Jun.	S. 11	519.90	3.03	0.37	67.35	993	46,360	2.3
	T. 16		- 11.03	2.45	20.25		- 25,370	-1.3
Sep.	T. 16	1086.00	- 17.09	2.99	32.68	1,000	- 39,310	-2.0
Nov.	S. 13	2950.77	- 29.85	3.19	87.65	986	- 211,940	-10.7
	C. 10		- 23.83	3.37	49.89		- 159,660	- 8.1
Women's Clothing Stores								
Jun.	TMIN	-3604.88	- 68.56	5.66	146.71	1,909	- 130,260	-3.4
	WIND		- 57.99	3.99	210.76		- 52,190	-1.4

TABLE II-1 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Women's Clothing Stores (contd.)								
Jun.	T. 16		128.41	6.79	357.41		295,340	7.7
	S. 11		- 12.23	0.68	320.54		-187,120	-4.9
Sep.	PPT.	638.01	58.34	4.81	147.10	1,879	75,260	2.0
	TMIN		- 19.04	2.72	49.09		- 38,080	-1.0
	S. 13		2.61	0.60	19.04		27,140	0.7
Family Clothing Stores								
Mar.	PPT.	112.93	134.75	22.25	36.67	878	125,320	7.1
	WIND		- 72.83	16.45	19.60		- 94,680	-5.4
Sep.	T. 10	2844.58	-183.24	20.14	82.81	911	-384,800	-21.1
	TMAX		73.30	16.77	19.10		190,580	10.5
	TMIN		59.75	6.54	83.37		119,500	6.6
	S. 13		4.93	0.79	39.20		51,270	2.8
Shoe Stores								
May	TMIN	-1064.21	14.91	2.74	29.72	810	26,830	1.7
	T. 10		15.80	4.24	13.87		22,120	1.4
	WIND		- 38.58	4.34	79.04		- 42,440	-2.6
	C. 10		- 2.76	0.78	12.46		- 27,050	1.7
Hardware Stores								
Jan.	SNOW	- 3.88	- 7.26	0.18	1606.26	661	- 51,910	-3.9
	S. 11		- 3.81	0.10	1357.31		- 32,390	-2.5
	C. 10		2.20	0.14	231.28		17,820	1.3
	WIND		- 5.10	0.46	120.55		- 11,220	-0.8
Mar.	T. 10	- 731.87	16.78	3.61	21.63	665	20,140	1.5
Sep.	T. 10	500.97	- 26.89	1.28	441.29	667	56,470	-4.2
	TMAX		9.58	1.07	80.83		24,910	1.8

TABLE II-1 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2} SD_i)$ Dollars	I
Hardware Stores (contd.)								
Sep.	S. 13		1.10	0.05	480.04		11,440	0.8
	TMIN		8.13	0.42	381.93		16,260	1.2
Oct. B.	TMAX	824.29	-22.10	1.28	298.35	683	- 35,150	-2.6
	T. 10		8.98	1.49	36.56		11,670	0.9
	S. 11		- 0.83	0.10	54.44		- 5,730	-0.4
Nov.	C. 16	652.41	- 7.79	0.82	87.70	645	- 56,870	-4.4
	PPT.		22.68	3.28	47.76		20,410	1.6
	S. 13		- 4.97	0.75	44.41		- 35,290	-2.7
Furniture Stores								
Feb.	C. 10	- 981.21	14.83	0.81	335.19	2,115	105,290	2.5
	PPT.		-12.72	1.27	101.02		- 40,830	-1.0
	C. 16		- 7.92	0.82	92.39		- 56,230	-1.3
	T. 16		9.64	1.18	66.82		16,390	0.4
May B.	TMAX	6144.44	-83.75	7.96	110.57	2,104	-159,130	-3.8
	C. 10		-14.54	1.58	85.08		-142,490	-3.4
Jul. B.	S. 13	6137.28	10.03	0.22	2140.09	2,197	104,310	2.4
	T. 16		-74.90	1.00	5616.51		-187,250	-4.3
	C. 16		-12.01	0.25	2257.73		-124,900	-2.8
	TMIN		-19.84	1.09	333.47		- 29,760	-0.7
Sep. B.	T. 10	3961.63	-393.59	59.67	43.50	2,233	-826,540	-18.5
	TMAX		298.58	47.59	39.36		776,310	17.4
Nov.	PPT.	-2163.22	- 59.03	2.92	408.95	2,231	- 58,440	-1.3
	T. 16		139.57	8.95	243.25		209,360	4.7
	T. 10		-157.66	9.17	295.43		-299,550	-6.7
	TMAX		62.59	7.87	63.21		100,140	2.2

