THE ESTIMATION OF THE DEGREE OF PRICING COMPETITION IN THE BRITISH COLUMBIA WINE INDUSTRY (1957-1986)

by

DEREK ADAMS

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Department of AGRICULTURAL ECONOMICS

The University of British Columbia
Vancouver, Canada

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ABSTRACT

Until the introduction of the trade liberalization initiatives of 1989, the wine producers of British Columbia appeared to have operated in an environment that fostered less than competitive behaviour. Two factors in particular may have been responsible for creating such an environment: (1) the structure of the industry was inherently oligopolistic; and (2) protection from foreign competition was afforded by the British Columbia government in the form of a wine policy that effectively created non-tariff trade barriers against foreign wine producers. This study econometrically tests the hypothesis that British Columbia wine producers behaved non-competitively during the years 1957 to 1986.

A model of the British Columbia wine industry is developed and used to estimate the degree of non-competitive pricing behaviour in the industry, and tests are undertaken to determine whether the estimate of behaviour is consistent with competitive or with other well known behavioral specifications. the main structural components of the industry are described in a model of oligopolistic behaviour using a linear system of equations, in which both demand and pricing equations appear. The parameters which affect each of these equations are estimated using the appropriate estimation technique.

The econometric results, and the subsequent statistical tests, support the hypothesis that the domestic wine industry in British Columbia operated in a non-competitive manner between

1957 and 1986. Specifically, the hypothesis of competitive behaviour is statistically rejected, whereas, the hypotheses of Cournot and collusive-type behaviour could not be rejected.

These results suggest that British Columbia consumers may have been sacrificing to firms at least a portion of the surplus they would have obtained in a perfectly competitive industry. In addition, it appears that the wine policy of the provincial government helped create a non-competitive industry that will likely have difficulty competing in today's global market for wine.

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1. INTRODUCTION

The British Columbia wine industry is relatively new when compared to other North American wine-producing regions. Whereas, the first commercial wine-growing venture in the United States occurred in 1793 in Pennsylvannia (Adams, 1990, p.491), and the first Canadian commercial vineyard and winery was established in Ontario in 1811 (Adams, 1990, p.492), it was not until 1921 that the first wines were produced in British Columbia. Even then, these wines were not produced from grapes, but from fermented loganberries acquired from the Saanich Peninsula on Vancouver Island. Eventually, the first grape wines would be produced in the early 1930's from grapes grown in the Okanagan Valley. These grapes, however, were North American varieties which are considered unsuitable for premium wine making.

Although the grape and wine industry of British Columbia has evolved over a period extending from 1921 to the present, most of the growth has occurred during the past forty years. This expansion was fuelled by a surge in Canadian wine consumption and a parallel introduction of French hybrid and premium European grape varieties. These new varieties supplanted the North American varieties and are capable of producing much higher quality wines than those previously available.

Although the rate of growth of the B.C. wine industry has been impressive, the "good times" may be over. Since 1989 which is when the Canada-U.S. Free Trade Agreement (FTA) as well as

other regulatory changes stemming from rulings by the General Agreement on Tariffs and Trade (GATT) came into effect , there have been serious concerns regarding whether the B.C. wine industry has an economically viable future. These concerns are well grounded. Indeed, between 1988 and 1991, British Columbia wine sales have decreased by 34 percent (BCLDB, QMR, Dec. 1991).

One reason why the future of the B.C. wine industry is bleak is because it did not appear to make the type of adjustments necessary to compete in today's global market. The industry for this pessimism is that the B.C. wine industry may have achieved its past success because of provincial government policies (Branson et al., 1986) coupled with a market structure that fostered less than perfectly competitive behaviour by the industry's firms. The elimination of many of the protectionist policies, as a result of the FTA and GATT rulings, appears to have left the B.C. wine industry vulnerable and unable to compete.

1.1 Problem Statement:

Until the introduction of the trade liberalization policies of 1989, the wine producers of British Columbia appear to have behaved less than perfectly competitive. Two factors may have been responsible for this behaviour: (1) the structure of the industry was inherently oligopolistic; and (2) protection was afforded by the British Columbia government in the form of a wine policy that effectively created non-tariff trade barriers

against foreign wine producers.

Determining the actual behaviour of domestic wine producers in British Columbia prior to the 1989 trade liberalization policies is of economic interest for several reasons. First, it will help us assess the likelihood of the current industry successfully competing in today's global wine industry. Second, it will allow us to scrutinize past government policies and better understand the consequences of such policies. Finally, it will allow us to calculate welfare losses attributable to less than competitive behaviour in the British Columbia wine industry.

1.2 Objectives of the Study:

The major objective of this study is to econometrically test the hypothesis that British columbia wine producers behaved non-competitively during the years 1957 to 1986. More generally, a model is developed and used to estimate the degree of non-competitive behaviour in the industry and tests are undertaken to determine whether the estimate of behaviour is consistent with competition or with other well known behavioral specifications. This major objective may be separated into several sub-objectives:

1. To describe the British Columbia wine industry in terms of the characteristics that may give rise to non-competitive behaviour;

2. To formulate a theoretical model of an oligopolistic industry that allows for alternative behavioral specifications;
3. To specify an econometric model consistent with the theoretical model and capable of utilizing information concerning industry structure and government policy that may have been conducive to the adoption of non-competitive behaviour;
4. To use the econometric model to test the hypothesis stated above; and
5. To discuss implications of the findings.

1.3 Research Procedure:

To achieve the objectives outlined above, the wine industry in B.C. will be modelled using a simultaneous system of equations in which both demand and marginal cost equations appear. Using demand and production theory, the variables which affect the demand and marginal cost of domestically produced wine will be specified. The parameters of these equations will be estimated using econometric techniques. A measure of the degree of competitiveness in the wine industry will then be constructed from these parameters. Finally, a series of formal hypothesis tests will be undertaken in order to determine the extent and likelihood of non-competitive behaviour in the British Columbia wine industry.

1.4 Thesis Guide:

Chapter 2 is a description of the British Columbia wine industry. The first section of Chapter 2 is an analysis of the structural characteristics of the industry that may have given rise to non-competitive pricing. The second part of Chapter 2 will discuss the role of the provincial government's wine policy in creating a non-competitive market environment.

In Chapter 3, a theoretical model consistent with an oligopolistic British Columbia wine market is formulated. Particular emphasis is placed on a framework which enables one to estimate the degree of competition present in the wine industry and also allows for the testing of various hypotheses concerning non-competitive behaviour. The first section of Chapter 3 reviews basic oligopoly theory. Following that, a brief discussion of relevant production theory is provided. The theoretical framework is fully specified in the last section of the chapter.

In Chapter 4, the data requirements and sources are discussed. The results of estimating the econometric model for the British Columbia wine industry are presented in Chapter 5. Finally, Chapter 6 is a discussion of the conclusions and implications which arise from the results of this study.

2. THE B.C. WINE INDUSTRY: CHARACTERISTICS AND POLICIES

Economic theory suggests that the behaviour of firms in a particular industry is likely to be related to the structural characteristics of the British Columbia wine industry. This chapter discusses the link between structural characteristics and firm behaviour in the B.C. wine industry. This chapter also presents an overview of provincial government interventionist policies that apparently has affected the market environment of the British Columbia wine industry.

2.1 General Overview of the B.C. Wine Industry:

This section discusses the location and types of wineries in the province, the types of grape varieties used in the production of the various domestic wines, and the market trend of wine consumption in British Columbia.

2.1.1 Location of the Wine Industry

The British Columbia wine-growing district is located in the Okanagan Valley, a 120-mile-long, narrow, steep-walled stretch of farmland, lakes and resorts between the Trepanier Plateau and the Monashee Mountains. It extends from the head the Okanagan Lake, above Vernon on Highway 97, southward across the United States border. When speaking of the Okanagan, one usually includes the lower Similkameen River Valley from Keremeos and Cawston to the Washington State line near Osoyoos.

As of 1992, there are twenty-one wineries in British

Columbia, with nineteen located in the Okanagan Valley. Andres, one of B.C.'s oldest wineries, is located at Port Moody, and one of B.C.'s newest, Domaine de Chaberton, is located in Langley (see Table 2.1 and Figure 2.1).

TABLE 2.1 B.C. WINERIES: CAPACITY AND LOCATION (1992)

Winery Type	Name	Capacity '000L	Location
Commercial:	Andres	11,200	Port Moody
	Brights	3,900	Oliver
	Calona	18,200	Kelowna
	Cartier	11,400	Penticton
	Mission Hill	3,000	Westbank
	Okanagan Vineyards	570	Oliver
Estate:	Cedar Creek	225	Kelowna
	Chateau St. Claire	295	Peachland
	Divino Vineyards	340	Oliver
	Gehringer Bros.	100	Oliver
	Gray Monk Cellars	205	Winfield
	Hainle Vineyards	< 100	Peachland
	Lecomte	180	OK Falls
	St. Lazlo	< 100	Keremeos
	Sumac Ridge	230	Summerland
	Quails' Gate	130	Westbank
Farmgate:	A & H Vineyards	< 50	Peachland
	Domaine de Chaberton	< 50	Langley
	Hillside Cellars	< 50	Penticton
	Lang Vineyards	< 50	Naramata
	Wild Goose	< 50	OK Falls

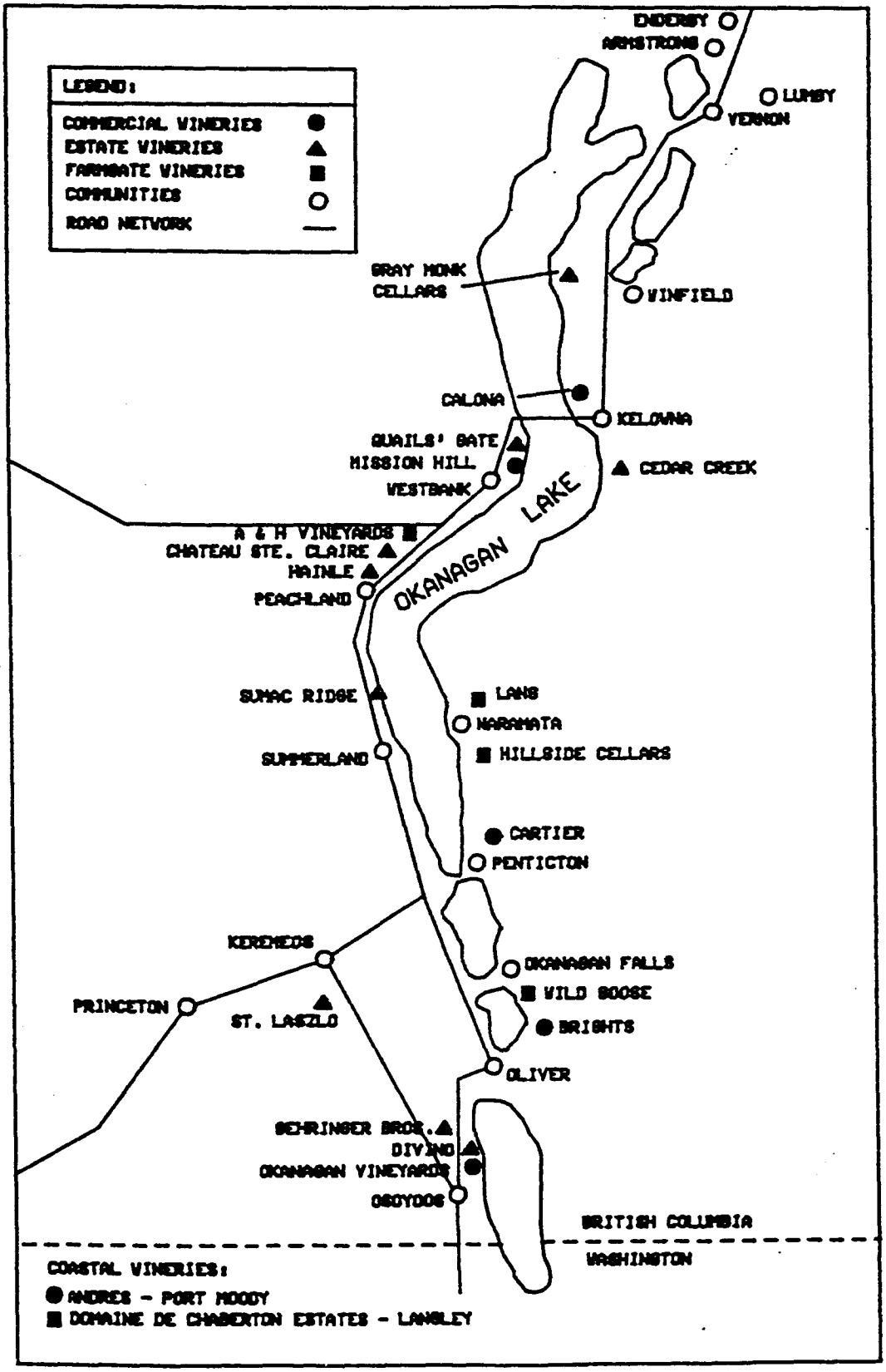
Source: various wineries.

2.1.2 Types of Wineries

Commercial wineries:

The first commercial wines produced in British Columbia were not made from grapes but from loganberries which grew on

FIGURE 2.1 LOCATION OF THE B.C. WINERIES (1992)



the Saanich Peninsula of Vancouver Island. In 1921, a commercial winery (Growers' Wine Company) was incorporated in Victoria as a means of absorbing the oversupply of loganberries in the region.

By 1927, wine production on Vancouver Island had outstripped the Saanich loganberry crop and the industry looked to the fledgling Okanagan grape industry to help meets its requirements (Hoeter, 1971, p.4). In 1928 the establishment of a 30-acre vineyard in Okanagan Mission by Growers' and Hughes ushered in British Columbia's grape wine industry (Nichol, 1983, p.34), and by 1931 Hughes had signed British Columbia's first grower contract with another Vancouver island based winery, Victoria Wines (Nichol, 1983, p.129).

The birth of a true grape wine industry in the Okanagan Valley occurred in the depths of the Depression as "...an economic salvage operation..." (Nichol, 1983, p.25). Apple prices in the region had plummeted to 1 cent per pound, virtually creating a worthless crop (Adams, 1990, p.441). At this time, Pasquale Capozzi, local grower, and W.A.C. Bennett[1], a local hardware dealer, agreed to back a project to create wine from the region's apple crop.

In September of 1932 the winery opened as the Domestic Wines and By-Product Company. The company manufactured not only

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[1]In 1940, Bennett left the wine business to pursue a career in politics. In 1952, when he became premier of the province, the provincial government began to take a more prominent role in the industry.

wines but a myriad of products, such as brandy, fruit juices, and tomato paste (Aspler, 1983, p.69). By 1934 they had realized that their apple wines could not compete with the grape wines being produced by the other wineries. They decided to switch to grapes and began importing them from California (Adams, 1990, p.442). With the change of style the former apple winery changed its name to Calona Wines in 1936. Soon after, Growers' and the Victoria wineries on Vancouver Island followed suit by importing grapes and "perpetuating the fiction of making domestic wines by using what local grapes as were available" (Aspler, 1983, p.70). For the next twenty-six years, the two major British columbia wineries (Growers' and Calona)[2] prospered by making low-quality fortified Canadian wines almost entirely from California grapes.

By the early 1960's the advent of new wineries started to encroach upon the supremacy of the older wineries. In 1961, Andres became operational in Port Moody; in 1966, both Casabello[3], and Mission Hill[4] became established in the Okanagan, while at the same time Jordan Valley Wines established

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[2]In 1936 Victoria Wineries was brought into the Growers' Company, which continued to market products under the Victoria Wineries label.

[3]Casabello was renamed Cartier wines in 1990, when its employees purchased the winery from Labatts.

[4]In 1969 Mission Hills was acquired by Ben Ginter and renamed Uncle Ben's Gourmet Winery. After suffering the consequences of marketing dubious wines it re-emerged as Golden Valley Wines in 1978. However, by 1981 Ginter was forced to sell the winery to the Mark Anthony Group, who immediately gave it back its original name.

a winery in New Westminister called Villa Wines.[5] Even the old Growers' winery was not exempt from change. In 1966, Growers, was absorbed by Castle Wines, a subsidiary of Imperial Tobacco, whose wines were marketed under the name Ste. Michelle.

There was continued change within the industry during the early 1970's and 1980's. In 1972, the brewery giant Carling O'Keefe bought Jordan Valley Wines. In 1973, Castle wines joined Jordan Valley under the ownership of Carling O'Keefe, and the amalgamated operation became known as Jordan and Ste. Michelle Cellars Ltd.[6] In 1981, Brights entered the commercial market, and was followed in 1983 by Beaupre.[7] Finally, in 1986, Brights purchased the commercial winery, Jordan and Ste. Michelle Cellars Ltd.[8] By the end of 1988 there were seven commercial wineries operating in the British Columbia domestic wine industry.

Commercial wineries were the predominant wineries in British Columbia during the period of this study (1957-1986). In 1988, the commercial wineries were responsible for 19,828,851L

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[5]Villa Wines' predecessor was called West Coast Wines, which entered the wine market in the early 1960's.

[6]In 1974 the New Westminister (Villa Wines) plant was shut down, and in 1977 the old Growers' winery in Victoria was closed, and the operation was moved to a new facility in Surrey.

[7]In 1989, Beaupre, a subsidiary of Potters Distillery, purchased Calona Wines, The new owners retained the original name of the winery.

[8]The relatively new Jordan facility constructed in Surrey in 1977 was shut down in 1990. Brights is currently looking for a buyer.

or 97 percent of total B.C. wine sales in B.C.; or 58 percent of total wine sales in B.C.(BCLDB, QMR, Dec. 1991).

As a condition of licensing, commercial winery applicants must have met the following basic requirements:

1. Size of vineyards:
   a. none

2. Production:
   a. no minimum
   b. no maximum

3. Source:
   a. must have contained at least 80 percent B.C. grape content.[9]

4. Wine Making and Bottling:
   a. whereas all wine must have been bottled on-site one could have blended wine produced in other countries.

5. Standards and Labelling:
   a. The only legislation which seems to have applied is that which relates to all foods (health and safety regulations).

Estate Wineries:

During the late 1970's the provincial government realized that there was great tourist potential for a thriving wine industry in the Okanagan Valley. After years of hesitation, on September 29, 1978, the Minister of Consumer and Corporate Affairs proposed the creation of cottage or estate wineries. According to the Minister, it was important to,

> "...encourage small family type operations that take pride in their product and strive for excellence, rather than large production" (Vielvoye, 1990, p.2).

