Intra B.C. Long Distance Telephone Demand Price Elasticities - An Empirical Investigation

by

Scott Bozman

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[redacted] DEAN
DATE Nov 25, 83

We accept this thesis as conforming to the required standard

[redacted]
Dr. G. R. Walter

[redacted]
Dr. L. I. Bakony

[redacted]
Dr. J. J. McRae

UNIVERSITY OF VICTORIA

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Supervisor: Professor Gerald R. Walter

ABSTRACT

Price elasticity estimates for toll telephone services have played an increasingly important role in the decisions of British Columbia Telephone Company and the Canadian Radio-television and Communications Commission. However, the results of any prior econometric analysis can only be interpreted with regard to the range of variation in the variables studied. In view of this, the purpose of this thesis is to produce and evaluate price elasticity estimates incorporating the recent recessionary period.

Two models were considered. A log Koyck specification was found to be superior to the flow adjustment model. In general, the results indicate that consumer behavior has changed significantly and price elasticities have become elastic on average. As work progressed on the model it became apparent that several problems could effect the reliability of parameter estimates. Nonetheless, this does not mean that the price elasticities presented here are without merit. Rather the usefulness of these results should be interpreted in their ability to indicate the general direction and magnitude of toll demand elasticities and to point out problem areas requiring further research.

Examiners: [redacted]

Dr. G.R. Walter

[redacted]

Dr. L.I. Bakony

[redacted]

Dr. J.J. McRae

[redacted]

Professor W.A. Neilson

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PREFACE

This paper is the product of an Economics Co-op position with the British Columbia Telephone Company. My primary employment responsibility was the theoretical and empirical evaluation of intra B.C. long distance telephone demand. Required tasks included a review of related topics, data and methodology, the provision of current estimates, linking the resulting information with in-house computer models and fully documenting the procedures utilized. I would like to express my sincere appreciation to Duncan Smeaton for making this opportunity available to me.

There are several other people who deserve recognition for their support of this project. Marshall Lee was kind enough to comment on a final draft of the paper. Debbie Gorham and Barb Nelson provided helpful suggestions at various stages of this study. Thanks also go to Laurie Thompson for translating my rather illegible handwriting into printed form. Finally, I am indebted to my thesis committee of Professors Jim McRae, Leo Bakony and Gerry Walter for their time, tolerance and guidance.

I. INTRODUCTION

The primary purpose of this thesis is to produce and evaluate price elasticity of demand estimates for different long distance telephone services within British Columbia. The need for this study was prompted by one major factor. Previous estimation attempts are biased by a limited time series data base which excludes the most severe recession since the Great Depression of the 1930's. Extending the period of analysis should allow better estimates of toll price elasticities to be obtained and the investigation of consumer responses to significant changes in economic environment.

Knowledge of the price elasticity of demand by market segment and mileage zone is useful for planning future rate structures. When an inelastic market has been identified, a real rate increase will increase total revenue. On the other hand, revenue may be increased in an elastic market by letting the rate of inflation lower the real cost of placing a toll call.[1] The latter assumption will only be true in the short run if consumers recognize small decreases in real prices. This information has also been used by British Columbia Telephone Company to determine the revenue impact of specific toll price changes. For example, consider the CRTC's recent approval of a three percent

[1] Although total revenue is maximized when the price elasticity of demand equals one, profits will only follow suit if marginal costs equal zero. A more realistic management strategy would maximize profits where marginal cost equalled marginal revenue somewhere in the elastic portion of the demand curve.

general rate increase and the provincial government's decision to impose a seven percent tax on long distance telephone traffic originating in B.C.[2]

The revenue implications of different price elasticities are summarized in the following table.[3]

Table 1

Intra-B.C. Elasticity Effects

	1983 July - December	1984
Residence:		
Price Change	10.4%	10.4%
Received Revenue	2.2%	2.1%
Received Revenue net of tax	- 4.5%	- 8.4%
Business:		
Price Change	10.8%	10.8%
Received Revenue	6.9%	4.5%
Received Revenue net of tax	0.0%	- 2.4%
Total:		
Price Change	10.6%	10.6%
Received Revenue	4.2%	0.7%
Received Revenue net of tax	- 2.6%	- 5.9%

This report tests for structural changes in Intra B.C. toll calling over a ten year period. Of particular interest are the effects of the late recession on consumer behavior. Residence and business calls have been distinguished by their point of origin. Further

[2] Canadian Radio-television and Telecommunications Commission, Telecom Decision CRTC 83-8, June 1983 and "Deluge of Legislation Creates Bedlam in House" Vancouver (B.C.) The Sun, 8 July 1983 p. A2.