TABLE II-1 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Fuel Dealers								
Jan.	TMIN	994.63	- 30.21	2.25	180.66	1,374	- 87,610	-3.2
Mar.	SNOW	2126.18	7.91	0.85	87.32	1,403	59,330	1.4
	T.16		- 55.46	4.64	142.60		- 83,190	-3.0
	C.16		6.09	0.71	74.12		56,640	2.0
Apr.	C.10	- 966.51	12.06	1.95	38.29	1,358	71,150	2.6
	SNOW		1442.50	301.96	22.82		57,700	2.1
Jul.	WIND	- 504.01	121.52	11.76	106.75	1,389	145,820	5.2
	C.10		- 11.17	1.41	62.81		-135,160	-4.9
	C.16		5.73	1.34	18.23		59,590	2.1
Sep.	S.11	573.39	- 9.18	1.31	49.12	1,322	- 81,700	-3.1
Dec.	T.10	1096.23	- 28.01	5.29	27.99	1,435	- 84,030	-2.9
Drug Stores								
Nov.	C.16	16.94	- 35.67	1.97	329.13	2,893	-260,390	-4.5
	T.16		61.37	5.05	147.79		92,060	1.6
	PPT.		74.57	7.72	93.22		73,080	1.3
	S.13		- 12.81	1.69	57.72		- 90,950	-1.6
Jewellery Stores								
Jan.	S.11	- 208.18	7.31	0.79	86.32	951	62,140	3.3
	PPT.		25.54	3.24	62.21		64,870	3.4
	WIND		- 12.69	3.38	14.13		- 27,920	-1.5
Feb.	T.16	- 305.72	191.89	4.41	1890.69	978	326,210	16.7
	TMAX		-187.94	5.03	1397.72		-319,500	-16.3
	SNOW		- 92.40	3.84	579.20		- 42,500	-2.2
	TMIN		16.88	0.79	457.51		43,890	2.2

TABLE II-1 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Jewellery Stores (contd.)								
Jul.	PPT.	1691.17	- 89.03	5.72	242.40	1,016	- 95,260	-4.7
	T.16		- 44.57	3.29	183.68		-111,430	-5.5
	TMIN		28.18	3.41	68.27		42,270	2.1
Sep. B.	C.16	- 678.91	- 1.90	0.30	39.14	1,036	- 12,350	-0.6
	TMIN		- 15.29	2.01	57.99		- 30,580	-1.5
	T.10		26.01	2.07	158.19		54,620	2.6
Oct.	TMAX	-2432.70	62.01	7.34	71.45	1,006	93,020	4.6
	TMIN		- 25.24	4.91	26.47		- 58,050	-2.9
Nov. B.	S.13	-2117.13	16.97	1.22	192.82	1,064	120,490	5.7
	C.10		13.17	1.68	61.38		88,240	4.1
	T.10		10.64	2.80	14.46		20,220	1.0

TABLE II-2

CLIMATIC EFFECT ON RETAIL SALES IN VICTORIA

Category and Month	Regressor	Constant	Coefficients of Regression	Standard Error of Regression Coefficient	F ratio to Remove	Average Monthly Sales	Climatic Effect on Sales	Climatic Index
	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Grocery Stores								
Mar.	SNOW	-1692.25	49.97	0.53	3045.59	3,548	217,370	3.1
	WIND		76.46	2.13	1287.59		122,340	1.7
	PPT.		-359.01	7.82	2107.02		-287,210	-4.0
	C.10		16.98	0.54	1000.38		154,520	2.2
Jul.	C.16	1900.92	- 12.38	0.25	2429.40	3,655	-136,180	-1.9
	TMIN		- 54.46	3.22	286.70		- 70,800	-1.0
	T.10		15.13	2.87	76.86		27,230	0.4
Oct.	TMAX	4268.13	- 75.20	18.19	17.09	3,722	- 97,760	-1.3
Nov.	S.13	-3277.77	5.34	0.69	58.94	3,747	48,060	0.6
	T.10		263.05	20.00	172.96		447,180	6.0
	TMIN		-207.04	17.65	137.62		-393,380	-5.2
	WIND		- 19.93	4.35	21.02		- 25,910	-0.3
Other Food Stores								
Jul.	S.13	- 106.12	2.28	0.19	148.82	777	25,080	1.6
	WIND		- 6.94	0.99	49.48		- 14,570	-0.9
General Stores								
May	C.16	- 88.52	0.90	0.06	212.12	75	8,190	5.5
	S.13		0.68	0.06	132.64		7,750	5.2
	WIND		- 1.32	0.28	22.32		- 1,060	-0.7