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[9]This regulation was known as the 80/20 rule.

On the heels of the government issuance of estate winery guidelines, Bob Claremont and his wife, Lee, acquired a facility built by Marion Jon in Peachland, and by 1979 Claremont Estate Winery began to vinify British Columbia's first estate bottled wines.[10]

Within the next three years Claremont was joined by four other small wineries in the Okanagan - Sumac Ridge, Vinitera[11], Uniacke Cellars[12], Gray Monk, and Divino Wines.

In 1986, the estate wineries, Gehringer Bothers, Lecomte, and St Lazlo entered the industry.Finally in 1987 the estate winery, Hainle Vineyards became the last entrant in the domestic wine industry prior to the dramatic economic changes incurred by the industry in the late 1980's. By the end of 1988 there were nine estate wineries operating in the British Columbia domestic wine industry.

Estate wineries are small scale wineries producing wine made from 100 percent B.C. grapes grown predominantly on the winery's own farm. Given that production restrictions were placed on this type of winery it was expected that they would produce premium wines. In 1988, the estate wineries accounted

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[10]In 1986, Claremont changed ownership and became Chateau Ste. Claire.

[11]In 1982, Vinitera Wineries had the dubious honour of becoming the first estate winery in British Columbia to go into receivership. In 1984, the winery was reorganized into Okanagan Vineyards and granted a commercial license.

[12]In 1987 Uniacke Cellars changed owners and became Cedar Creek Estate Winery.

for 627,536L or 3 percent of total B.C. wine sales in B.C.; or 2 percent of total wine sales in B.C. (BCLDB, QMR, Dec. 1991).

As a condition of licensing, applicants must have met the following basic requirements:

1. Size of vineyards:
   a. minimum 20 acres
   b. maximum none

2. Production:
   a. minimum 7,500 gallons
   b. maximum 30,000 gallons

3. Source:
   a. 100 % B.C. grapes of which a minimum of 50% must have come from the winery's farm.

4. Wine Making and Bottling:
   a. within one year of licensing, all wine must have been produced and bottled on-site.

5. Standards and Labelling:
   a. whereas estate wineries operated under the content regulations stated above, they were not required to specify the contents on their labels.

2.1.3 Evolution of Grape Varieties and Wine Quality

During the early 1920'2 a Hungarian wine-maker, Dr. Eugene Rittich, visited the Okanagan Valley and thought that its climate might be suitable for growing wines. Dr. Rittich made some experimental plantings that proved him right, and he interested a farmer, by the name of J.W. Hughes, in planting a vineyard in the Okanagan Mission area. By 1926 Hughes owned 75 acres of land in the Kelowna area, on which he planted

labsruca[13] grape varieties (Nichol, 1983, p. 129). Thus, the Okanagan Valley followed the example of the eastern United States and Ontario in founding their grape growing industry on the native North American varieties (ie. labruscas and American hybrids[14]).

During the 1930's experiments were once again undertaken by Dr. Rittich in order to prove that fine wine producing grapes could be produced in the Okanagan. In 1938, results of these test demonstrated conclusively that viniferas[15] would not only survive in the Okanagan Valley, but would yield commercially acceptable crops (Nichol, 1983, p.131). Unfortunately, premium viniferas exceeded the needs of the fresh market and the wineries in quality and price. Thus, the growers kept to those varieties which had already served both the table grape and wine markets well in Ontario and the eastern United states, that is, the native North American varieties.[16] The viticulture virtues

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[13]Labsruca grapes are a species of vines that are native to the North eastern United States and Eastern Canada.

[14]A hybrid is a variety of grape obtained through cross pollination between varieties drawn from more than one species. Hybrids are referred to as being American or French, depending on where they were first propagated.

[15]Vinifera is a species of vines native to Europe. All the great wines of Europe are made from grape varieties falling within the confines of this species.

[16]Some blame must be placed on the Summerland Research Station. It is only in recent years that the Station has extended its breeding material beyond North American varieties to include, first, the French hybrids of the 1960's, and more recently the vinefera varietals.

of these varieties -winter hardiness, disease resistance and prolific yields- provided the growers with security while supplying the wineries with an inexpensive raw material for their fortified wines. The coarse overbearing flavours of these varieties were not a serious disadvantage considering the naivety of the average wine consumer at this time. Campbell's Early, Sheridan, Concord and Patricia, all red varieties, were planted and were later made into wine and brandy for the making of ports, sherries and fortified berry wines. Somewhat later, Delaware, Portland, Diamond and Niagara were planted for use in the making of "White Port".[17] These fortified wines and the two wineries that supplied them ruled the British Columbia market until 1961, when Andres and West Coast Wines challenged their supremacy with the introduction of generic table wines.[18]

With the growth of an entirely new generic table wine market, North American varieties began to be superseded by the French hybrids. Experimentation with French hybrids began in 1950. By 1959 interspecific hybrids such as Bath and Okanagan Riesling, and French hybrids such as Bertyle Seyve, Aurora,

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[17]A survey taken in 1952 showed a total of 425 acres of grapes in British Columbia, 383 of which were planted to American hybrid (labrusca-type) varieties (B.C. Select standing Committee, 1978, p.44).

[18]A surge in the province's table wine sales brought on the "pop" wine craze of the early 1970's. The emergence of "pop" wines in the United States, served as a model for Andres' 7 percent alcohol, Concord-based "Baby Duck". Introduced in 1971, it became the largest selling wine in Canada by the end of the decade. Only in the early 1980's did sales for this product peak.

Rougeon, Marechal Foch, Chancellor, Verdelet, De Chaunac, Rosette, Chelois, and Cascade were being introduced and planted for wineries (Vielvoye, 1991, p.i).[19] These French hybrids were used in the production of the growing generic table wine market, while the remaining North American hybrids and labruscas were confined to the production of "jug" wines. These selections became the backbone of the domestic wine industry until the renewed attempts to grow European varieties other than the French hybrids proved successful in the mid-to-late 1970's.[20]

Generics are blended wines given proprietary names. The source of these names may be wine producing regions in Europe (i.e. Burgundy, Chablis), or they may be names of pure invention. British Columbia's "import alternatives"[21] dominate the generics and they appear in a variety of formats: the one-gallon jug, the bag-in-the-box, the Tetra Brik, corked magnums, or corked 750 ml. bottles. It is for this reason that the difference between the generics and jug wines lies not so much in format as in quality and style. Jug wines carry brand names predating the wine boom and they offer a long-standing clientele

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[19]Vineyard acreage grew from 572 acres in 1960, to 2414 acres by 1970. Between 1970 and 1974 another 650 acres of vines were added, bringing the total acreage to 3066 acres (Nichol, 1983, p.136).

[20]By 1974, only twenty percent of total grape acreage was being allotted to the old North american varieties (Nichol, 1983, p.101).

[21]These are wines made locally in a style designed to emulate European wines and are often given foreign-sounding names (i.e. Andres' Hochtaler, and Calona's Schloss Laderheim)

sweet, sometimes highly alcoholic white and red wines. As a rule-of-thumb, the jug wines do not carry pseudo-European brand names nor do they appear in corked bottles.

By the mid to late 1980's, the grape growing industry began moving towards the adoption of the highest quality European or vinifera varieties. From the mid to late 1970's there was a resurgence of interest in grape varieties imported from the United States and Europe. New variety experiments using vinifera varieties from Washington State in 1974, followed by introductions from Germany in 1977, had proved successful (Vielvoye, 1991, p.i). By 1983 a growing trend in the Okanagan grape growing industry became evident; older table grape selections, and French red hybrids were quickly being replaced by new white French hybrids, and vinifera cultivars. By 1988 this trend saw the expansion of vinifera varieties such as Riesling, Pinot Blanc, Ehrenfelser, and Gewurztraminer into the Okanagan vineyards.[22]

However, even with this trend towards the adoption of vinifera varieties, the commercial wineries added limited production premium varietal lines more for their prestige value in marketing the jugs and generics than out of any serious commitment to the marketing of premium wine (Nichol, 1983, p.147). Thus, it was left to the estate wineries to develop a market for premium British Columbia wines, a market which the

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[22]By the end of 1988, the grape industry consisted of over 200 vineyards growing 3,400 acres of grapes.

commercials were hoped to eventually pursue and cultivate.

2.1.4 Wine Market Trends

In order to develop a full understanding of the British Columbia wine industry it is necessary to review the changes that have occurred in consumer preferences for wine over the past few decades. There has occurred two major trends in the wine market which have had an important impact on the industry. The first was a shift in drinking habits from spirits and beer to wine; while the second was a shift in preference to white wine over the traditional red wine mainly produced by the industry. Whereas the first trend was beneficial to the B.C. wine industry the latter change has caused some difficulty.

In 1975 the per capita consumption (over 15 years) of spirits, beer and wine was respectively 13.9L, 112.7L and 11.9L in British Columbia. By 1987 the per capita consumption was 10.2L, 100.2L and 20.6L in British Columbia (Statistics Canada, catalogue 63-202). It is clear that while per capita consumption of spirits and beer decreased by 27% and 11% respectively since the mid-seventies, wine consumption has increased by 73% in British Columbia.

Figure 2.2 shows the historical volume sales by category in B.C. from 1957 to 1988 (fiscal years). Wine sales show the greatest sales growth and continued to grow even after beer and spirit per capita consumption peaked around 1980.

Before 1970, imports were not widely consumed in British

Columbia and did not pose an economic threat to the viability of the domestic wine producers. The average Canadian consumer of wine in those days was more interested in a wine that was cheap and strong. In fact, according to Branson et al. (1986, p.10), the British Columbia wineries saw themselves as being in the 'plonk' business and were not really interested in quality.

By the early and mid 1970's there was a dramatic shift in consumer preferences with dry table wines becoming more popular. Since the domestic wine industry could not meet this increase in demand, imported wine sales began to rise rapidly (see Figure 2.3).

Between 1970 and 1980 imported wine sales had increased by over 500%. By 1988 imported wine sales accounted for 40% of total wine sales in British Columbia and in terms of dollar sales 53% (BCLDB, QMR, Dec. 1991).

Whereas, in 1977, red wine accounted for more than one half (53%) of the wine consumed in the province, by 1980 this ratio had been reversed and red wine accounted for only 34% of total consumption (Branson et al., 1986, p.11). By 1988 white wine accounted for 74% of total table wine sales, and 65% of all wine sales in British Columbia (BCLDB, QMR, Dec. 1991). In terms of thousands of litres consumed, white wine increased from 7,104L in 1977 to 22,035L in 1988, while red wine consumption stayed fairly constant over this period, 7,500L (BCLDB, QMR, Dec. 1991, and Branson et al., 1986, p.11).

FIGURE 2.2 PER CAPITA ALCOHOL CONSUMPTION (1957-1988)

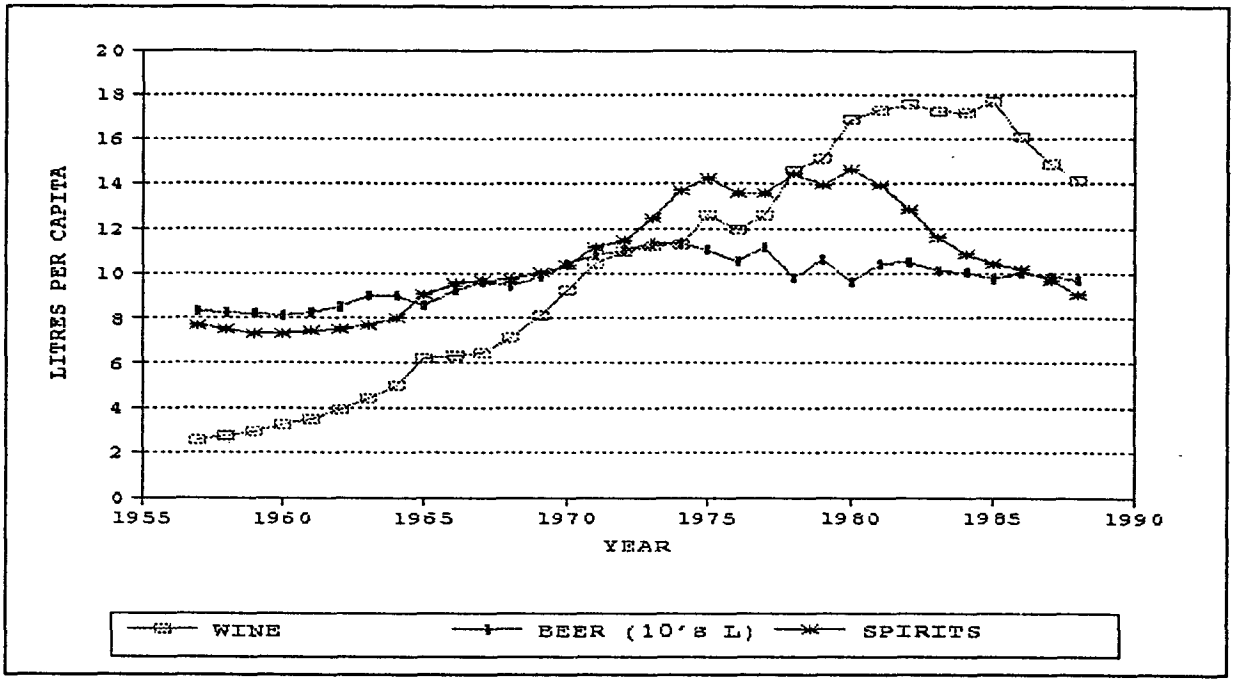
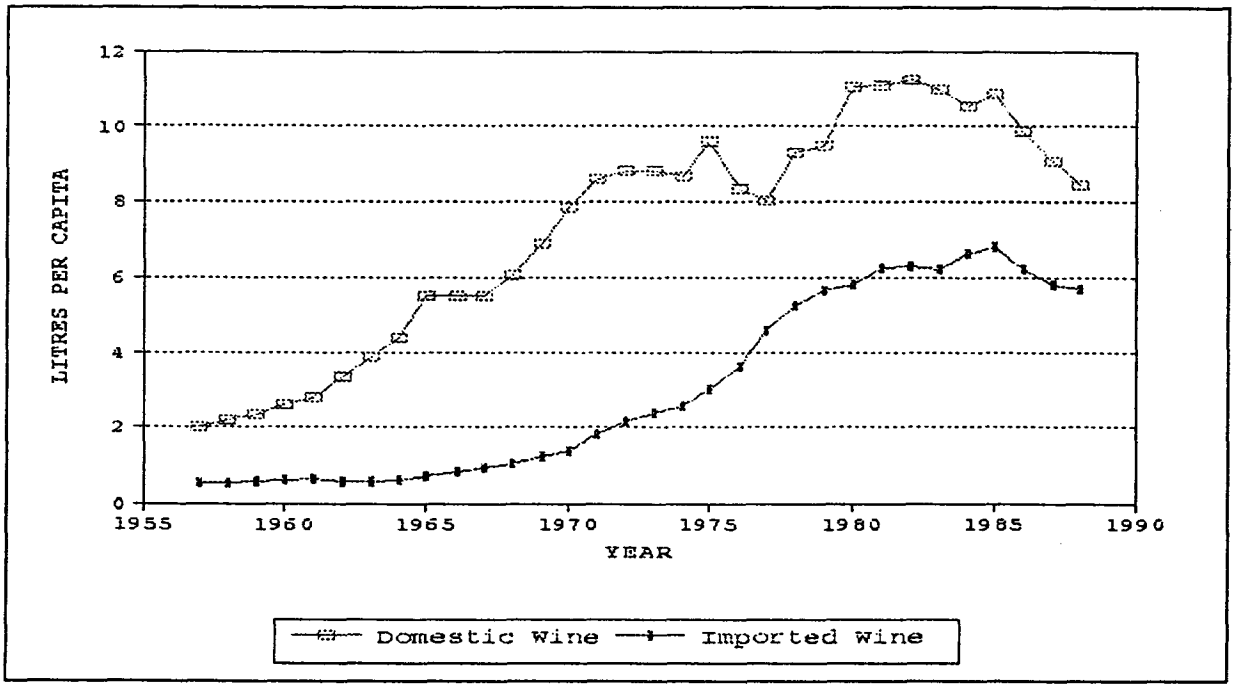


FIGURE 2.3 PER CAPITA WINE CONSUMPTION (1957-1988)



Source (both graphs): Statistics Canada; BCLDB, QMR, Dec. 1991.

2.2 Market Structure of the B.C. Wine Industry:

This section presents the factors inherent to the British Columbia wine industry that may have given rise to non-competitive pricing behaviour. Drawing upon textbook expositions such as Scherer (1980)[23], the relationship between the market structure of the domestic wine industry and possible non-competitive conduct may be hypothesised.

The extent to which price in an oligopoly can exceed the long-run competitive level, depends upon the success of firms in coordinating their pricing decisions (i.e. in order to achieve joint maximization of profits). Such coordination depends upon the following factors:

(a) the number and size distribution of firms in the industry.
(b) the similarity of costs between firms.
(c) the level of entry barriers to the industry.
(d) the industry's pricing method.

(a) One structural dimension with an obvious influence on pricing conduct is the number and size distribution of the producers. Generally, the more firms a market includes, the more difficult it is to maintain prices above cost.

The number of wine producers in British Columbia has always been quite small (see Figure 2.4). In fact, between 1957 and 1986, there were an average of five commercial wineries in

[23]In addition, the paper by Grant (1982) contains an excellent discussion on market structure and oligopoly pricing behaviour.

operation.[24]

Since Scherer (1980, p.199), states that, as a very crude general rule, firms are likely to begin ignoring their influence on prices when their number exceeds ten or twelve; then the small number of commercial wineries would make the achievement of successfully coordinated pricing decisions a distinct possibility.

One other point merits further consideration here; does the presence of numerous small firms operating on the fringe of an otherwise oligopolistic industry affect pricing behaviour (see Figure 2.5).

In the case of the British Columbia wine industry, estate wineries only started to appear in the late 1970's. By 1986, they had only acquired one percent of total wine sales in the province (BCLDB, QMR, Dec. 1990). Although, as can be seen from Figure 2.5, imported wine sales have increased their share of total wine sales in the province, government policies have effectively limited imported wine sales from affecting the price levels of the domestic wineries (the government wine policies will be discussed in more detail in the following section of this chapter).

In general, the breakdown of oligopoly price structures are more likely the higher the proportion of industry capacity in the hands of fringe producers; therefore, it would seem that

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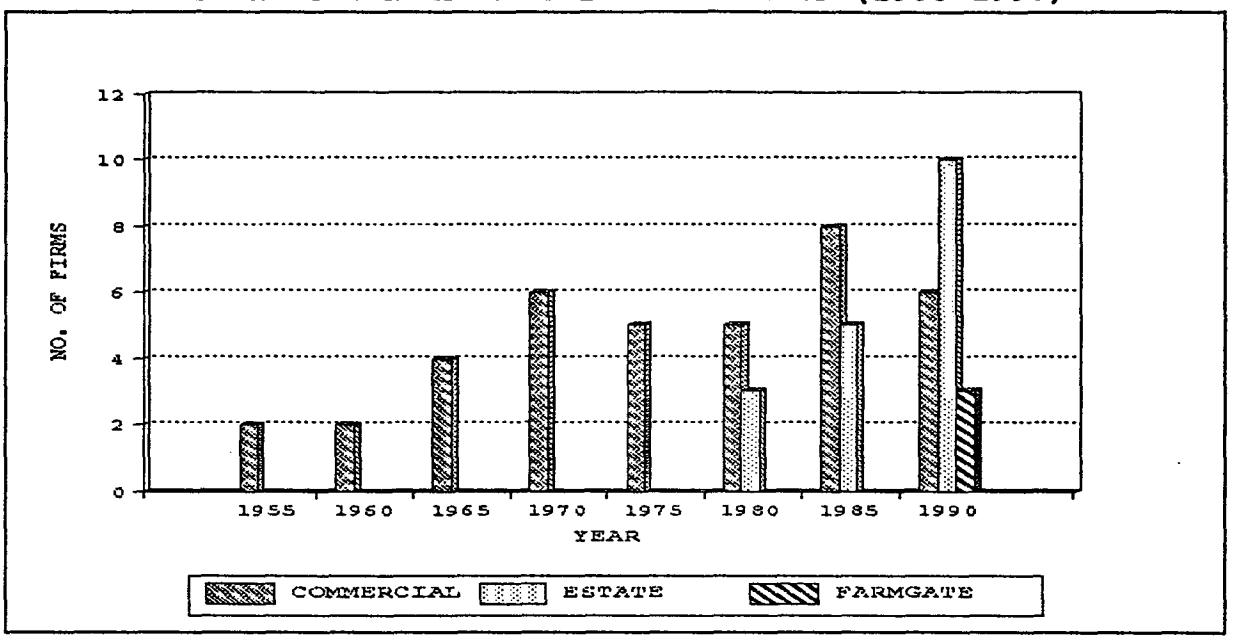
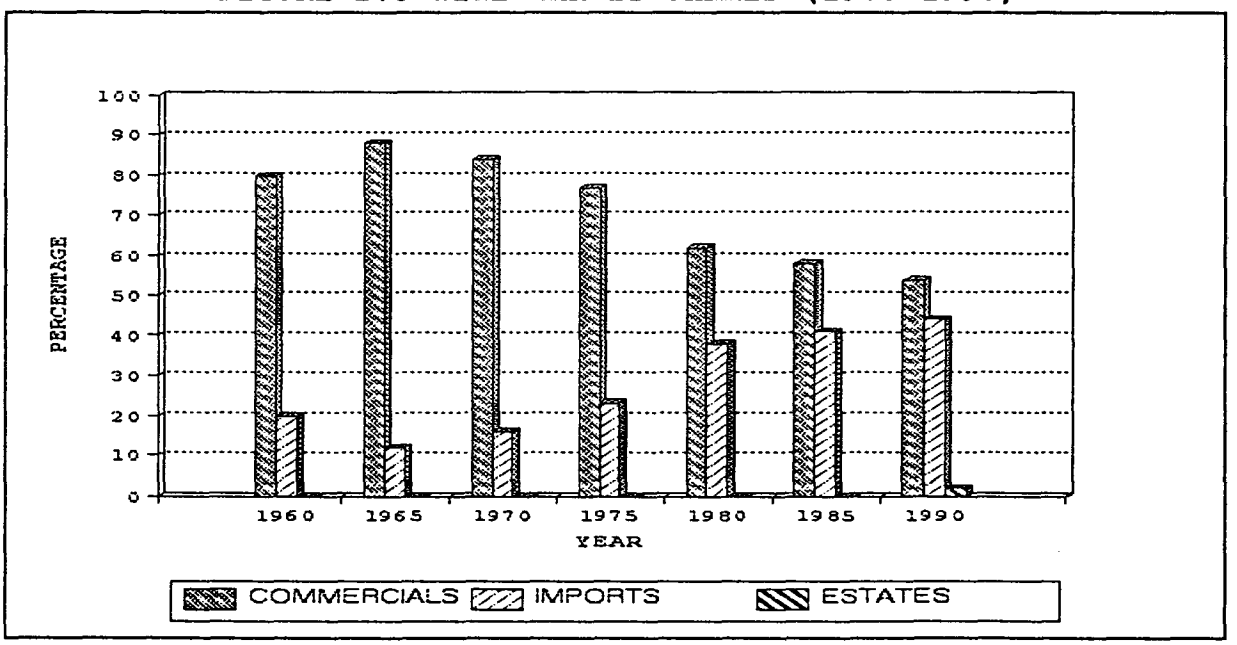
[24]It is assumed that the number of estate wineries is insignificant since their contribution to domestic output was relatively insignificant over the sample period.

FIGURE 2.4 NUMBER OF B.C. WINERIES (1955-1990)



Source: various historical references.

FIGURE 2.5 WINE MARKET SHARES (1960-1990)



Source: Statistics Canada, cat 63-202; BCLDB, QMR, Dec. 1991.

since the fringe's capacity is small relative to total industry output, the leading producers (i.e. commercials) will be more apt to ignore the fringe group (i.e. estates) and persevere in their efforts to hold their own price line.

(b) The absence of any significant cost differences between firms promotes unanimity concerning the pricing strategy to be adopted by each firm.

In reference to the British Columbia wine industry, although firm-specific cost data could not be obtained, the general similarity in sizes implies similar cost structures. In addition, the similarity between the firms in their production methods and sources of inputs (i.e. B.C./U.S. grapes, imported grape juice, imported bulk wine, bottles, labour, etc.) suggests that no firm was likely to perceive an absolute cost advantage over any of the other firms.

(c) The possibility of new firms entering an industry is an important determinant of non-competitive pricing behaviour. The relatively high fixed costs likely provided a significant barrier to entry in the British Columbia domestic wine industry (in addition, the requirement of significant technical expertise in wine-making may have also been a barrier to entry). For example, in 1978, the value of the wine industry's plants and facilities (including equipment) was valued at $15 million (B.C., Select Standing Committee, 1978, p.69). Total domestic wines sales for that year was valued at $45 million (Statistics Canada, cat. 63-202), resulting in industry fixed costs worth 33

percent of total sales. In 1991, the value of the industry's plants and facilities was valued at $42 million (Vielvoye, 1991, p.29). Total domestic wine sales in that year was valued at $107 million (BCLDB, QMR, Dec. 1991), resulting in industry fixed costs worth 39 percent of total sales.

(d) Where firms price by means of announced price lists, coordination of pricing decisions is easier than where prices are negotiated individually with customers or where tenders are submitted for individual orders. For the British Columbia wineries, their wholesale prices are announced on the basis of a scheduled price list to the Liquor Distribution Branch. A winery must submit a notice of a price change by the second day of a financial period in order for it to take effect for the following period. There are twelve financial periods in a year, usually between four to five weeks in duration. They begin on a Wednesday and end on a Tuesday, with the exception of financial periods that start April 1, or end March 31.

To a large degree, none of these factors taken singly appears to be a sufficient condition, nor, with the possible exception of the number of participants, even a necessary condition for effective non-competitive pricing behaviour; instead the broad combination of these factors would seem to be enough to predict that non-competitive conduct is a distinct possibility in this industry's case.

2.3 Government Intervention in the B.C. Industry:

In order to clearly illustrate the provincial governments' role in creating a market environment that may have given rise to non-competitive behaviour, a presentation of the government's wine policy is presented in the next section.

2.3.1 The Development of a Provincial Wine Policy

The Liquor Control Board's intervention on behalf of the grape industry began in 1960 when the Board was approached by a business group interested in establishing wineries in the province. It became apparent to the board that this group was interested in establishing a manufacturing base for the production of domestic wine out of California grapes and bulk wine (Nichol, 1983, p.135). Even though the existing wineries were taking a growing proportion of the domestic grape crop[25], the British Columbia content in domestic wines at this time was still very minuscule. In this context the Board decided to require wineries to increase the British Columbia content in their wines as a condition of licensing.

The wineries were expected to either acquire their own vineyards or to extend their contracted acreage. In addition, the wineries were expected to increase the domestic content of their wines, initially set at twenty-five percent (Aspler, 1983, p.70). To encourage the planting of new vineyards, the Board

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[25]In 1960, grape growing in the Okanagan Valley was confined to a mere 572 acres of which only 325 were in production (Nichol, p.135).

stated that the quota would rise to fifty percent in 1962 and to sixty-five percent by 1965 (Aspler, 1983, p.70). This policy soon had the desired effects, whereas, as late as 1956, sixty percent of the grape harvest had been sold as table grapes, by 1962 this figure had dropped to thirty-six percent and in the following year had dropped down to only eight percent (Nichol, 1983, p.133). Within four years of the institution of the LCB's wine policy, total domestic grape acreage had increased by four hundred percent (Aspler, 1983, p.70), and by 1970 approximately 2,400 acres had been planted (Vielvoye, 1987, p.1).

By 1967, the British Columbia content of domestic wine had been raised to eighty-one percent (Nichol, 1983, p.135). This content requirement caused much consternation amongst the wineries. The wineries complained that any further escalation of this quota would cut them off from their American grape sources, and leave them entirely dependent on the Okanagan vintage. In 1968, the Board decided that there would be no further quota increases and settled on eighty percent as the British Columbia content requirement. However, after a disastrous 1969 Okanagan grape crop, the Liquor Board decided to adapt a more flexible policy; eighty percent content became a goal rather than a strictly enforced requirement. This meant that the importation of grapes and bulk wine became conditional upon the wineries' purchase of the entire domestic grape crop. This arrangement became known in the industry as the eighty/twenty rule.

In the early and mid-1970's there occurred a dramatic shift

in consumer tastes that resulted in another bout of government intervention, this became known as the 1977 Wine Policy. The 1977 Wine Policy originated from a growing preference amongst consumers for dry table wines. Since the British Columbia wineries produced very little table wine they were not able to meet this new demand. The Liquor Board had no option other than acquiring more imported table wine. The domestic producers began to lose market shares and by 1977 had less than half of the market in terms of dollar sales (Branson et al., 1986, p.43).[26]

Since the wineries had the wrong type of wines, a poor image, and a lead time of five years before any new vines planted would be in full production, the wineries turned to the governments for aid. After failing to persuade the federal government to intervene, they turned their efforts towards Victoria. In March of 1977, the British Columbia Ministry of Consumer and Corporate Affairs responded to this strong lobby from the wineries and grape growers by announcing its new Wine Policy. The policy gave the wine industry some major concessions (B.C., Select standing Committee, 1978, pp.38-40),

- the provincial mark-up on domestic wines was reduced from 66% to 46%, while that on imported wines was reduced from 117% to 100%.
- no listings would be granted for imported wines that were either in bottles larger than 1 litre or which

[26]Changes in the exchange rate also began to turn against the domestic producers at the same time, as many European currencies fell against the Canadian dollar in the mid-1970's.

would retail for less than $2.75 per 750 ml. bottle.

- to give their products a boost, the wineries were allowed to open a retail store on their premises.
- under the supervision of the federal and provincial Ministries of Agriculture, a five-year grape growing program was introduced at a cost of $133,000 to upgrade the quality of grapes used.[27]

Thus, the wineries received almost all the concessions they wanted, and had to give up very little in return.[28]

By the mid 1980's the same shifts in consumer preferences that had necessitated the 1977 wine Policy created another serious problem for the domestic wine industry. The continuous growing demand for white table wine combined with a flat market for red[29], resulted in a chronic surplus of red grapes for the domestic producers. Acres planted to white grapes began to increase in 1977, when the Minister of Agriculture began to give some incentive to plant white grapes. The result of the 1977 to 1979 plantings was about a fifty-fifty split between the red and white harvest by 1983, however, this was still too much red (Branson et al., 1986, p.50). Eventually the wineries became

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[27]This program was directed by the world famous viticulturist, Dr. Helmet Becker. Dr. Becker selected 27 European varieties for testing in the Okanagan.

[28]Automatic listings were restricted to sixty-six, and any one brand was restricted to three sizes (Branson et al., p.47).

[29]In 1982, B.C.'s commercial wineries had a five-year supply of red wine in their inventories, close to seven million gallons (Aspler, p.73).

frustrated with having to buy useless red grapes from the Okanagan growers and attempted to cancel their grape contracts. The court action which resulted from these cancelled contracts was dropped under the terms of an agreement reached between the wineries, the growers, and the provincial government.

In September of 1985, both the federal and provincial governments announced a solution to the province's red and white grape imbalance. The overall plan called for the replanting of red grape acreage and the elimination of the current red wine surplus. The governments purchased the 1985 red grape crop and 600,000 gallons of red wine which was distilled by the wineries into pure alcohol and re-sold to the wineries (Branson et al., 1986, p.54). In addition, the growers received financial assistance in converting their red grape acreage into white, which led to the evolvement from a 1977 red/white acreage ratio of 67:33 to a late 1987 25:75 ratio (BCGMB, 1987a, p.1).[30]

From this overview of the provincial government's Wine Policy prior to 1989, it is apparent that the government insulated domestic wine producers from any pressures arising from outside competitors. In fact, it effectively created non-tariff trade barriers to foreign produced wine.

The following sub-sections present in more detail the methods the provincial government used in order to protect the domestic wine industry from outside market forces.

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[30]For an update on recent government policy changes since 1989, see section 6.2.

2.3.2 Active Government Support

Active government support for the domestic wineries in British Columbia stems from the provincial government's control of licensing and sales. The two legislative acts that are at the basis of this control are the Liquor Control and Licensing Act and the Liquor Distribution Act. The Liquor Control and Licensing Act, through which the Liquor Control and Licensing Branch (LCLB) operates, controls under which circumstances alcohol may be sold or consumed, and licenses producers and vendors of alcohol. Sections 55 and 58 prohibit the manufacture of wine (except for home consumption) except under a license to be renewed at the end of each fiscal year (March 31). The Liquor distribution Act establishes that the Liquor Distribution Branch (LDB) is the sole purchaser (both in and out of the province) of all wine for resale in British Columbia.

The provincial government used its dominant position as the preeminent retailer of wine, and its ability to regulate listings, prices, retail outlets and licenses, to actively protect the domestic wine industry from any foreign competitive initiatives. In fact, it used its legislative powers to effectively create a barrier-to-entry for foreign produced wine that hindered the development of a truly competitive wine market.

A brief summary of the major government legislative powers used in supporting the domestic wine industry are presented below.

Pricing:

One method utilized by the government to protect the domestic wine industry was the LDB's ability to regulate retail wine prices in government liquor stores.[31] In return for using British Columbia grapes in the manufacture of domestic wines, the wineries were granted a price concession at the distribution level (known as a preferential mark-up). This mark-up was the cornerstone of the provincial government policy for the industry. The provincial government used this method to mark-up imported wines approximately twice as much as domestic wines. For example, in 1988 the mark-up on imported table wines was 110 percent compared to only 50 percent for domestic table wines (see Table 2.2).

The price mark-up was certainly the most important government support policy used, as it allowed the wine industry to have a substantially higher cost structure and yet be priced below low cost imports. According to the Grape Marketing Board (BCGMB, 1987b, p.3), in 1987 the industry's average retail selling price per litre was $4.42 versus $7.75 for imports, and their lowest priced wines were about $1.50 per litre lower than the cheapest imports.

It was believed by the industry, that if the price differentials were removed the domestic wine industry would not be able to compete with the wines from other countries (BCGMB,

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[31]See Appendix A for the British Columbia Liquor Distribution Branch's domestic wine pricing scheme.

1987b, p.3).

TABLE 2.2 PROVINCIAL MARK-UP RATES

		B.C.	Imported	Other Cdn.
Table:	1971	60%	104%	90%
	1975	66%	117%	100%
	1977	46%	100%	100%
	1981	50%	110%	110%
Fortified:	1971	70%	110%	90%
	1975	78%	122%	100%
	1977	78%	122%	100%
	1981	82%	118%	110%

Note:(1) Table includes red, white, rose table wines plus the sparkling wines.
(2) Estate wineries were subjected to a 15 percent mark-up.
(3) See section 6.2 for recent changes to the preferential price mark-up.
Source: Conversation with Gordon Hall, Manager of Corporate Research and Policy Development, BCLDB.

Listings:

Since the provincial government owns all the main liquor stores in B.C. anyone wanting to sell a wine product must get the LDB to carry their good. This is known as acquiring a listing.[32] To receive a listing the agent of the wine product must have submitted an application for listing. Those applications which were accepted are given a conditional listing. If the product achieved its sales quota in test stores within 18 months it was granted a general listing. If in the future a general listing failed to reach its quota it was

[32]s single listing is considered to be one brand of one size.

delisted.

There were three main methods that allowed this listing technique to favour British Columbia wines over imports. First, all domestic commercial wineries were accorded automatic general listings without going through the listing process.[33] Second, while domestic wine may have been bottled in any size, imports were not allowed in sizes larger than 1.5 litres. Finally, while a Canadian agent may have submitted an unlimited number of applications annually, a foreign agent could submit only nine (see Table 2.3 for recent listings).

TABLE 2.3 RECENT WINE LISTINGS

Year	Domestic	Imported
1980	321	321
1981	365	416
1982	352	374
1983	379	382
1984	394	383
1985	390	399
1986	396	406
1987	344	405
1988	344	435

Source: BCLDB, Annual Reports.

The listing process gave the government certain scope to discriminate against imported wines. There was no appeal of a listing decision, and a rejected applicant was not advised as to

[33]By the late 1980's all domestic wineries licensed prior to January 1982, were granted sixty-six automatic listings . Those wineries licensed after January 1982 were accorded fourteen automatic listings.

why his wine was rejected (Brandon et al., 1986, p.29). With this type of subjective process, the LDB could have decided not to list wines which would have been deemed too competitive with domestic wines. According to Rowe (1978, p.63 and p. 75), of all the provincial liquor authorities operating in Canada, the British Columbia LDB was the most blatant about not listing any imported wine which would have competed too strongly with the domestic products.