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
General Stores (contd.)								
Jul.	TMIN	36.87	- 1.37	0.02	3265.87	74	- 1,780	-1.2
	C.10		0.29	0.01	2683.49		3,220	2.2
	S.11		0.20	0.01	1453.64		2,200	1.5
	WIND		0.54	0.02	1035.10		1,130	0.8
Nov.	TMAX	- 4.85	- 1.84	0.54	11.47	76	- 2,940	-1.9
	C.10		- 0.36	0.04	89.70		- 2,200	-1.4
	TMIN		2.70	0.43	38.60		5,130	3.4
	WIND		1.14	0.19	37.48		1,480	1.0
Department Stores								
Feb.	WIND	-1626.46	92.99	10.54	77.85	3,042	102,290	1.7
	S.13		5.15	1.32	15.33		58,710	1.0
	C.16		4.94	1.76	7.86		41,000	0.7
Jul.	C.10	1948.63	- 9.91	0.51	374.04	3,144	-110,000	-1.7
	T.10		- 21.46	3.07	48.91		- 38,630	-0.6
	WIND		- 14.98	2.26	43.99		- 31,460	-0.5
Aug.	T.10	-3557.57	33.19	2.35	199.98	3,168	49,790	0.8
	C.16		14.71	0.70	435.99		172,170	2.7
	S.13		10.88	0.63	298.64		134,910	2.1
Sep. B.	T.10	4128.52	- 92.03	0.59	24626.99	3,158	-147,250	-2.3
	S.11		15.73	0.11	20357.90		122,690	1.9
	PPT.		- 51.73	1.45	1265.36		- 30,520	-0.5
	C.16		2.17	0.18	151.82		9,110	0.1
Oct.	T.10	3447.24	-145.85	4.65	985.00	3,199	-116,680	-1.8
	TMAX		63.04	3.35	353.39		81,950	1.3
	C.16		5.99	0.22	746.89		55,710	0.9
	S.13		2.27	0.28	64.86		27,010	0.4

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Variety Stores								
Feb.	C.16	- 235.98	1.56	0.11	200.68	254	12,950	2.5
	WIND		12.66	0.90	196.72		13,930	2.7
	PPT.		- 6.69	0.68	97.84		- 11,980	-2.4
Mar.	S.13	- 83.99	1.42	0.35	16.34	259	14,300	2.8
Motor Vehicles								
Feb.	PPT.	- 894.97	-138.22	10.33	179.15	2,655	-247,410	-4.7
	C.10		33.82	3.10	119.18		253,650	4.8
	C.16		- 17.78	2.25	62.24		-147,570	-2.8
Apr.	T.10	-16519.10	335.01	46.28	52.39	2,679	435,510	8.1
	SNOW		7320.46	1222.62	35.85		366,020	6.8
May	C.16	4218.20	- 46.52	4.98	87.08	2,690	-423,330	-7.9
	S.11		- 23.16	3.25	50.68		-312,920	-6.0
	C.10		3.92	0.95	16.94		73,700	1.4
Jul.	C.16	- 199.02	12.29	0.47	684.21	2,732	135,190	2.5
	C.10		- 9.61	0.57	287.63		-106,670	-2.0
	TMIN		97.95	6.39	235.06		127,330	2.3
	T.10		- 83.35	6.71	154.07		-150,030	-2.7
Aug.	C.10	-6790.73	22.15	2.43	82.95	2,788	296,810	5.3
	T.10		84.14	22.10	14.49		126,210	2.3
	WIND		56.34	16.32	11.91		61,970	1.1
Garages								
Mar.	S.13	- 146.69	1.62	0.18	77.42	1,252	16,360	0.7
	C.16		- 6.08	0.53	133.21		- 60,800	-2.4
	C.10		6.91	0.70	96.20		62,880	2.5
	PPT.		- 14.20	3.14	20.44		- 11,360	-0.5