2.3.3 Passive Government Support for the Wineries

In addition to the provincial government's active support for the industry, the government also provided passive support. This support took the form of weak wine standards, appellation[34] regulations and labelling regulations. In other words, the provincial government aided the industry by not applying regulations which were adopted by other wine producing regions.

Unlike many wine producing regions in the world, in British Columbia there were no basic wine standards for domestically produced wine.[35] In fact, the only legislation which appears to have applied to domestically produced wine is that which relates to all foods (ie. health and safety regulations). Thus, a British Columbia winery could manipulate its wine's varietal

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[34]A strict appellation regulation would require that only wines with an 100% British Columbia grape content would be allowed to be labelled and identified as British Columbia wines.

[35]See section 6.2 which contains a brief summary of strict new wine standards, appellation controls and labelling regulations.

flavour, colour, acidity, sugar level and body by resorting to amelioration[36] with sugar and water.

Tied very closely to, and in fact inseparable from wine standards are the appellation controls and labelling regulations. While the standards define and quantify the parameters of quality wine, the appellation controls and labelling regulations readily identify these wines for the consumer. Contrary to the practices of the best wine producing areas of the world, for most of its history British Columbia did not have any standard appellation or labelling requirements regarding origin, type of grape, or year of bottling. Thus, commercial wineries could "...have imported wine in bulk, bottled it in B.C. and still have called it a B.C. wine" (Branson et al., 1986, p.34). Similarly according to a major participant in the industry, namely the Grape Marketing Board,

> "Much of today's negative image of B.C. wine can be attributed to a lack of virtually any standards and appellations. The public has been confused by the myriad number of products called B.C. wine. These wines are produced from grapes and wine coming from many different areas and these wines are made to various degrees of quality standards" (BCGMB, 1989, p.10).

Thus far, this study has described the structural characteristics of the British Columbia wine industry that may have been conducive to the adoption of non-competitive pricing

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[36]Amelioration is the process, whereby the addition of such additives as sugar and water are used to change a wine's characteristics. The practise is illegal in the European Economic Community, California and as of 1983, New Zealand (Nichol, p.157).

behaviour by the domestic producers (ie. general overview, industrial infrastructure, government wine policy). This has been a static description of the industry and does not allow for any analytical testing of the industry's underlying market structure. In order for empirical research to be initiated an economic model of the wine industry in British Columbia has to be created. The theoretical basis for this model is presented in the following chapter.

3. A MODEL OF OLIGOPOLISTIC BEHAVIOUR IN THE B.C. WINE INDUSTRY

In this chapter a model of oligopolistic behaviour in the British Columbia wine industry is presented. This model is subsequently used to specify an empirical model which is used to estimate the degree of competition in the British Columbia wine industry. First, some basic oligopoly theory is discussed. Second, a brief review of empirical work in industrial organization devoted to the question of inferring the existence of non-competitive behaviour from data on observed market outcomes is presented. Finally, the third section specifies a model capable of testing various hypotheses about non-competitive behaviour in the British Columbia wine industry.

3.1 Oligopoly Theory:

An oligopolistic market is one in which the number of firms is small enough for the activities of one firm to noticeably affect the activities of the other firms and for the activities of the other firms to noticeably affect that firm in question. As stated by Friedman (1983, p.1),

> "The key distinguishing feature that sets oligopoly apart from competition and from (textbook) monopoly is that oligopolists are strategically linked to one another."

Thus, the quintessential feature of an oligopoly is interdependence: the actions of all the individual firms in an industry are affected by and react to the actions of the other firms. It is this interdependence, or more specifically,

conjectural variation, that is the common concept to all models of oligopoly.

During the past decade there has been extensive consideration of the appropriate definition of this conjectural variation concept (influential articles include Bresnahan (1981), Perry (1982), Kamien and Schwartz (1983), and Boyer and Moreaux (1983)). Although minor variations in the definition of the conjectural variation do occur, for the purpose of this study, a middle-of-the-road view, described, for example in Bresnahan (1989), Brander and Spencer (1985) and Brander and Zhang (1990), is adopted. From these authors' work, one can think of the conjectural variation as an indicator of the degree of competition, and therefore refer to the conjectural variation as simply a conduct parameter of an oligopoly model.

Before specifying a conjectural variation model most appropriate for the British Columbia wine industry, previous empirical studies of market power in single markets will be presented. The following section focuses primarily on relevant econometric applications.

3.2 Literature Review:

The traditional approach to inferring the existence of non-competitive behaviour was simply to regress various elements of market structure on industry profitability. One of the major problems with this approach,

> "...is that profits are a kind of accounting residual which give a little bit of information on a lot of things, but not a lot of useful information on anything in particular" (Geroski, 1988, p.11).

After several decades, empirical work has begun to turn from examining simple correlations between industry structure and profitability towards looking more closely at the pricing behaviour underlying them. This recent work attempts to make inferences about the existence of non-competitive conduct from observed data on costs, demand and equilibrium prices and quantities.[37] The basic approach of this work is to regard a given vector of observed industry prices and outputs as the outcome of profit-maximizing behaviour, and then to ask what type of pricing conduct would have had to occurred in order to generate those prices and outputs as an equilibrium outcome. Most of these methods involve parameterizing the marginal revenue function of some firm i in industry j, and measuring the extent to which observed price exceeds marginal revenue at observed outputs. In general, an integral feature of this method is to estimate a marginal cost function and then to detect significant differences between it and prices at observed outputs (e.g. Applebaum, 1979).

More recent work is concerned with specifying marginal revenue functions in a precise way, in particular, by using

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[37]For a survey on econometric studies of market power see Bresnahan (1989).

conjectural variations[38] (e.g. Iwata, 1974). Iwata generated extraneous estimates of cost and demand functions for the Japanese Flat Glass industry and then, using the first order conditions describing output choice together with observed prices and outputs, solved directly for the implied values of the conjectural variations.

The most elaborate exercise of this type is the study done by Gollop and Roberts (1979) on firms in the U.S. Coffee Roasting industry. They attempted to estimate a pattern of conjectural variations across rival firms i rather than either a single conjectural variation parameter for firm i vis-a-vis all rivals, or a single summary number aggregated across all firms. In order to reduce the set of estimable parameters, Gollop and Roberts imposed an a priori structure expressing the conjectures of all firms in terms of those of certain benchmark firms.[39]

Others have argued that it would be useful to estimate conjectures subject to the constraint that the estimates are interpretable in the light of familiar oligopoly models. This is the type of research undertaken by Roberts (1984), Spiller and

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[38]One alternative is the conjectural variation elasticity which is the conjectural variation of firm i multiplied by its market share (e.g. Applebaum (1982), Dickson (1983), Lopez (1984), and Schroeter (1988)).

[39]One could go even further and try to explain why one firm's conjectures take one value, and another firms a different value. Slade (1987) explained the variations in conjectures across firms by examining correlations between the estimated conjectures and firm characteristics.

Favaro (1984), and Slade (1987). In Roberts (1984) case, he examines several solution concepts (including price-taking, Cournot, and Dominant firm behaviour) using Gollop and Roberts (1979) database. The implication of this research, is that if one imposes a particular pattern of conjectures on the data, one need only estimate cost and demand parameters; were one to estimate an arbitrary set of conjectures, then one can compare them to values implied by the different oligopoly models which are computable given knowledge of costs and demand.

Although this study's research is related to that pioneered by Iwata (1974) and Gollop and Roberts (1979), the methodology used in this study is adopted from Bresnahan's (1982) theoretical basis for a conjectural variation-type model. Bresnahan developed a general conjectural variation model and proceeded to show that the oligopoly solution concept can be estimated econometrically. As with Bresnahan's model this study's model is estimated at the industry level (due to data limitations) rather than at the firm-specific level.

From this brief overview, it is apparent that it is possible to use intra-industry data on prices, costs and outputs to estimate firm and industry specific conjectural variations, and hence be able to make some relatively unambiguous inferences about the existence and exploitation of market power.

3.3 Theoretical Framework:

In this section a conjectural variations model of the British Columbia wine industry is developed.

Consider an industry in which N firms produce a homogeneous product Y using η inputs. Let the cost function of the i^{th} firm be given as $c^i=c^i(y^i,w)$ where y^i is the output of the i^{th} firm and w is the price vector of the inputs.

Let the market demand curve facing the industry be written in its inverse form:

$$P = D(Y, z) \tag{3.1}$$

where P is the price of the output, z is a vector of exogenous variables, and total output is,

$$Y=\sum_{i=1}^{N} y^i \tag{3.2}$$

The problem facing the i^{th} firm, is to maximize profits subject to a given technology. Profits equal revenue minus cost; revenue is the level of output times the price of the output; and cost is the sum of each input times the wage of each input.

The i^{th} firm's profit maximization problem can be written as: $\max [Py^i - c^i(y^i,w): P=D(Y,z)]$

Solving the first-order condition of profit maximization, yields:

$$P(Y, z) + y^i\left(\frac{\partial P(Y, z)}{\partial y^i}\right) = \frac{\partial c^i(y^i, w)}{\partial y^i} \tag{3.3}$$

which can be rewritten as,

$$P(Y,z) + y^i\left(\frac{\partial P(Y,z)}{\partial Y}\right)\left(\frac{dY}{dy^i}\right) = \frac{\partial c^i(y^i,w)}{\partial y^i}. \qquad (3.4)$$

The total derivative $dY/dy^i \equiv \theta^i$ is the i^{th} firm's conjectural variation.

Comparing the above equation with similar equations for benchmark market structures (i.e. competition, Cournot, and collusion), it follows (see Varian, 1984, p.103) that:

(1) $\theta^i=0$ implies that the underlying market structure is competitive. In this scenario the firm believes that the price will not change with respect to a change in its output. This conjecture is consistent with the Bertrand model, which requires, in the homogeneous product case, that price equal marginal cost.

(2) $\theta^i=1$ implies Cournot behaviour. In this scenario the i^{th} firm believes that the other firms will not change their output decisions in response to a change in its output.

(3) $\theta^i=Y/y^i$ implies that the firms are exhibiting collusive behaviour. Substituting this term into the first-order condition will generate the first-order condition for a monopoly.

3.3.1 Work with Aggregate Industry Data

Certain aggregation conditions must be maintained in order that equation (3.4) can be written for the industry as a whole. According to Chambers (1988, p.183), the basic assumptions that have to be adopted in order for equation (3.4) to achieve aggregation consistency are: (1) each firm-level marginal cost

must equal the industry's marginal cost; and (2) each firm-level marginal cost must be independent of output.[40]

We proceed by specifying two identities. First, if C(Y,W) is the industry cost function and $c^i(y^i,w)$ is the i^{th} firm's cost function (assume all firms face the same input prices), it follows that:

$$C(Y,W) = \sum_{i=1}^{N} c^i(y^i,w) \tag{3.5}$$

(i.e. industry costs equal the sum of costs for all firms in the industry). Second, we restate equation (3.2):

$$Y = \sum_{i=0}^{N} y^i \tag{3.6}$$

(i.e. aggregate output equals the sum of each firm's output).

Any functional form capable of satisfying both of these properties (3.5 and 3.6) is now a candidate for an industry cost function. However, for C(Y,W) to be consistent with these conditions the class of candidate functions is considerably restricted. To see this, differentiate (3.5) with respect to y^i, which yields:

$$\frac{\partial C(Y,W)}{\partial y^i} = \frac{\partial C(Y,W)}{\partial Y}\frac{\partial Y}{\partial y^i} = \frac{\partial c^i(y^i,w)}{\partial y^i} \tag{3.7}$$

Thus, $\partial C(Y,W)/\partial y = \partial c^i(y^i,w)/\partial y^i$ for all i, since $\partial Y/\partial y^i = 1$. In other

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[40]These conditions are similar to those put forward by Gorman (1961), and adopted by Appelbaum (1982), Lopez (1984), and Schroeter (1988) in their market studies. Their sufficient condition for the existence of an aggregate cost function is that firms have quasi-homothetic costs. That is, the firms' cost functions are: $c^j(w,y_j) = h(w)y_j + g^j(w)$, and hence, the aggregate cost function is: $C(w,Y) = h(w)Y + g(w)$, where $Y = \Sigma y_j$ and $g(w) = \Sigma g^j(w)$.

words, aggregation consistency requires that each firm-level marginal cost must equal the aggregate marginal cost of the industry. Moreover, since this result must apply regardless of the level of y^i it follows that each firm-level marginal cost must be independent of y^i because from the aggregate perspective it is irrelevant which firm produces which units of output. This last result also implies that aggregate marginal cost is independent of aggregate output.[41]

Returning to the optimality condition (3.4) which simply states that each firm equates its marginal cost with its perceived marginal revenue, it follows from (3.4) that if marginal costs are the same for all firms and if one assumes that all the firms have identical conjectural variations[42], then, in equilibrium, all firms must be producing at the same level of output. Hence, in equilibrium, the output of each firm is equal to Y/N.

Using the aggregation properties of the industry cost function, the above equilibrium conditions, and the assumption that each firm's production function is characterized by constant returns to scale, then according to Chambers (1988, p.182), one can specify the theoretical form of the aggregate cost function as,

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[41]This can be seen in a number of ways, but the easiest is to differentiate (3.5) with respect to y^i.

[42]Appelbaum (1982), Lopez (1984), and Schroeter (1988) make similar assumptions.

$$\begin{aligned} C(Y,W) &= \sum_{i=1}^{N} y^i C^i(w) \\ &= y^i \sum_{i=1}^{N} C^i(w) \\ &= Y \sum_{i=1}^{N} \frac{1}{N} C^i(w) \\ &= YC(W) \end{aligned} \tag{3.8}$$

where $Y=Ny^i$. This is consistent with aggregation theory since, each firm-level marginal cost is equal to industry marginal cost, each firm-level marginal cost is independent of y^i, and industry marginal cost is independent of aggregate output. Aggregation is also valid because C(Y,W) is a multiple of a sum of concave functions and hence must be concave.

If firms have identical marginal costs and conjectures, and the equilibrium output of each firm is equal to Y/N, then the optimality condition (3.4) can be written as,

$$\begin{aligned} P(Y,z) + \theta^i y^i \left(\frac{dP(Y,z)}{dY}\right) &= \frac{dc^i(y^i,w)}{dy^i} \\ P(Y,z) + \theta\left(\frac{Y}{N}\right)\left(\frac{dP(Y,z)}{dY}\right) &= \frac{dC(Y,W)}{dY} \\ P(Y,z) + \lambda Y\left(\frac{dP(Y,z)}{dY}\right) &= C(W) \end{aligned} \tag{3.9}$$

where $\lambda=\theta/N$.

Equation (3.9) states that in equilibrium, perceived marginal revenue equals industry marginal costs and is, therefore, the same for all firms.

One should notice that the constructed variable λ will range between 0 and 1, since θ was restricted between the range

of 0 and ($Y/y^i=N$). Using the same benchmark market structures as before, when λ equals zero, each firm in the industry is behaving competitively ($\lambda=(0/N)=0$); when λ equals 1/N, the firms are displaying Cournot behaviour; and when λ equals one, all firms are collectively behaving as a single monopolist ($\lambda=(N/N)=1$).

In order for this theoretical model to be applied to the British Columbia wine industry, specific functional forms must be specified for the underlying functions. These functional forms, which are presented in the next chapter, are used to obtain the complete system of equations based on the theoretical equations (3.1) and (3.9).

4. ECONOMETRIC MODEL OF THE B.C. WINE INDUSTRY

Having previously outlined a theoretical model that can be applied to the British Columbia wine industry, this chapter will focus on developing the corresponding econometric model.

First, the demand function facing the wine industry is specified. Second, the industry's aggregate cost function is specified. Third, the full econometric model of the British Columbia wine industry is presented. In the last section, data sources and price index procedures are detailed.

4.1 Demand Curve (Industry):

Most studies of the demand for alcoholic beverages in Canada make no distinction between domestic and imported beverages (e.g. Johnson and Oksanen (1977), Fuss and Waverman (1987), and others). Consumers, on the other hand, treat domestic and imported beverages as different and clearly distinguish between them (e.g. Adrian and Ferguson, 1987; Alley, 1988; and others). Casual empiricism indicates that many Canadian wine drinkers regard Canadian wine generally as distinctly inferior to imported wine. thus, for this study a highly disaggregated demand function will be adopted.

A statistical linear demand equation can be written as,

$$Y_t^D = \alpha_0 + \alpha_1 PDW_t + \alpha_2 PIW_t + \alpha_3 PDB_t + \alpha_4 PIB_t + \alpha_5 PDS_t + \alpha_6 PIS_t + \alpha_7 PDI_t + \alpha_8 T + v_t \qquad (4.1)$$

$$t=1,\ldots,T$$

where Y^D: aggregate quantity of domestic wine

PDW: retail price index of domestic wine

PIW: retail price index of imported wine

PDB: retail price index of domestic beer

PIB: retail price index of imported beer

PDS: retail price index of domestic spirits

PIS: retail price index of imported spirits

PDI: personal disposable income

T: time trend

The variable Y^D is the quantity of domestic wine consumed, measured in litres per head of population aged fifteen years and over. The explanatory variables are the retail (domestic and imported) price indexes each for wine, beer, and spirits[43], personal disposable income per capita, and in order to allow for changing tastes, a trend variable. The α_i's, i=1...7, are unknown scalars to be estimated and v_t is a random disturbance term whose properties will be discussed later.

The appropriate explanatory variables were deflated by the consumer price index in order to make the demand equation homogeneous of degree zero.

4.2 Cost Function (Industry):

In section (3.3.1) an aggregate cost function was specified

[43]Variables representing domestic and imported ciders and coolers were initially included in this equation, however the resulting statistical results were poor and the variables were dropped from the structural equation (ciders were introduced in 1973 and coolers in 1985).

that allowed the aggregation of firm-level cost functions to the industry level (equation [3.8]). Recall that with this function aggregate marginal cost is independent of aggregate output.

Diewert (1971) has proposed a class of functions that are sufficiently rich in parameters and at the same time consistent with this economic theory. In the present context it is convenient to adopt his generalized (Leontief) linear cost function (for constant returns to scale). For econometric estimation this study will use the following specific functional form for $C(Y;W_L,W_C,W_M)$, where L, C, and M refer to labour, capital and intermediate inputs:

$$C_t(Y_t^S, W) = Y_t^S \sum_i \sum_j b_{ij} W_i^{\frac{1}{2}} W_j^{\frac{1}{2}} + \delta_t \qquad (4.2)$$
$$i,j = L,C,M$$
$$t = 1,\ldots,T$$

The b_{ij}'s are parameters of the model and the matrix $[b_{ij}]$ is symmetric. The term δ is a random disturbance term.

4.3 The Full Econometric Model:

The full model of the British Columbian wine industry can now be specified, using the demand equation (4.1), the cost equation (4.2) and the aggregate optimality condition given by (3.9).

Recall that the price variable in equation (3.9) is equal to the price the producers receive for their product. In the British Columbia wine market the price the wineries receive is

not the same as the retail price used in demand equation (4.1). The difference in the two prices is due to the fact that the BCLDB adds various excise taxes and mark-up rates to the wineries selling price, or as it is known in the industry: the landed cost price (see Appendix A for a detailed account of BCLDB pricing methods). However, since a complete provincial mark-up schedule was not available for the entire period this study covers, and because excise taxes could not be accurately valued[44], the exact price the wineries received for their wine could not be calculated. In order to circumvent this data limitation problem, provincial mark-up rates and excise taxes were assumed to be constant over the time period. This enables one to approximate the price the wineries received as,

$$P_{\text{landed cost}} + \beta_o = P_{\text{retail}},$$

which can alternatively be written as,

$$P_{\text{landed cost}} = P_{\text{retail}} - \beta_o.$$

The optimality condition (3.8) can now be written as,

$$(PDW_t - \beta_0) + \lambda Y_t^S \left(\frac{dPDW_t}{dY_t^S} \right) = \frac{dC(Y_t^S, W)}{dY_t^S} \qquad (4.3)$$

Expressing equation (4.1) as an inverse demand function and differentiating with respect to Y^D, yields the equation,

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[44]The amount of excise taxes applied to wines depends on the percentage alcohol by volume in each wine. Since Statistics Canada's wine categories contain wines that have varying percentage alcohol contents, the amount of excise taxes added to this group's retail value could not be accurately determined.

$$\frac{dPDW_t}{dY_t^D} = \left(\frac{1}{\alpha_1}\right) \tag{4.4}$$

Now differentiate equation (4.4) with respect to Y^S, to determine the marginal cost function:

$$\frac{dC(Y_t^S, W)}{dY_t^S} = \sum_i \sum_j b_{ij} (W_i)^{\frac{1}{2}} (W_j)^{\frac{1}{2}} \tag{4.5}$$

Substituting equations (4.4) and (4.5) into the aggregate optimality condition (4.3), results in,

$$PDW_t = \beta_0 + \left(\frac{-\lambda}{\alpha_1}\right) Y_t^S + \sum_i \sum_j b_{ij} (W_i)^{\frac{1}{2}} (W_j)^{\frac{1}{2}} + u_t \qquad \begin{matrix} i,j = L,C,M \\ t = 1,\ldots,T \end{matrix} \tag{4.6}$$

where PDW: retail price index of domestic wine

Y^S: aggregate quantity of domestic wine

W_C: price index of capital

W_L: price index of labour

W_M: price index of intermediate goods

The variable PDW is the retail price index for domestic wine. The explanatory variables are the quantity of domestic wine produced in litres per head of population aged fifteen years and over, the price indexes each for capital, labour, intermediate goods and energy, and in order to allow for technological change, a time variable. The b_{ij}'s and the term (λ/α_1) are scalars to be estimated and u_t is a random disturbance term whose properties will be discussed later.

Equations (4.1) and (4.6) and the equilibrium condition:

$$Y_t^D = Y_t^S \qquad (4.7)$$

completely specify the statistical model of the industry. It should be noted that these equations are a simultaneous system in which both the demand and pricing equations appear.

4.3.1 Simultaneity

The method of ordinary-least-squares (OLS) may not be applied to estimate a single equation embedded in a system of simultaneous equations if one or more of the explanatory variables are correlated with the disturbance term in that equation. Since in this model there are two equations (4.1 and 4.6) that both contain an explanatory variable that is endogenous to the system, each equation's random variable is not independent of all the explanatory variables and as a consequence any estimates derived from OLS will be both biased and inconsistent.

4.3.2 The Identification of the Model

After applying the rank and order conditions (see Appendix C), the model specified in the previous section was found to be overidentified. This overidentification, combined with the simultaneity of the model, implies that it is appropriate to use the three-stage-least squares (3SLS) method of estimation, treating Y, and PDW (retail) as endogenous variables and all the others as predetermined. This estimation technique is

implemented through use of the econometrics computer software package SHAZAM (White, 1990).

In the case of the British Columbia domestic wine industry there are 17 free parameters to be estimated. Given the 3SLS estimates, one can calculate the degree of industry competition variable, λ.

4.4 Data and Price Index Construction:

A time series data set was constructed for the sample period 1957 to 1986. Data for the years 1987 and 1988 were not available because: (1) the last issue of Statistics Canada, catalogue 63-202, The Control and Sale of Alcoholic Beverages in Canada, ends with the 1987 fiscal year (it has since been discontinued), and (2) in 1988 the B.C. wineries stopped allowing Statistics Canada to publish their cost data in Statistics Canada, catalogue 31-203, The Manufacturing Industries of Canada. As well, the study purposely excludes the years 1989 to the present because in 1989 the Canada-U.S. free trade agreement and GATT rulings came into effect. Appendix B contains all the sources for the data used in calculating the model's variables, as well as a table of the actual data (endogenous and predetermined variables) used in the estimation of the model's parameters.

The endogenous variables are the quantity of domestic (B.C.) wine measured in litres per head of population aged 15 years and over, and the retail price index for domestic wine

deflated by the consumer price index (CPI). The predetermined variables are the price indexes of the substitute beverages (imported wine, imported and domestic beer, and imported and domestic spirits), and the input prices (capital, labour and intermediate goods) deflated by the CPI; personal disposable income per capita aged 15 years and over again deflated by the CPI. Finally, in order to allow for changing tastes a trend variable is included.

4.4.1 Price Index Procedure

Because wine is not a perfectly homogeneous product (even though the model assumes it is) it is necessary to use price indices rather than actual prices in the analysis.

Diewert (1976, 1978) recommends using Irving Fisher's ideal index in conjunction with the generalized Leontief cost function that is employed in this study. This price index is defined as a function of the price vectors in periods 0 and 1, P_0 and P_1, respectively, and the corresponding quantity vectors Y_0 and Y_1.

$$Fisher's\ Ideal\ Index = \left(\left(\frac{\sum P_t Y_0}{\sum P_0 Q_0} \right) \left(\frac{\sum P_t Y_t}{\sum P_0 Y_t} \right) \right)^{\frac{1}{2}} \qquad (4.8)$$

In the following chapter the estimates of the econometric model's parameters are presented. In addition, the econometric estimates, based on certain economic and statistical criteria, are evaluated.

5. ECONOMETRIC RESULTS OF THE MODEL

In this chapter, the econometric model for the B.C. wine industry is used to test the hypothesis that firms behaved non-competitively during the years between 1957 and 1986. The parameters required for the estimation of the industry's degree of competition variable (λ) are obtained from econometric estimation of the demand and price optimality equations presented in chapter 4.

In section 1, the estimated equations are presented and the reliability of the estimated parameters are determined. In section 2, an estimate of λ is calculated from the estimated coefficients of the system's parameters.

5.1 Econometric Results:

The estimated parameters of the model are presented in Table 5.1. The estimated model is evaluated in this section using the following three criteria: (1) statistical criteria (first-order tests) defined by statistical theory; (2) a priori economic criteria, which are determined by the postulates of economic theory and relate to the sign and the magnitude of the parameters; and (3) econometric criteria (second-order tests) defined by econometric theory.

TABLE 5.1 ESTIMATED MODEL PARAMETERS

Equation	Variable	Coefficient	St. Error	T-Ratio	Elast. at Means
(4.1)	PDW	-29.44	14.880	-1.979*	-3.942
	PIW	1.212	3.353	0.362	0.162
	PDB	-2.021	2.888	-0.700	-0.289
	PIB	10.754	4.080	2.636*	1.453
	PDS	-3.141	8.082	-0.389	-0.423
	PIS	7.935	5.317	1.492	1.108
	PDI	0.001	0.001	-0.744	-0.606
	T	0.417	0.078	5.315*	0.897
	α_o	19.019	14.714	1.293	2.638
(4.6)	Y^S	0.026	0.008	3.368*	0.197
	W_L	1.011	0.648	1.560	1.074
	W_C	1.129	0.944	1.197	1.148
	W_M	3.397	1.524	2.229*	3.817
	$W_L W_C$	0.767	1.244	0.617	0.791
	$W_L W_M$	-3.808	1.700	-2.241*	-4.147
	$W_C W_M$	-3.389	1.927	-1.759	-3.611
	β_o	1.670	0.142	11.756*	1.730

* significant at the 5 percent level of significance.

5.1.1 Statistical and A Priori Economic Criteria

The value of R^2 for equation (4.1) is 0.9472, which indicates that approximately 95 percent of the variation of Y^D is explained by the regression plane. The value of R^2 for equation (4.6) is 0.9512, which indicates that approximately 95 percent of the variation of the price of domestic wine (PDW) is explained by the regression plane. Out of the seventeen estimated coefficients, seven were significant at the five percent level of significance.[45]

[45]The critical asymptotic t value at the 5 percent level of significance is 1.960.

The calculated income elasticity for the demand equation is found to be -0.606, which classifies B.C. wine as an inferior good. (this result will be compared to the results from other empirical studies latter in this section).

With respect to domestic wine's Marshallian own-price elasticity, the inferior good (B.C. wine) appears to be a normal good. The own price elasticity is highly elastic with an estimated value of -3.942 (as before, this result will be compared to other empirical results latter in this section).

Other results of interest obtained from the estimated parameters of the demand equation are the Marshallian cross price elasticities. Imported wine, imported beer and imported spirits appear as substitutes to B.C. wine with respective cross price elasticities of 0.162, 1.454 and 1.108. Domestic beer and domestic spirits, meanwhile, appear as complements, with respective cross price elasticities of -0.289 and -0.423. These results are not that difficult to comprehend since according to Alley (1988, p. 46),

> "...contrary to the prevailing view expressed by others it is not at all surprising that alcoholic beverages are net or gross complements for each other."

The point that alcoholic beverages may be complements can be illustrated if one thinks of consumers making decisions in two stages. Accordingly, consumers may be thought of as first allocating expenditures first, among broad commodity groups and,

second, among individual commodities within groups.[46] For example, consider the effect of an increase in the price of domestic beer on domestic wine consumption in terms of two parts. The first effect works working through group expenditures will be negative, it will result in a reduction in the demand for alcoholic beverages as a group.[47] The second effect depends on the degree of intragroup substitutability between domestic beer and domestic wine. Even if this effect positive, the combined effect may be negative. In other words, if the degree of intragroup substitutability is less than the degree of intergroup substitutability then the first effect will dominate and domestic beer and domestic wine, overall, be net complements. Likewise, the same argument could be applied to the domestic spirits case.

The remaining variable in the demand equation, the time trend, has a positive coefficient indicating that there is a positive trend in B.C. wine consumption over the sample period.

The own-price elasticity derived in this study can be compared to similar elasticities calculated in other studies (see Table 5.2). Notice that whereas this study's own-price elasticity is highly elastic (-3.942), the own-price elasticities in other studies are uniformly inelastic. These results, however, do not necessarily mean that this study's

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[46]See Deaton and Muellbauer (1980, pp.120-137) for a detailed discussion on two-stage budgeting.

[47]This effect will be larger the greater the percentage of income spent on the beverage whose price has increased.

TABLE 5.2 ELASTICITY ESTIMATES FOR WINE (SHORT & LONG RUN)

		Johnson & Oksanen (1977)	Fuss & Waverman (1987)	Adrian & Fergus (1987)	Alley (1987)	Johnson & Oksanen (1989)
SR	price:	-0.680	-0.760	X	X	-0.70/-0.79
	income:	0.010	0.540	X	X	1.01/ 0.08
LR	price:	-1.360	-0.760	-0.610	-0.727	-1.17/-0.79
	income:	0.020	0.700	0.700	-0.523	2.19/ 1.89

Note: the studies by Fuss/Waverman and Johnson/Oksanen provide estimates calculated from the demand for all beer, wine, and spirits in Canada; the study by Adrian/Ferguson provides estimates calculated from the demand for domestic and imported: beer, wine and spirits in Canada; and the study by Alley provides estimates calculated from the demand for domestic and imported: beer, wine and spirits in British Columbia.

estimates are invalid. One must remember that one is comparing elasticities obtained from different specified models (see note following table 5.2). Of the four previous studies reviewed, only Alley (1988) estimates elasticities for B.C. wine. While Alley's estimated income elasticity of -0.523 compares favourably with this study's income elasticity of -0.606, the own-price elasticities are distinctly different. However, if one takes into consideration that this study uses annual data taken from 1957-1986, while Alley uses monthly data taken from April 1981 to August 1986, then one explanation for the difference is that for the period this study covers, consumers primarily regarded B.C. wine as an inferior good with many substitutes; while for the period Alley's study covers, consumers regarded

B.C. wine as an inferior good with few available substitutes.[48] This explanation is supported by the cross-price elasticities provided by both studies. From this study, imported wine, imported beer and imported spirits appear as substitutes for B.C. wine, whereas Alley's study perceived imported wine and U.S. wine as weak substitutes.[49] This makes sense if one considers wine drinkers as naive wine consumers until the late seventies when imported wine sales began to increase dramatically.

The same statistical and a priori criteria that was used in assessing the reliability of the demand equation's parameters is now applied to the estimated optimality equation (4.6). The b_{ij} parameters (where i=j) can be related to own-price elasticities of the various factors of production. The own-price elasticities are derived from the individual factor demand equations. While these factor demand equations are not estimated in this model, it must be the case that the b_{ij} term should be greater than or equal to zero. The b_{ij} parameters (where $i \neq j$) can also be related to the elasticities of substitution between the various factors. These elasticities are also derived from the individual factor demand equations. However, the larger the b_{ij} term, the larger the elasticity of substitution between factors i and j (Varian,

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[48]The higher the number of substitute goods available the more elastic the own-price elasticity will become.

[49]Alley's Marshallian cross-price elasticities for imported wine and U.S. wine are 0.092 and 0.037 respectively.

1984, p.181).

From Table 5.1 it is apparent that all three factor inputs (labour, capital, and intermediate goods) display negative own-price elasticities. Thus a percentage increase in the wage level of any of these factors will lead to a decrease in factor usage. Relating these results to our supply equation a percentage increase in the wage levels of these factors will increase marginal cost, and thus increase the price of the output.

Also from Table 5.1 it appears that only labour and capital are substitutes among input pairs. This can be explained if one believes that as the number of workers decrease, there is a trend toward expanding degree of winery mechanization. A complementary situation is found for the remaining two pairs of inputs: labour and intermediate goods, and capital and intermediate goods. If one perceives that increasing amounts of intermediate goods (grapes) will lead to additional requirements of labour and capital, in order to facilitate this action, then the estimated results are reasonable.

5.1.2 Testing for Autocorrelation

The application of statistical criteria are valid only if the assumptions of the three-stage-least squares regression model stated in chapter 4 are satisfied. For example, if the assumptions concerning the error term are incorrect, the statistical tests are invalidated. Thus, in order for the above criteria to be accepted one should first make sure that the

basic assumptions of the simultaneous-equations system are satisfied. One of the assumptions of 3SLS is that each equation in the model is serially independent, that is each equation displays non-autocorrelation.

To determine if equation (4.1) or equation (4.6) display signs of autocorrelation, it is necessary to compute the Durbin-Watson d statistic (see Appendix D for actual SHAZAM output). Both equations' d statistics[50] fall into the indecisive zone and hence the Durbin-Watson test is inconclusive.

Koutsoyiannis (1977, p.216), suggests the following test for autocorrelation. It has the advantage that it is applicable to any form of autocorrelation and it provides estimates of the coefficients of the autocorrelation relationship. The procedure involves applying OLS to the residuals of the estimated model:

$$\varepsilon(t) = \varrho\varepsilon(t-1) + \nu(t)$$

Autocorrelation is judged in the light of the statistical significance of the ϱ's and the overall fit of the above regressions. That is, one may carry out any one of the tests of statistical significance for the estimates of ϱ's of the autocorrelation relationship as well as an F test for the overall significance of the regression. If the ϱ's are found to be statistically significant one accepts that the residuals are autocorrelated, provided that the overall correlation coefficient (for the autoregressive relationship) is

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[50]Equation 4.1's d statistic is 1.843 and equation 4.6's d statistic is 2.261.

statistically significant and reasonably large[51] (the results of this test are presented in Table 5.3).

TABLE 5.3 OLS RESULTS FOR FIRST-ORDER AUTOREGRESSION

Variable	Coefficient	T-Ratio	F-Statistic
v_{t-1}	0.050	0.254	0.065
u_{t-1}	-0.282	-1.514	2.291

Since both t values are less than the critical t value at 5 percent level of significance[52], one can accept the null hypothesis that the coefficients are not significantly different than zero. Also, in both cases the computed F value is less than the critical F value at 5 percent level of significance[53] and one can accept the null hypothesis that the lagged residuals have no influence on the current residuals. From the above statistical tests it is apparent that both equation (4.1) and (4.6) do not exhibit any serial correlation in their respective residuals and hence no remedial measures are needed.

5.3 Estimation of the Variable λ:

In this section an estimate of λ, which is the measure of

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[51]This test does not have the power properties of the Durbin-Watson test in finite samples, but it is asymptotically equivalent.

[52]The critical t value at 28 degrees of freedom and 5 percent level of significance is 2.048.

[53]The critical F value for 1 and 28 degrees of freedom at 5 percent level of significance is 4.20.

the non-competitive behaviour in the British columbia wine industry is derived from the estimated coefficients of the model's parameters. Recall that the estimated coefficient on the quantity variable in equation (4.6) equals $-\lambda/\alpha_1$ where α_1 is the estimated slope of the demand curve for B.C. wine. As mentioned in section 3.3 the variable λ will range between 0 and 1. When λ equals zero, each firm in the industry is operating at a competitive level, and likewise when λ equals one, all firms in the industry are collectively behaving as a single monopolist. Thus, the calculation of λ from the estimated model will provide a relative measure of market structure.