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Garages (contd.)								
Jun.	PPT.	-806.44	-96.00	4.36	485.77	1,273	-29,760	-1.2
	TMAX		30.92	1.61	367.39		52,560	2.1
	T.10		-21.25	1.28	273.58		-27,630	-1.1
	C.16		2.00	0.20	95.43		25,000	1.0
Jul.	C.10	831.89	-3.26	0.42	59.24	1,277	-36,190	-1.4
	T.16		-10.57	2.60	16.53		-19,030	-0.7
Sep.	C.10	179.23	1.71	0.42	16.31	1,291	9,060	0.4
	PPT.		47.77	1.67	820.70		28,180	1.1
	S.11		6.51	0.31	450.63		50,780	2.0
	TMIN		-15.97	0.88	327.11		-22,360	-0.9
Men's Clothing Stores								
May	TMAX	-221.00	9.53	0.43	484.81	159	18,110	5.7
	T.16		-9.11	0.43	457.67		-17,310	-5.4
	TMIN		3.11	0.27	145.68		3,640	1.1
	WIND		1.04	0.20	25.77		830	0.3
Jun.	PPT.	9.52	-15.68	3.39	21.34	159	-4,860	-1.5
Sep.	T.10	222.80	-3.84	0.89	18.66	160	-6,140	-1.9
Dec.	SNOW	-2.98	0.88	0.20	19.12	164	4,710	1.4
Women's Clothing Stores								
Apr.	T.10	693.59	-13.57	2.09	41.70	288	-17,510	-3.0
	PPT.		-28.38	8.63	10.84		-8,800	-1.5
Jul.	TMIN	289.88	-15.06	0.87	302.21	290	-19,580	-3.4
	T.16		8.87	0.66	180.73		15,970	2.7
	S.13		-0.67	0.08	76.71		-7,370	-1.3
	PPT.		-6.11	1.62	14.29		-3,060	-0.5

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Women's Clothing Stores (contd.)								
Dec.	SNOW	188.53	-2.79	0.26	114.86	293	-14,760	-2.5
	C.10		2.17	0.34	40.03		-8,750	-1.5
Family Clothing Stores								
Feb.	WIND	-129.16	11.76	2.64	19.88	149	12,940	4.3
Jul.	C.16	156.21	-1.92	0.29	44.97	155	-21,120	-6.8
	S.13		-0.93	0.29	10.45		-10,230	-3.3
Sep.	TMIN	255.43	14.11	3.82	13.63	155	19,750	6.4
	S.11		2.55	0.33	58.22		19,890	6.4
	T.16		-19.37	3.22	36.11		-36,800	-11.9
Shoe Stores								
Jan.	C.10	331.66	-2.31	0.28	69.98	150	-14,780	-4.9
	PPT.		10.48	1.57	44.37		21,170	7.1
	TMIN		-5.31	1.49	12.75		-11,150	-3.7
Mar.	S.13	-62.34	0.64	0.07	74.22	150	6,460	2.2
	WIND		2.64	0.46	32.36		4,220	1.4
	PPT.		-3.61	0.90	16.23		-2,890	-1.0
Apr. B.	S.11	62.93	-1.80	0.08	563.85	150	-22,500	-7.5
	C.10		-2.14	0.10	424.22		-18,190	-6.1
	T.16		4.24	0.43	97.23		4,660	1.6
	WIND		-2.37	0.28	74.33		-3,560	-1.2
Jun.	TMAX	-220.24	4.16	0.47	78.75	151	7,070	2.3
	WIND		-4.03	0.88	20.82		-3,630	-1.2
Sep.	C.10	218.12	-1.39	0.11	170.98	150	-7,370	-2.5
	T.10		-3.14	0.34	84.99		-5,020	-1.7
	C.16		0.73	0.14	29.01		3,070	1.0

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Shoe Stores (contd.)								
Oct. B.	C.16	8.88	- 0.32	0.09	11.63	152	- 2,980	-1.0
	S.13		0.65	0.03	411.57		7,740	2.5
	TMAX		- 2.57	0.13	404.52		- 3,340	-1.1
	C.10		1.72	0.21	66.69		10,150	3.3
Dec. B.	WIND	- 9.49	0.99	0.08	171.73	152	1,090	0.4
	SNOW		0.38	0.01	682.21		2,010	0.7
	PPT.		- 0.67	0.09	59.70		- 630	-0.2
Hardware Stores								
Jun.	TMIN	- 455.88	9.14	2.23	16.74	201	10,050	2.5
Jul. B.	WIND	19.97	- 5.92	0.13	1950.01	198	-12,430	-3.1
	C.10		- 1.05	0.03	1704.12		-11,660	-2.9
	TMIN		1.80	0.18	98.22		2,340	0.6
Oct.	T.10	426.90	- 8.23	1.61	26.26	203	- 6,580	-1.6
Dec.	WIND	- 161.60	18.63	1.64	128.22	206	20,490	5.0
	TMIN		23.46	3.45	46.11		63,340	15.4
	T.10		-22.88	3.61	40.21		-54,910	-13.3
Furniture Stores								
Jan.	SNOW	24.32	- 3.94	0.40	95.59	455	-13,710	-1.5
	PPT.		4.67	0.73	40.65		9,430	1.0
	WIND		- 3.44	1.07	10.20		- 5,160	-0.6
	C.16	467.43	- 0.93	0.15	36.71	474	-10,230	-1.1
	TMIN		-13.56	1.68	65.17		-17,630	-1.9
	T.16		4.54	1.38	10.91		8,170	0.9