An estimate of λ and corresponding hypothesis tests can be easily performed by applying a linear hypothesis test on selected regression coefficients. For example, by testing if $(\alpha_1 \times (-\lambda/\alpha_1)=0$, SHAZAM will calculate the actual test value of $-\lambda$. From the results of the linear hypothesis test, the calculated value of λ is equal to 0.7773.

Three separate hypotheses will be tested. The null hypothesis corresponding to these tests are: (1) $\lambda=0$ (i.e. firms in the industry behave competitively); (2) $\lambda=1/N=1/5=0.20$[54] (i.e. firms in the industry exhibit Cournot-Nash behaviour); and (3) $\lambda=1$ (i.e. firms in the industry achieved perfect

[54]Note that under Cournot behaviour, $\lambda=1/N$. This study uses N=5, since this is the average number of commercial wineries in operation in British Columbia between 1957 and 1986.

collusion).[55]

The first hypothesis to be tested is whether the British Columbia wine industry operated competitively over the sample period (price-taking conduct). In this study, if $\lambda=0$ then the industry is said to display competitive behaviour. Thus, in applying the test on the regression coefficients, the null hypothesis will take the form,

$$H_o: (\alpha_1 \times (-\lambda/\alpha_1)) = -\lambda = 0$$

The alternative hypothesis (H_1) is an alternative assumption about the parameter, a counter proposition to the null hypothesis. Since from a priori economic theory the value for λ is said to lie between 0 and 1, H_1 takes the form,

$$H_1: -\lambda < 0$$

In 3SLS, SHAZAM provides an asymptotic normal statistic (computed t statistic) with the hypothesis test. The asymptotic normal statistic computed for the test is equal to -1.711 (see Table 5.4). The asymptotic critical t value at 5 percent level of significance is equal to -1.645 (one-tail test). Since the observed value of the statistic falls in the critical region one can reject the null hypothesis that $-\lambda$ is not significantly different from zero. In other words, competitive conduct is rejected as a possible pricing behaviour for the British Columbia wineries.

Using the same procedure one can test the hypothesis that

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[55]See Appendix D for the Shazam output pertaining to the hypotheses tests.

the firms in the industry acted under Cournot behaviour. This is achieved by testing if λ is equal to 0.20. Thus, in order to apply the test on the regression coefficients the null hypothesis will take the form,

$$H_o: (\alpha_1 \times (-\lambda/\alpha_1)) = -\lambda = -0.20$$

and the alternative hypothesis H_1 takes the form,

$$H_1: -\lambda \neq -0.20$$

The asymptotic normal statistic computed for the test is equal to -1.271. The asymptotic critical t value at 5 percent level of significance is equal to 1.960 (two-tail test). Since the value of the test statistic does not fall in the critical region one can not reject the null hypothesis that $-\lambda$ is not significantly different from -0.20 at 5 percent level of significance. In other words, Cournot behaviour can not be rejected for the wineries.

Finally, one can test the hypothesis that the firms operated collusively. In other words, the hypothesis that λ is equal to one is statistically tested. Thus, in order to apply the test on the regression coefficients the null hypothesis will take the form,

$$H_o: (\alpha_1 \times (-\lambda/\alpha_1)) = -\lambda = -1$$

Since from a priori economic theory the value of λ is said to lie between 0 and 1, H_1 takes the form,

$$H_1: -\lambda > -1$$

The asymptotic normal statistic computed for the test is equal to 0.490. Since the value of the statistic does not fall in the

critical region one can not reject the null hypothesis that $-\lambda$ is not significantly different from negative one at 5 percent level of significance. In other words, one can not reject the hypothesis of collusive behaviour amongst the wineries.

TABLE 5.4 HYPOTHESIS TESTING RESULTS

	Price-taking (λ=0)	Cournot (λ=0.20)	Collusion (λ=1)
Asymptotic Normal Statistic	-1.711[a]	0.490[b]	-1.271[c]

Note: [a] rejected at the 5 percent level of significance.
[b] accepted at the 5 percent level of significance.
[c] accepted at the 5 percent level of significance.

If the results of this study accurately reflect the actual competitive nature of the B.C. wine industry in the past (1957-1986), then the hypothesis tests suggest that the firms in this oligopolistic industry did not operate under competitive pricing behaviour (since both Cournot and collusive pricing conducts can not be rejected as possible market outcomes).

Alternatively, one could use a Bayesian approach to testing the three hypotheses as detailed by Brander and Zhang (1990). In the context of a U.S. duopoly airline route they construct a prior distribution for λ, combine it with sample information and then compare the posterior and prior distributions. In this study's case, one would need to have an exceptionally strong prior belief that the industry was competitive in order for one's posterior beliefs to be still consistent with the

competitive model given the data set. The advantage of this approach is that it allows one to rank the Cournot-case and the Collusive-case (which is not possible in the current analysis) by determining the strength of the prior required to ensure that a particular hypothesis is not rejected. Although Brander and Zhang's (1990) approach would generate additional insights into the problem at hand, it is not employed in this study because of the relatively complex nature of the approach.

A summary of this study's results, together with a discussion of how recent trade liberalization initiatives may have effected these findings, is presented in the following chapter.

6. SUMMARY AND CONCLUSIONS

In this chapter, the major findings of this thesis are summarized and recommendations on future research are presented. In addition, due to recent trade developments, the last section of the chapter will deal with the dramatic changes the wine industry has gone through since 1989.

6.1 Summary:

The major objective of this study has been to determine the underlying market structure of the domestic wine industry in British Columbia, in the years prior to the Free-Trade Agreement and recent GATT rulings (1989), through the use of conjectural variation theory. In order to achieve this objective, a mathematical model of the B.C. wine industry was constructed using a simultaneous system of equations.

The major structural relationships were defined in terms of demand and price equations. The parameters of these equations were estimated using econometric techniques. The estimated parameters are then used to develop a variable that provides an empirical measure of the degree of oligopolistic power of the industry. Various hypothesis about the underlying structure of the B.C. wine industry were then tested.

The results of this study suggest that the domestic wine industry in British Columbia operated in a non-competitive manner between 1957 and 1986. Specifically, given the assumptions of the model, the hypothesis of competitive

behaviour in the British Columbia wine industry was rejected in favour of other hypotheses concerning non-competitive behaviour. Two such hypotheses that could not be statistically rejected were Cournot and Collusive type behaviours. These results suggest that the wine industry may have been earning above normal profits over the sample period. This would mean that consumers may have been sacrificing to firms at least a portion of the surplus they would have obtained in a perfectly competitive industry.

Two factors may have been directly responsible for this pricing behaviour: (1) the structure of the industry was inherently oligopolistic; and (2) protection was afforded by the provincial government in the form of a wine policy that effectively created non-tariff trade barriers against foreign wine producers. Although the provincial government's policies were intended to help and foster the growth of the domestic wine industry, it appears (from this study's results) that the eventual result was the creation of a non-competitive wine industry that would be unable to compete in the global market for wine.

There are a number of ways in which the study could be improved upon. First, the assumptions that all firms in the industry have identical marginal costs, identical conjectural variations, produce at the same level of output, and produce an identical homogeneous product is clearly not an accurate rendition of the British Columbia wine industry. Perhaps the

strongest of these assumptions is that output is homogeneous. Although this study aggregated the different categories of wine into a single commodity group, on closer scrutiny one can see that there exists a myriad of wine products that are produced by the B.C. wineries (i.e. red, white and rose table wines, crackling wines, sparkling wines...etc.). In addition, winery production of ciders (introduced in 1974) and coolers (introduced in 1985) were ignored in this study due to the reasoning that these products could not be justifiably aggregated into the single homogeneous category of wine. Constructing a model which would allow for this product heterogeneity would undoubtedly result in a more accurate depiction of the industry.

Specifying the demand and marginal cost equations to be linear in the parameters is considered to be rather restrictive. Unfortunately, the benefits gained from having more theoretically sound structural equations may be lessened when λ is estimated, since the simultaneous system's optimal pricing equation will be rather complex when either the demand or the marginal cost curve have nonlinear parameter specifications.

Finally, it should be noted that any extension of the time series data beyond this study's thirty year sample period would most certainly result in better parameter estimates of the model. In addition, if in the future sufficient firm-specific data becomes available then one should be able to extend the hypothesis testing applied here (Bertrand, Cournot, and

collusion) to include the testing for dominant firm behaviour. The dominant firm model could be used to explain the output and pricing behaviour of a single profit-maximizing firm or group of firms which operate in an industry with a fringe group of competitive producers.

6.2 Recent Developments:

During the late 1980's two major trade events occurred that led directly to a restructuring of the provincial governments domestic wine policy; they were the United States-Canada Free Trade Agreement (FTA) and trade rulings administered by the General Agreement on Tariffs and Trade (GATT).

On January 1, 1989, the FTA came into affect. Under the provisions set forth under this agreement Canada will eliminate the price mark-up differential between Canadian and U.S. wines over a seven-year period (see Table 6.1 for recent domestic and U.S. mark-ups). In addition, the British Columbia Liquor Distribution Branch had to provide U.S. wines immediate and equal access to listings and distribution channels. This meant that the automatic listings the provincial Liquor Board provided for domestic wines would no longer be in affect.[56]

Relating to the production side of the industry, the 80/20 rule ceased to be enforced, allowing the commercial wineries unlimited access to U.S. grapes. The domestic content

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[56]Automatic listings measures may be provided, however, if they apply only to estate wineries that existed prior to October 4, 1987, and produce less than 30,000 gallons of wine annually.

requirements for estate wineries, however, would not be affected.

TABLE 6.1 RECENT MARKUP SCHEDULE (Jan. 1, 1991)

		Percentage Markup
Table:	(30-100% B.C. content)	83%
	(0-29% B.C. content)	88%
	B.C. Estate	68%
	Other Canadian	100%
	U.S.	100%
	Other Imported	106%
Fortified:	(100% B.C. content)	107%
	(30-99% B.C. content)	111%
	(0-29% B.C. content)	113%
	Other Canadian	115%
	U.S.	115%
	Other Imported	122%

Source: BCLDB Markup Schedule, Nov. 27, 1990.

In November of 1987, the international body that administers trade complaints under the GATT agreed with a complaint brought forth by the European Economic Community (EEC) that Canadian provinces unfairly discriminated against European imported wines. The ruling gave Canada one year to comply to its provisions of an immediate improvement of the Canadian provinces' pricing, listing and distribution policies. Under this agreement, which took affect on April 1, 1989, the British Columbia Liquor Distribution Branch adopted a restructuring scheme that was similar to the one applied under the recent FTA (see Table 6.1 for recent European mark-ups). That is, a seven-year phase out of price mark-up differentials and immediate

equality in listings and distribution practises.

To further comply with the requirements of these international agreements, a cost of service differential has been built in to the pricing schedule. This concept adds to imports (other Canadian, U.S., and other imports) those costs that are specifically applicable to imports. The cost of service differential is an amount per litre and is added in the pricing formula after regular mark-ups have been applied and before Goods and Services Tax and provincial Social Services Tax.

The effects of both these trade initiatives were already being felt by the end of the 1989 summer. As a result of the signing of the FTA and the decision of GATT the British Columbia grape and wine industry was forced to restructure and focus solely on quality. The Grape and Wine Sector Adjustment Program (GWSAAP) provided $28 million to the British Columbia industry to adjust grape acreage, varieties, production and assist with promotion of qualifying wines (Vielvoye, 1991, p.3).

Grapes used for blended wines were removed from the ground and vineyards were replanted (a total of 2,308 acres of grapes were removed). While in 1983 only 274 acres were allotted to the growing of vinifera grapes, by 1990 this had been increased to 782 acres, and in 1991 to 901 acres (BCGMB, 1991, p.7). In 1988, the industry consisted of 233 vineyards growing 3,300 acres of grapes (Vielvoye, 1990), by 1990, only 126 vineyards were left, growing 1,589 acres of grapes (Vielvoye, 1991, p.1). See Table 6.2 for a comparison of vineyards and grape crops between 1988

and 1990.

TABLE 6.2 COMPARISON OF 1988-1990 VINEYARD AND CROP

	1988	1989	1990
Total Grape acreage	3300	1000	1589
Number of Vineyards	233	107	126
Wine Crop (Tons)	17,981	3,599	4,827
Wine Crop Value ($)	12.6M	3.4M	4.4M

Source: Vielvoye, 1990 and 1991.

All wine grape acreage planted at the time of the GWSAAP was contracted to wineries for a seven-year period ending after the harvest in 1994. New plantings since the GWSAAP may or may not be contracted, which suggests industry movement towards a non-regulated market after 1994 (Vielvoye, 1991, p.4).

The repercussions of both the FTA and the GATT rulings were also being felt in the marketplace. By the late 1980's the domestic wineries began to lose market shares to imported products (see Table 6.3). Whereas, in 1988 British Columbia wines accounted for 60 percent of all wine sales, by the end of 1989 this figure had dropped to 53 percent, by 1990 to 50 percent, and by 1991 had fallen to 48 percent (BCLDB, QMR, Dec. 1991).

This reduction in traditional domestic market shares resulted in the domestic commercial wineries increasing the amount of imported wine bottled under license in British Columbia. It was reasoned that due to the market trend the

TABLE 6.3 RECENT WINE MARKET SALES (LITRES)

	1988	1989	1990	1991
B.C. Commercials	19.8M	17.4M	16.2M	15.3M
B.C. Estate	0.63M	0.60M	0.65M	0.80M
Total B.C. Wine	20.4M	18.0M	16.9M	16.1M
Bottled In B.C.[a]	0.05M	1.5M	2.0M	2.1M
Other Cdn.	0.11M	0.12M	0.14M	0.29M
Imports[b]	13.5M	14.4M	15.0M	15.2M

Note:[a] this shows the sales of 100% imported wines that are bottled in B.C. and marketed as imported wines.
[b] this figure excludes bottled in B.C. imported wine sales.
Source: BCLDB, QMR, Dec. 1991.

commercials had to look to other places for product in order to keep their facilities functioning (BCGMB, 1989, p.8). Thus, import bottling became a larger part of their business. Whereas, in 1988 only 50,884 litres of imported wine was bottled in British Columbia, by the end of 1989 this figure had increased to 1,460,457 litres, and by 1991 had reached 2,092,414 litres (BCLDB, QMR, Dec. 1991).

By the end of the 1989 summer, local wineries and growers unanimously agreed on new British Columbian wine standards to be approved by the provincial cabinet in time for 1989's mid-September harvest. After extensive consultation with B.C. grape growers and wineries, the British Columbia cabinet on September 21, 1989 approved the establishment of an industry led Premium Wine Industry Strategy with a broad mandate to establish rigorous quality standards (B.C. Ministry of Agriculture and

Fisheries, 1989). It gave the industry the authority to establish its own organization, backed by government legislation, to promote its products and provide for its future. In addition the estates were now allowed to produce up to 40,000 gallons of wine annually (an increase of 10,000 gallons), and a new category of mini estate winery was created. These 'farm-gate' operations were to be farmer owned and operated with a 10,000 gallon production limit.

The British Columbia Wine Institute (BCWI) was officially launched by Agriculture and Fisheries Minister John Savage and the 19 founding member wineries of the Institute in August of 1990 (B.C. Ministry of Agriculture and Fisheries, 1990). The British Columbia Wine Institute is a corporation established under the B.C. Wine Act passed in the same year by legislature. The Act provides the Institute with the legislative authority to set, monitor and enforce minimum standards for the quality and the labelling of B.C. wines, and to charge levies on wines and grapes. The Institute can change fees for testing and certifying wines and can also suspend certification if a product is found to be below standard. The first seven members of the BCWI, representing the various sectors of the industry, were appointed by the Lieutenant Governor in Council.

On May 24, 1991, the standards of quality for the Vintners Quality Alliance (VQA) label for British Columbia wines was approved by Cabinet Order in Council announced by Minister of Agriculture, Fisheries and Food Larry Chalmers:

> "The British Columbia wine industry has responded to the increased pressure of the international marketplace with vision and a well developed industry strategy... The British Columbia Wine Institute has developed appellation standards consistent with those of the leading wine producing areas of the world" (B.C. Ministry of Agriculture, Fisheries and Food, 1991, p.1.)

Wines which carry the VQA seal must meet strict production standards set by the B.C. Wine Institute. To earn the VQA label, a wine must:

1. be 100 percent grown and vinted in British Columbia.
2. be 85 percent by volume of the named grape varietal.
3. be 95 percent by volume of the vintage recorded on the label.
4. pass taste testing by a panel of wine makers and independent wine experts testing for flaws, adherence to varietal characteristics and acid-sugar balance.
5. conform to internationally accepted standards of acid and sulphite limits.

6.3 Conclusion:

These new developments, the restructuring of the province's wine policy, and the movement towards imported bulk wine bottling by the commercials and a high-quality premium wine industry by the estate and farmgate wineries, will certainly affect the pricing behaviour of the domestic industry. Since the domestic wineries will no longer operate within a highly protected market and hence, must face competition from products from both the U.S. and other wine producing countries, there is a definite reservation in applying this study's findings of non-competitive pricing conduct (between 1957 and 1986) to the domestic wine industry of the early 1990's.

The ability of the wine industry to raise and maintain

prices above the competitive level depended upon their success in defending monopolistic price levels against competitive initiatives from both within and without the industry. Protection from outside competition was afforded by provincial government assistance, and the incentive to competition from within was dampened by the precarious economic situation of the industry. However, with the recent rulings from GATT and the current Free-Trade Agreement with the United States, the domestic wine industry has no option other than to adjust to competitive pricing behaviours and practices. From recent industry reactions (i.e. import bottling by the commercials, premium wine policies by both the estate and farmgate wineries), the wine industry in British Columbia does appear to be responding to the new competitive atmosphere of a global wine market.

BIBLIOGRAPHY

Agriculture Canada. Agriculture and Food in British Columbia, 1988.

Adams, Leon, D. The Wines of America. 4th. ed. Toronto: McGraw-Hill Publishing Company, 1990.

Alley, A.G. "Consumer Demand for Alcoholic Beverages in British Columbia With and Without Free Trade." Unpublished Masters Thesis, Department of Economics, University of Victoria, 1988.

Adrian, M. and B.S. Ferguson. "Demand for Domestic and Imported Alcohol in Canada." Applied Economics 19 (1987):531-540.

Applebaum, E. "Testing Price Taking Behaviour." Journal of Econometrics 9 (1979):283-294.

Applebaum, E. "The Estimation of the Degree of Oligopoly Power." Journal of Econometrics 19 (1982):287-299.