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2} SD_i)$ Dollars	I
Fuel Dealers								
Jan.	T. 10	495. 17	-31. 14	1.67	348. 94	422	- 68,510	-8.1
	T. 16		19.24	1.65	136. 16		42,330	5.0
	S. 13		- 1.10	0.09	133.65		- 10,230	-1.2
Mar.	T. 16	986.46	-21.07	2.68	62.00	431	- 33,710	-3.9
Jul.	T. 16	1215.02	-22.13	3.20	47.87	426	- 39,830	-4.7
	S. 13		2.30	0.53	17.52		24,200	2.8
Sep. B.	WIND	990.22	-16.89	1.28	173.72	406	- 18,580	-2.3
	TMIN		-18.43	0.69	704.10		- 25,860	-3.2
	C. 10		1.64	0.21	58.20		8,690	1.1
Nov.	S. 13	- 328.21	2.96	0.25	144.07	431	26,640	3.1
	C. 10		2.41	0.23	111.43		14,700	1.7
	C. 16		1.06	0.20	28.84		7,420	0.9
	TMIN		- 1.23	0.23	28.44		- 2,340	-0.3
Dec.	T. 16	427.91	-10.16	2.46	17.13	441	- 25,400	-2.9
Drug Stores								
Feb.	WIND	- 802.79	35.58	0.56	3988.59	474	39,140	4.1
	S. 11		3.78	0.08	2037.19		44,600	4.7
	C. 16		2.91	0.10	918.30		24,150	2.5
	TMIN		1.17	0.18	40.24		2,690	0.3
Mar.	C. 16	- 247.93	9.09	1.07	72.52	481	90,900	9.4
	TMIN		-91.61	12.22	56.23		-109,930	-11.4
	T. 16		67.33	9.91	46.11		107,730	11.2
Sep.	S. 11	- 176.02	2.38	0.54	19.28	488	18,560	1.9
Oct.	T. 16	978.95	-18.38	3.70	24.71	491	- 18,380	-1.9

TABLE II-2 (continued)

	X	a_o	a_i	Sa_i	F	Thousands of Dollars	$a_i(\bar{X}_i \pm \frac{1}{2}SD_i)$ Dollars	I
Jewellery Stores								
Jan.	PPT.	130.06	2.37	0.27	74.74	211	4,790	1.1
	S.13		2.45	0.08	1015.43		22,790	5.4
	S.11		- 2.67	0.19	204.82		-28,360	-6.7
	C.10		- 1.64	0.26	39.52		-10,500	-2.5
Jun.	TMIN	669.01	-50.10	3.93	162.15	224	-55,110	-12.3
	TMAX		32.49	2.67	148.00		55,230	12.3
	S.13		- 3.39	0.29	134.81		-44,070	-9.8
Jul. B.	TMIN	391.18	- 6.84	0.12	3141.61	226	- 8,890	-2.0
	WIND		4.84	0.05	8342.94		10,160	2.2
	T.16		- 5.54	0.11	2389.59		- 9,970	-2.2
	T.10		4.45	0.15	829.36		8,010	1.8
Sep. B.	PPT.	- 338.40	2.68	0.22	144.24	230	1,580	0.3
	C.16		- 1.89	0.04	2029.64		- 7,940	-1.7
	TMIN		8.33	0.13	3971.05		11,660	2.5
	WIND		1.35	0.15	76.94		1,490	0.3
Oct.	TMAX	- 583.01	10.27	1.79	32.84	224	13,350	3.0
Dec. B.	T.10	- 114.00	-30.81	2.56	144.21	234	-73,940	-15.8
	T.16		32.90	2.53	168.66		78,960	16.9

Surname: WHITMORE Given Names: Angus D'Arcy

Place of Birth: Foam Lake, Saskatchewan. Date of Birth: December 7, 1942.

Education Institutions Attended, with Dates of Entering and Leaving:

University of British Columbia	1961	1964
University of Victoria	1965	1970

Degrees, Diplomas, Etc., Awarded, with Dates and Names of Institutions:

B. Sc.	1967	University of Victoria
T. T.	1970	University of Victoria
P. C.	1972	British Columbia Dept. of Education

Honors and Awards:

J. Allan Scholarship - 1961/62.

Government of British Columbia Scholarship - 1961/62.

National Research Council Postgraduate Scholarship - 1968/69.

Publications:

1969 The value of weather : challenge of assessment, Australian Geographer, Vol. 11, No. 1, March, pp. 22-28, (with W. J. Maunder).