Aspler, T. Vintage Canada. Scarborough: Prentice-Hall Canada Inc., 1983.

Boyer, M. and M. Moreaux. "Conjectures, Rationality and Duopoly Theory." International Journal of Industrial Organization 1 (1983):23-41.

Brander, J.A., and B. Spencer. "Tacit Collusion, Free Entry and Welfare." Journal of Industrial Economics 33 (1985):277-294.

Brander, J.A., and A. Zhang. "Market Conduct in the Airline Industry: an Empirical Investigation." Rand Journal of Economics 21 (1990):567-583.

Branson, D., B. Hallam, D. Smith, and J. Thomas. "Government Support for the British Columbia Wine Industry." Unpublished Graduate Paper, Department of Business and Commerce, University of British Columbia, 1986.

Bresnahan, T.F. "Duopoly Models with Consistent Conjectures." American Economic Review 71 (1981):934-945.

Bresnahan, T.F. "The Oligopoly Solution Concept is Identified." Economics Letters 10 (1982):87-92.

Bresnehan, T.F. "Empirical Studies of Industries with Market Power." Chap. 17 in Handbook of Industrial Organization, Vol.II, edited by R. Schmalensee and R. Willig. New York: North-Holland, 1989.

British Columbia. Department of Agriculture. Production of Berry Crops with an Estimate of Farm Value, 1957-1986.

----------. Ministry of Agriculture and Fisheries, News Release 89-17.

----------. Ministry of Agriculture and Fisheries, News Release 90-12.

----------. Ministry of Agriculture, Fisheries and Food, News Release 91-9.

----------. Ministry of Finance and Corporate Affairs. British Columbia Financial and Economic Review, 1982-1987.

----------. Select Standing Committee on Agriculture. The Grape and Wine Industries in British Columbia: A Commodity Report, August 1978.

British Columbia Grape Marketing Board. British Columbia Wine and Grape Industry Status Report 1990, 1991.

----------. Discussion Paper No.1: Brief History of the B.C. Grape and Wine Industry, 1987a.

----------. Discussion Paper No.2: British Columbia Wine Policy, 1987b.

----------. The Required Elements of a British Columbia Premium Wine Policy, May 8, 1989.

British Columbia Liquor Distribution Branch. Ministry of Consumer and Corporate Affairs. Annual Reports No.60-65, 1981-86.

----------. Ministry of Finance and Corporate Relations. Annual Report No.66, 1987.

----------. Ministry of Labour and Consumer Affairs. Quarterly Market Review, December 1990 and 1991.

----------. Ministry of Labour and Consumer Services. Annual Report No.67, 1988.

Chambers, R.G. Applied Production Analysis. New York: Cambridge University Press, 1988.

Cubbin, J. Market Structure and Performance: the Empirical Research. New York: Harwood Academic, 1988.

Deaton, A. and J. Muelbauer. Economics and Consumer Behaviour. New York: Cambridge University Press, 1980.

Diewert, W.E. "An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function." Journal of Political Economy 79 (May/June 1971):481-507.

Diewert, W.E. "Exact and Superlatiuve Index Numbers." Journal of Econometrics 4 (1976):115-145.

Diewert, W.E. "Superlative Index Numbers and Consistency in Aggregation." Econometrica 46 (July 1978):883-900.

Dominion Bureau of Statistics/Statistics Canada. Catalogues: 13-211, 13-213, 13-531, 13-568, 31-203, 31-208, 32-207, 62-010, 63-002, 63-202, 68-201, 68-205, 91-203, 91-210, 91-508.

Friedman, J.W. Oligopoly Theory. New York: Cambridge University Press, 1983.

Fuss, M. and L. Waverman. "The Demand for Alcoholic Beverages in Canada." Working Paper No. 8714, Department of Economics, University of Toronto, 1987.

Geroski, P.A. "In Pursuit of Monopoly Power: Recent Quantitative Work in Industrial Economics.: Journal of Applied Econometrics 3 (1988):107-123.

Gollop, F.M. and M.J. Roberts. "Firm Interdependence in Oligopolistic Markets." Journal of Econometrics 10 (1979):313-331.

Grant, R.M. "Pricing Behaviour in the UK Wholesale Market for Petrol 1970-80: A 'Structure-Conduct Analysis'." Journal of Industrial Economics 30 (1982):271-292.

Hoeter, B.W. "Vines and Wines in Western Canada." Essay for Diploma of Oenology, Oenological Research Laboratories, Surrey, England, 1971.

Intriligator, M.D. Econometric Models, Techniques and Applications. Englewood Cliffs: Prentice-Hall, Inc., 1978.

Iwata, G. "Measurement of Conjectural Variations in Oligopoly." Econometrica 42 (September 1974):947-966.

Johnson, J. and E. Oksanen. "Estimation of Demand for Alcoholic Beverages in Canada From Pooled Time series and Cross Sections." Review of Economics and Statistics 59 (1977):113-118.

Johnson, J., E. Oksanen, M. Veall, and D. Fretz. "Short Run and Long Run Elasticities for Canadian Consumption of Alcoholic Beverages: An Error-Correction Mechanism Cointegration Approach." Quantitative Studies in Economics and Population Research Report No. 253, McMaster University, July 1989.

Johnston, J. Econometric Methods. 2d. ed. New York: McGraw-Hill, 1972.

Kamien, M.I., and N.L. Schwartz. "Conjectural Variations." Canadian Journal of Economics 16 (1983):191-211.

Koutsoyiannis, A. Theory of Econometrics. 2d. ed. London: The MacMillan Press Ltd., 1977.

Lopez, R.E. "The Structure of production and the Derived Demand for Inputs in Canadian Agriculture." American Journal of Agricultural Economics 62 (1980):38-45.

Lopez, R.E. "Applications of Duality Theory to Agriculture." Western Journal of Agricultural Economics 7 (1982):353-366.

Lopez, R.E. "Measuring Oligopoly Power and Production Responses of the Canadian Food Processing Industry." Journal of Agricultural Economics 35 (1984):219-230.

Nichol, A. Wines and Vines of British Columbia. Vancouver: Bottesini Press, 1983.

Parks, R.W. "Price Responsiveness of Factor Utilization in Swedish Manufacturing, 1870-1950." Review of Economics and Statistics 53 (1971):129-139.

Perry, M.K. "Oligopoly and Consistent Conjectural Variations." Bell Journal of Economics 13 (1982):197-205.

Roberts, M.J. "Testing Oligopolistic Behaviour." International Journal of Industrial Organization 2 (1984):367-383.

Scherer, F.M. Industrial Market Structure and Economic Performance. 2 ed. Chicago:Rand McNally, 1980.

Schroeter, J.R. "Estimating The Degree of Market Power in the Beef Packing Industry." Review of Economics and Statistics 70 (1988):158-162.

Slade, M.E. "Conjectures, Firm Characteristics, and Market Structure." International Journal of Industrial Organization 4 (1986):347-369.

Spiller, P.T. and E. Favaro. "The Effects of Entry Regulation on Oligopolistic Interaction: the Uruguayan Banking sector." Rand Journal of Economics 15 (1984):244-254.

Varian, H. Microeconomic Analysis. 2d. ed. New York: W.W. Norton and Company, 1984.

Vielvoye, J. "Grape Industry In British Columbia." Photocopy, 1987.

Vielvoye, J. "Presentation to the 1990 Grape and Wine Forum." In Grape and Wine Forum Proceedings, April 4 and 5, 1990. Victoria: British Columbia Ministry of Agriculture and Fisheries, 1990.

Vielvoye, J. Profile of the Grape and Wine Industry of British Columbia. Victoria: Extension Systems Branch, British Columbia Ministry of Agriculture, Fisheries and Food, 1991.

White, K., S.D. Wong, D. Whistler, and S.A. Huan. SHAZAM User's Reference Manual Version 6.2. New York: McGraw-Hill, 1990.

APPENDIX A: BCLDB DOMESTIC WINE PRICING METHOD

A. British Columbia Wine Taxation and Markups

Both levels of government (federal and provincial) are involved in the determination of the retail price of wine in British Columbia.

Federal:

The federal revenue on wine products arises from:

(a) the federal sales tax applied at the manufacturer's trade level.

(b) the excise tax on the sales of wines.

The Excise Tax Act is the statutory basis of the excise tax, the main component of which is the general manufacturer's sales tax The sales tax is a tax of general application in that it applies to all goods manufactured or produced in Canada or imported into Canada unless the goods are exempted by a provision of the act.

The remainder of the excise tax structure consists of taxes and duties on a prescribed list of goods (for example, wine ($/L), spirits ($/L), and beer ($/HL)).

Until 1980, the federal sales tax was applied on the manufacturers' selling price exclusive of all other excise taxes. Commencing April 22, 1980, the excise tax on wine was included in the price on which the federal sales tax was calculated.

Provincial:

Provincial liquor authorities have monopoly control over the sale of beverage alcohol within their jurisdiction. They derive revenue from within the retail price structure through two markups; an ad-valorem type of markup and a specific volume markup (since April 1985). The cost base for markup purposes includes the manufacturers selling price and all federal taxes and levies. The provincial government obtains additional revenue from the collection of retail sales tax applied to the sum of all of the foregoing.

The next section illustrates the process through which the cost components are calculated. The example used below is that of a case of domestic wine (that is, wine from B.C.) containing six 1.5 litre bottles of red table wine. The applicable rates are from 1985 (Source: BCLDB cost card, 1985).

In Bond Cost = Prime Cost (from Producer) + Freight

EXAMPLE: In Bond Cost = $14.03 + $0.14 = $14.17

The cost of freight for the case of six was $0.016/L.

Excise Tax = Bottles per case x Bottle Size X Excise Rate

EXAMPLE: Excise Tax = 6 x 1.5 x $0.4472/L = $4.02

Federal Sales Tax = (Prime Cost + Excise Tax) x (Fed. Tax)

EXAMPLE: Fed. Sales Tax = (14.03 + 4.02) x 0.13 = $2.35

Note that the federal sales tax base does not include freight charges. This makes a difference for imported wines which have a much higher freight cost than the domestics.

Duty Paid Cost = In Bond Cost + Fed. Tax + Excise Tax

EXAMPLE: Duty Paid Cost = 14.17 + 2.35 + 4.02 = $20.54

Cost Per Selling Unit = Duty paid Cost/No. of Selling Units

EXAMPLE: Cost Per Selling Unit = 20.54/6 = $3.4233

As of April 1985 an adjustment factor was created, it took the form of a volume markup ($/L).

Adjustment Factor = cents/L x No. of Litres in Selling Unit

EXAMPLE: Adjustment Factor = 0.04 x 1.5 = $0.06

Adjustment Cost = Cost per Selling Unit + Adjustment Factor

EXAMPLE: Adjustment Cost = 3.4233 + 0.06 = $3.4833

Markup Factor = (1.00 + Markup) x (Prov. Sales Tax)

EXAMPLE: Markup Factor = 1.50 x 1.07 = 1.605

Display Price = Adjustment Cost Unit x Markup Factor

EXAMPLE: Display Price = 3.4833 x 1.605 = $5.5907

This figure is rounded up to $5.60 so that the resulting tax included display price will end in a 5 or a 0.

APPENDIX B: DATA SOURCES, CONSTRUCTION AND TABLES

A. The Data Sources:

Consumption:

Sources: Dominion Bureau of Statistics/Statistics Canada, 63-202, The Control and Sale of Alcoholic Beverages in Canada (March 31, 1957 to March 31,1987).

Consumption data for each of beer, spirits and wine (non-sparkling plus sparkling) were obtained from the above sources as sales of alcoholic beverages by volume. Source data are given on a fiscal year basis and were adjusted to a calendar year basis as follows:

$$Cons._{Dec.31,t} = .25\,Cons._{March31,t} + .75\,Cons._{March31,t+1} \qquad (B.1)$$

Source data after 1978 are given in '000 litres; pre-1978 figures were converted for consistency with post-1978 data as '000 litres = '000 gallons x 4.4546.

Expenditure:

Source: Same as for consumption.

Data were obtained as sales of alcoholic beverages by value ($'000 current) on a fiscal year basis and were adjusted to calendar year as for consumption above. Expenditures are exclusive of general retail sales taxes (these taxes were added in this study).

Consumer Price Index:

Source: Dominion Bureau of Statistics/Statistics Canada, 62-002, Prices and Price Indexes (1957-1974) and 62-010, Consumer Prices and Price Indexes (1975-1987).

The CPI (all items) for the representative city (Vancouver) was not available with consistent expenditure weights for the entire sample period. Three series were used, with overlapping observations for 1971 and 1981 which allowed a best guess consistency adjustment to be made. The CPI index for the sample period has 1981 as its base year.

Population:

Source: Dominion Bureau of Statistics/Statistics Canada, 91-203, Population Estimates by Marital Status, Age and Sex, for Canada and Provinces (June 1, 1956 - June 1, 1970), 91-508, Intercensal Annual Estimates of Population by Sex and Age for Canada and Provinces (June 1, 1971 - June 1, 1981), and 91-210, Postcensal Annual Estimates of Population by Marital Status, Age, Sex and Components of Growth for Canada, Provinces and Territories (June 1, 1982 - June 1, 1988).

Source data are population aged 15 years and over, in thousands as of June 1 each year. To obtain a year-end value, source data were adjusted as follows:

$$Pop._{Dec.31,t} = .42\,Pop._{June1,t} + .58\,Pop._{June1,t+1} \qquad (B.2)$$

Income:

Source: Dominion Bureau of Statistics/Statistics Canada, 13-531, National Income and Expenditure Accounts (1957-1984), and 13-213, Provincial Economic Accounts (1985-1986).

Data are personal disposable income in millions of current dollars.

Provincial Sales Tax:

Source: Dominion Bureau of Statistics/Statistics Canada, 68-201, Principal Taxes and Rates (1957-1978), 68-205, Provincial Government Finance (1979-1981), Ministry of Finance and Corporate Affairs, B.C. Financial and Economic Review, (1982-1987).

The provincial sales tax applied on alcoholic beverages are ad-valorem taxes.

Capital:

Source: Dominion Bureau of Statistics/Statistics Canada, 13-568, Fixed Capital Flows and Stocks: Occasional (1957-1983), 13-211, Fixed Capital Flows and Stocks: Annual (1984-1987).

Data is the price index for capital expenditure on plant and equipment (total components) for the whole of the food and beverage industry in Canada scaled to 1971=100.

Labour:

Source: Dominion Bureau of Statistics/Statistics Canada, 31-208, Manufacturing Industries of B.C., Yukon and the N.W.T. (1957-1959,1961, 1967-1971), 31-203, Manufacturing Industries of Canada (1972-1987), 32-207, Wineries (1960, 1962-1966).

Data are employment levels of production (and related workers) and administration staff, and their respective wages and salaries ($ '000 current).

Materials:

Source: B.C. Department of Agriculture, Production of Berry Crops with an Estimate of Farm Value (1957-1974), B.C. Grape Marketing Board (1974-1987).

Expenditure and quantity data for British Columbia grapes were obtained from the above source as sales ($ '000 current) and volume (lbs.) of grapes for processed use ($ '000 current). Source data for the quantity values are given in lbs. which were converted to kg=lb x 2.54.

B. Variable Construction:

The Exogenous Variables:

PDB: annual prices for domestic beer were constructed by dividing its expenditure series (sales tax added) by its consumption series, and then deflating by the CPI. A simple price index was created by dividing the price series by its

value in 1971.

PIB: a simple price index for imported beer was created using the same method.

PDS: a simple price index for domestic spirits was created using the same method.

PIS: a simple price index for imported spirits was created using the same method.

PIW: two price series for wine were created, one using expenditure (sales tax added) and consumption data for non-sparkling wines, and the other using data for sparkling wines[57]. After these two price series were deflated by the CPI they were used with their corresponding consumption data to create a Fisher Ideal price index for total imported wine (1971=1).

PDI: the personal disposable income series was divided through by the population aged 15 years and over series and was then deflated by the CPI in order to construct the personal disposable income per capita variable.

W_K: the price index for capital expenditure on plant and equipment (total components) was taken directly from the data source (1971=1).

W_L: two price series for labour were created, one using the

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[57]Sparkling wines have been carbonated at some point in their production and contain more than seven percent of absolute alcohol by volume. Nonsparkling wines contain primarily table wines containing between eight and fourteen percent alcohol by volume, and fortified wines containing over fourteen percent alcohol by volume.

employment level of production workers and their wages and the other using the employment level of administration staff and their salaries. After these two series were deflated using the CPI they were used along with the employment data to create a Fisher Ideal index for the price of labour (1971=1).

W_M: annual prices for British Columbia grapes used in the wine industry was created by dividing its expenditure series by its quantity series and then deflating by the CPI. A simple price index was then constructed by dividing through with the price value of 1971.

The Endogenous Variables:

Y: Since the expenditure and consumption data for wine was obtained from Statistics Canada catalogues the study had to adopt its categorization technique. Two sub-groups of wine were identified: sparkling and non-sparkling, which were aggregated into the quantity variable (Y) measured in litres of wine per head of population aged 15 years and over.

PDW: Two price series for B.C. wine were constructed using the expenditure (sales tax added) and consumption data for sparkling and non-sparkling wine. After these two series were deflated they were used along with their corresponding consumption data to create a Fisher Ideal price index (1971=1).

C. DATA TABLES:

Year	Y	PDW	PIW	PDB	PIB	PDS	PIS
1957	1.999	0.833	0.785	0.812	0.999	0.855	0.836
1958	2.228	0.837	0.790	0.837	0.933	0.864	0.832
1959	2.375	0.835	0.786	0.836	0.913	0.889	0.850
1960	2.625	0.830	0.763	0.855	0.906	0.900	0.859
1961	2.804	0.842	0.778	0.864	0.885	0.899	0.861
1962	3.336	0.850	0.859	0.867	0.949	0.898	0.915
1963	3.867	0.808	0.854	0.861	0.812	0.897	0.917
1964	4.379	0.833	0.857	0.865	0.871	0.909	0.909
1965	5.490	0.846	0.863	0.875	0.921	0.913	0.896
1966	5.530	0.863	0.895	0.878	0.912	0.899	0.927
1967	5.505	0.896	0.929	0.891	0.912	0.919	0.964
1968	6.082	0.938	0.966	0.924	0.949	0.970	1.001
1969	6.884	0.940	0.996	0.945	0.963	0.977	1.011
1970	7.852	0.941	1.067	0.947	1.053	0.972	1.041
1971	8.608	1.000	1.000	1.000	1.000	1.000	1.000
1972	8.838	1.057	1.124	1.045	1.184	1.056	1.057
1973	8.838	1.068	1.185	1.077	1.212	1.080	1.092
1974	8.682	1.210	1.214	1.135	1.404	1.128	1.142
1975	9.613	1.259	1.431	1.165	1.418	1.251	1.291
1976	8.344	1.442	1.502	1.341	1.424	1.364	1.386
1977	8.040	1.442	1.481	1.436	1.379	1.369	1.446
1978	9.301	1.459	1.638	1.591	1.070	1.409	1.514
1979	9.464	1.544	1.764	1.779	1.259	1.495	1.687
1980	11.054	1.763	1.966	2.176	1.609	1.632	1.908
1981	11.082	2.077	2.028	2.412	1.809	1.834	2.201
1982	11.221	2.286	2.000	2.775	2.027	2.043	2.443
1983	10.986	2.433	2.026	3.059	1.953	2.235	2.557
1984	10.519	2.507	2.010	3.235	1.977	2.377	2.602
1985	10.867	2.543	2.067	3.661	2.136	2.482	2.678
1986	9.849	2.732	2.363	3.936	2.263	2.572	2.776

Year	PDI	W_L	W_C	W_M	CPI
1957	2347.92	0.480	0.689	0.746	0.741
1958	2354.90	0.470	0.700	0.746	0.764
1959	2440.36	0.508	0.707	0.714	0.778
1960	2478.97	0.518	0.718	0.717	0.785
1961	2488.99	0.542	0.732	0.747	0.787
1962	2580.07	0.594	0.749	0.723	0.790
1963	2684.05	0.633	0.770	0.721	0.802
1964	2829.18	0.645	0.812	0.744	0.808
1965	3016.31	0.666	0.855	0.722	0.823
1966	3176.93	0.717	0.891	0.758	0.843
1967	3340.59	0.762	0.883	0.791	0.874
1968	3458.19	0.811	0.883	0.767	0.906
1969	3692.82	0.911	0.918	0.817	0.937
1970	3839.80	0.984	0.966	0.960	0.968
1971	4106.68	1.000	1.000	1.000	1.000
1972	4643.63	1.043	1.033	1.202	1.040
1973	5362.55	1.166	1.087	1.277	1.110
1974	6166.15	1.368	1.241	1.621	1.239
1975	7077.18	1.660	1.389	1.813	1.401
1976	7869.35	1.749	1.488	2.053	1.537
1977	8641.21	2.008	1.621	1.945	1.647
1978	9525.71	2.355	1.777	2.117	1.774
1979	10578.14	2.601	1.975	2.356	1.911
1980	12011.99	2.656	2.201	2.850	2.090
1981	13823.48	3.209	2.455	3.026	2.389
1982	14836.14	3.723	2.650	3.217	2.668
1983	14908.61	3.880	2.648	3.621	2.807
1984	15635.77	3.932	2.738	3.640	2.898
1985	16432.63	4.237	2.874	3.432	2.991
1986	16944.36	3.652	3.025	3.859	3.089

APPENDIX C: MODEL IDENTIFICATION

A. Establishing Identification From the Structural Form of the Model

1. The Order Condition for Identification[58]

This condition is based on a counting rule of the variables included and excluded from the particular equation. It is a necessary but not sufficient condition for the identification of an equation. The order condition stated by Gujarati (1988, p. 586), is that:

> "in a model of M simultaneous equations, in order for an equation to be identified, the number of predetermined variables excluded from the equation must not be less than the number of endogenous variables included in that equation less 1."

Let M = number of endogenous variables in model
m = number of endogenous variables in given equation
K = number of exogenous variables in model
k = number of exogenous variables in given equation

Then the order condition for identification may be symbolically expressed as

$$K - k \geq m - 1$$

If K-k=m-1, the equation is just identified; but if K-k.m-1. it is overidentified.

---

[58]The term order refers to the order of a matrix, that is, the number of rows and columns present in a matrix

B. The Rank Condition for Identification[59]

The order condition for identification is necessary for a relation to be identified, but it is not sufficient, that is, it may be fulfilled in any particular equation and yet the relation may not be identified. Therefore one needs both a necessary and sufficient condition for identification. this is provided by the rank condition of identification, which Gujarati (1988, p.588) stated as:

> "in a model containing M equations in M endogenous variables, an equation is identified if and only if at least one non-zero determinant of order (M-1)(M-1) can be constructed from the coefficients of the variables (both exogenous and predetermined) excluded from that particular equation but included in the other equations of the model."

Recalling from chapter three that the structural model of the B.C. wine industry is given by,

$$Y_t^D = \alpha_0 + \alpha_1 PDW_t + \alpha_2 PIW_t + \alpha_3 PDB_t + \alpha_4 PIB_t + \alpha_5 PDS_t + \alpha_6 PIS_t + \alpha_7 PDI_t + \alpha_8 t + v_t$$

$$\begin{aligned} PDW_t = b_0 + \left(-\frac{\lambda}{\alpha}1\right) Y_t^S + b_1 w_1 + b_c w_c \\ + b_g w_g + b_{1c} w_1^{\frac{1}{2}} w_c^{\frac{1}{2}} + b_{1g} w_1^{\frac{1}{2}} w_g^{\frac{1}{2}} \\ + b_{cl} w_c^{\frac{1}{2}} w_g^{\frac{1}{2}} + u_t \end{aligned} \qquad \text{(C.1)}$$

$$Y_t^D = Y_t^S$$

one can trace the identifiableness of an equation of this

---

[59]The term rank refers to the rank of a matrix and is given by the largest-order square matrix (contained in the given matrix) whose determinant is non-zero.

structural model using the conditions stated above.[60]

1. Order Condition: $(K-k) \geq (m-1)$

In the above model one has,

$$K=13 \quad k=7 \quad M=3 \quad m=1$$

for the first equation.

Therefore $(13-7) \geq (3-1)$

Consequently the first equation is overidentified.

For the second equation, one has

$$K=13 \quad k=6 \quad M=3 \quad m=1$$

Therefore $(13-6) \geq (3-1)$

Consequently the second equation is also overidentified.

2. Rank condition:

Following the procedure explained in depth by Koutsoyiannis (1977), one can form five non-zero determinants of order $(M-1)=(3-1)=2$ for the first equation, and seven non-zero determinants of order 2 for the second equation.

One can see, from above, that the equations of the model both satisfy the order and rank conditions for identification.

---

[60]See Koutsoyiannis (1977, pp. 352-361), for detailed examples on the application of both the order and rank conditions on structural models.

APPENDIX D: SHAZAM OUTPUT

```
|_READ (4) QDWC PIDW PIIW PIDB PIIB PIDSP PIISP PL PC PG PDICAP
CPI
  12 VARIABLES AND        30 OBSERVATIONS STARTING AT OBS
1
```

THREE-STAGE-LEAST SQUARES ESTIMATION OF MODEL:

```
|_SYSTEM 2 PIW PDB PIB PDSP PISP PDI WL WC WG WLWC WLWG WCWG T
/ DN RSTAT RESID=E
|_OLS QDWC PDW PIW PDB PIB PDSP PISP PDI T
|_OLS PDW QDWC WL WC WG WLWC WLWG WCWG

THREE STAGE LEAST SQUARES--     2 EQUATIONS
 13 EXOGENOUS VARIABLES
  2 POSSIBLE ENDOGENOUS VARIABLES
 15 RIGHT-HAND SIDE VARIABLES IN SYSTEM
MAX ITERATIONS=1 CONVERGENCE TOLERANCE=0.10000E-02
       30 OBSERVATIONS
DN OPTION IN EFFECT - DIVISOR IS N

ITERATION      0 COEFFICIENTS
  -28.909    1.4911    -1.8086    10.529    -3.2082    7.4996
  -0.10025E-02    0.41717    0.26370E-01    0.99152    1.1189
   3.3632    0.75677    -3.7602    -3.3653

ITERATION     0 SIGMA
  0.48313
 -0.50566E-03  0.40156E-03

BREUSCH-PAGAN LM TEST FOR DIAGONAL COVARIANCE MATRIX
   CHI-SQUARE=0.39538E-01 WITH 1 DEGREES OF FREEDOM
LOG OF DETERMINANT OF SIGMA=-8.5489

ITERATION     1 SIGMA INVERSE
   2.0726
   2.6098        2493.5

ITERATION      1 COEFFICIENTS
  -29.442    1.2121    -2.0208    10.754    -3.1413    7.9351
  -0.99010E-03    0.41723    0.26400E-01    1.0108    1.1294
      3.3970    0.76703   -3.8077    -3.3886

ITERATION     1 SIGMA
  0.48979
 -0.65191E-03  0.40185E-03
LOG OF DETERMINANT OF SIGMA=  -8.5354
```

SYSTEM R-SQUARE=0.9870 ... CHI-SQUARE=130.39 WITH 15 D.F.

VARIABLE	COEFFICIENT	ST.ERROR	T-RATIO
PDW	-29.442	14.880	-1.9786
PIW	1.2121	3.3529	0.36151
PDB	-2.0208	2.8877	-0.69978
PIB	10.754	4.0797	2.6361
PDSP	-3.1413	8.0821	-0.38867
PISP	7.9351	5.3171	1.4924
PDI	-0.99010E-03	0.13315E-02	-0.74359
T	0.41723	0.78494E-01	5.3154
QDWC	0.26400E-01	0.78392E-02	3.3676
WL	1.0108	0.64804	1.5598
WC	1.1294	0.94367	1.1969
WG	3.3970	1.5242	2.2287
WLWC	0.76703	1.2442	0.61651
WLWG	-3.8077	1.6990	-2.2411
WCWG	-3.3886	1.9268	-1.7586

THE ESTIMATED PARAMETERS OF EQUATION (4.1):

EQUATION 1 OF 2 EQUATIONS
DEPENDENT VARIABLE=QDWC 30 OBSERVATIONS

R-SQUARE=0.9472
VARIANCE OF THE ESTIMATE-SIGMA**2=0.48979
STANDARD ERROR OF THE ESTIMATE-SIGMA=0.69985
SUM OF SQUARED ERRORS-SSE=14.694
MEAN OF DEPENDENT VARIABLE=7.2087

VARIABLE NAME	ESTIMATED COEFFICIENT	ASYMPTOTIC STANDARD ERROR	T-RATIO	ELASTICITY AT MEANS
PDW	-29.442	14.880	-1.9786	-3.9417
PIW	1.2121	3.3529	0.36151	0.16234
PDB	-2.0208	2.8877	-0.69978	-0.28888
PIB	10.754	4.0797	2.6361	1.4537
PDSP	-3.1413	8.0821	-0.38867	-0.42299
PISP	7.9351	5.3171	1.4924	1.1076
PDI	-0.99010E-03	0.13315E-02	-0.74359	-0.60564
T	0.41723	0.78494E-01	5.3154	0.89711
CONSTANT	19.019	14.714	1.2926	2.6384

DURBIN-WATSON=1.8433 VON NEUMANN RATIO=1.9068 RHO=0.04959
RESIDUAL SUM=0.21005E-12 RESIDUAL VARIANCE=0.48979
SUM OF ABSOLUTE ERRORS=15.584
R-SQUARE BETWEEN OBSERVED AND PREDICTED=0.9476
RUNS TEST: 15 RUNS, 16 POSITIVE, 14 NEGATIVE,
NORMAL STATISTIC = -0.3484

THE ESTIMATED PARAMETERS OF EQUATION (4.6):

EQUATION 2 OF 2 EQUATIONS
DEPENDENT VARIABLE = PDW 30 OBSERVATIONS

R-SQUARE=0.9512
VARIANCE OF THE ESTIMATE-SIGMA**2=0.40185E-03
STANDARD ERROR OF THE ESTIMATE-SIGMA=0.20046E-01
SUM OF SQUARED ERRORS-SSE=0.12056E-01
MEAN OF DEPENDENT VARIABLE=0.96510

VARIABLE NAME	ESTIMATED COEFFICIENT	ASYMPTOTIC STANDARD ERROR	T-RATIO	ELASTICITY AT MEANS
QDWC	0.26400E-01	0.78392E-02	3.3676	0.19719
WL	1.0108	0.64804	1.5598	1.0737
WC	1.1294	0.94367	1.1969	1.1479
WG	3.3970	1.5242	2.2287	3.8171
WLWC	0.76703	1.2442	0.61651	0.79114
WLWG	-3.8077	1.6990	-2.2411	-4.1465
WCWG	-3.3886	1.9268	-1.7586	-3.6109
CONSTANT	1.6700	0.14205	11.756	1.7304

DURBIN-WATSON=2.2612 VON NEUMANN RATIO=2.3392 RHO=-0.28150
RESIDUAL SUM=0.30309E-13 RESIDUAL VARIANCE=0.40185E-03
SUM OF ABSOLUTE ERRORS=0.48369
R-SQUARE BETWEEN OBSERVED AND PREDICTED=0.9515
RUNS TEST: 18 RUNS, 16 POSITIVE, 14 NEGATIVE,
NORMAL STATISTIC=0.7715

HYPOTHESES TESTS:

HYPOTHESIS TEST: λ=0 (COMPETITIVE BEHAVIOUR)
TEST PDW:1*QDWC:2=0
TEST VALUE=-0.77726 STD. ERROR OF TEST VALUE 0.45415
ASYMPTOTIC NORMAL STATISTIC=-1.7114627
WALD CHI-SQUARE STATISTIC=2.9291047 WITH 1 D.F.

HYPOTHESIS TEST: λ=-1 (COLLUSIVE BEHAVIOUR)
TEST PDW:1*QDWC:2=-1
TEST VALUE=0.22274 STD. ERROR OF TEST VALUE 0.45415
ASYMPTOTIC NORMAL STATISTIC=0.49044429
WALD CHI-SQUARE STATISTIC=0.24053560 WITH 1 D.F.

HYPOTHESIS TEST: λ=-0.20 (COURNOT BEHAVIOUR)
TEST PDW:1*QDWC:2=-0.20
TEST VALUE=-0.57726 STD. ERROR OF TEST VALUE 0.45415
ASYMPTOTIC NORMAL STATISTIC=-1.2710813
WALD CHI-SQUARE STATISTIC=1.6156477 WITH 1 D.F.

OLS RESULTS FOR FIRST-ORDER AUTOREGRESSION:

OLS ON THE RESIDUALS OF EQUATION (4.1):

```
|_SAMPLE 2 30
|_OLS ED LED / NOCONSTANT RSTAT
```

```
 R-SQUARE=0.0023 R-SQUARE ADJUSTED=0.0023
VARIANCE OF THE ESTIMATE-SIGMA**2=0.52322
STANDARD ERROR OF THE ESTIMATE-SIGMA=0.72334
SUM OF SQUARED ERRORS-SSE=14.650
MEAN OF DEPENDENT VARIABLE=0.34226E-02
LOG OF THE LIKELIHOOD FUNCTION=-31.2479
RAW MOMENT R-SQUARE=0.0023
```

ANALYSIS OF VARIANCE - FROM ZERO

	SS	DF	MS	F
REGRESSION	0.33850E-01	1.	0.33850E-01	0.065
ERROR	14.650	28.	0.52322	
TOTAL	14.684	29.	0.50634	

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 28 DF	ELASTICITY AT MEANS
LED	0.49588E-01	0.19496	0.25435	0.48127

```
DURBIN-WATSON=1.9299 VON NEUMANN RATIO=1.9988 RHO=-0.00154
RESIDUAL SUM=0.51487E-01  RESIDUAL VARIANCE=0.52322
SUM OF ABSOLUTE ERRORS=15.346
R-SQUARE BETWEEN OBSERVED AND PREDICTED=0.0023
RUNS TEST: 14 RUNS, 15 POSITIVE, 14 NEGATIVE,
NORMAL STATISTIC=-0.5615
COEFFICIENT OF SKEWNESS=0.5494 WITH STANDARD DEVIATION OF 0.4335
COEFFICIENT OF EXCESS KURTOSIS=1.6222 WITH STANDARD DEVIATION OF
0.8452
```

GOODNESS OF FIT TEST FOR NORMALITY OF RESIDUALS - 6 GROUPS

OBSERVED	1.0	5.0	8.0	12.0	2.0	1.0
EXPECTED	0.7	3.9	9.9	9.9	3.9	0.7

```
CHI-SQUARE=2.3981 WITH  3 DEGREES OF FREEDOM
```

OLS ON THE RESIDUALS OF EQUATION (4.6):

```
|_OLS ES LES / NOCONSTANT RSTAT
```

```
R-SQUARE=0.0724   R-SQUARE ADJUSTED=0.0724
VARIANCE OF THE ESTIMATE-SIGMA**2=0.36113E-03
STANDARD ERROR OF THE ESTIMATE-SIGMA=0.19003E-01
```

SUM OF SQUARED ERRORS-SSE=0.10112E-01
MEAN OF DEPENDENT VARIABLE=-0.11522E-02
LOG OF THE LIKELIHOOD FUNCTION=74.2905
RAW MOMENT R-SQUARE=0.0756

ANALYSIS OF VARIANCE - FROM ZERO

	SS	DF	MS	F
REGRESSION	0.82748E-03	1.	0.82748E-03	2.291
ERROR	0.10112E-01	28.	0.36113E-03	
TOTAL	0.10939E-01	29.	0.37721E-03	

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 28 DF	ELASTICITY AT MEANS
LES	-0.28150	0.18597	-1.5137	0.33839

DURBIN-WATSON=1.7049 VON NEUMANN RATIO=1.7658 RHO=0.05225
RESIDUAL SUM=-0.22107E-01 RESIDUAL VARIANCE=0.36113E-03
SUM OF ABSOLUTE ERRORS=0.40846
R-SQUARE BETWEEN OBSERVED AND PREDICTED=0.0739
RUNS TEST: 17 RUNS, 14 POSITIVE, 15 NEGATIVE,
NORMAL STATISTIC=0.5745
COEFFICIENT OF SKEWNESS=0.0125 WITH STANDARD DEVIATION OF 0.4335
COEFFICIENT OF EXCESS KURTOSIS=0.8340 WITH STANDARD DEVIATION OF 0.8452

GOODNESS OF FIT TEST FOR NORMALITY OF RESIDUALS - 6 GROUPS

OBSERVED	1.0	3.0	11.0	11.0	2.0	1.0
EXPECTED	0.7	3.9	9.9	9.9	3.9	0.7

CHI-SQUARE=1.7735 WITH 3 DEGREES OF FREEDOM
|_STOP