[3] H.G. Ware and M.R. Siddons estimates of the impact of these price alterations on Intra B.C. toll revenue are based on zero growth. Memorandum, B.C. Telephone Company, 12 July 1983.

disaggregation is based on the class and time of call. This resulted in nine residence and three business segments with seven mileage zones. In all, the demand equations for eighty-four different toll telephone services are estimated. The implications of this method of disaggregated analysis may be seen in a brief expansion of the "Table of Contents".

Section II presents a brief history of British Columbia Telephone Company in order to become familiar with this particular telecommunications carrier. In addition, a review of the relevant literature on toll demand was deemed to be instructive. In Section III, the characteristics of the demand for telephone service are examined to determine the theoretical foundation of the Intra B.C. toll demand model. Variable definitions and the empirical results from estimation of the model are contained in Section IV. The goal of this procedure is to provide a simple framework for isolating the effects of price changes holding everything else constant. My conclusions are contained in Section V. Recommendations for further research precede the observations which result from an in depth analysis of the demand for intra B.C. long distance telephone services. Appendix A documents data sources and the derivation of all data files. This section also contains tables listing the calculated regression coefficients and the results of a structural change test.

II. BACKGROUND INFORMATION

II.1 Origins of B.C. Telephone Company

The first telephones were installed in British Columbia in 1878 on Vancouver Island. William H. Hall manufactured two telephones which were installed between a mine and Departure Bay several miles away. Six years later, the first mainland system was established by the New Westminster and Port Moody Telephone Company Limited. However, the parent company of British Columbia Telephone Company was not incorporated until April 12, 1916. At that time, the federal government granted the Western Canada Telephone Company the power to operate anywhere in the province of British Columbia. On November 29, 1919, Western Canada Telephone Company was granted permission to change its name to British Columbia Telephone Company. Shortly thereafter the assets of the largest provincial telephone companies were acquired by the federal company. This was the beginning of B.C. Tel as it exists today.

Growth and Corporate Ownership

From 1952 to 1978, B.C. Telephone Company expanded its service area until it now includes ninety-seven percent of the geographic land mass and most of the population of the province. This was accomplished by purchasing the assets of several smaller companies; Mission Telephone in 1952, Kootenay Telephone in 1953, Chilliwack Telephone in 1954, Northwest Telephone in 1961, and Okanagan Telephone in 1966. The major exceptions not covered by the B.C. Tel service area are the city of Prince Rupert and some isolated locations along the northern border of British Columbia.

Anglo-Canadian Telephone Company has controlled a large percentage of B.C. Telephone Company voting stock since 1935. Other major stockholders include B.C. Resources Investment Corporation and General Telephone and Electronics Corporation. With a majority interest in Anglo-Canadian Telephone, GTE effectively controls B.C. Tel. In turn, B.C. Telephone owns two operating companies. It purchased all the outstanding shares of Canadian Telephones and Supplies Ltd. in 1973. This firm specializes in the installation of large automated office equipment. Furthermore, AEL Microtel Limited became a subsidiary of B.C. Tel in 1979. The assets of two manufacturing organizations, GTE Automatic Electric and GTE Lenkurt Electric, were acquired and combined. Microtel manufactures telecommunications equipment and has one of the largest research and development organizations in Canada.

History of Regulation

Like most other public utilities, British Columbia Telephone Company is regulated by the government. Prior to 1976, the company reported to the Canadian Transport Commission due to its federal charter. Any matters related to rates, services or the issuance of capital stock must now be approved by the Canadian Radio-television and

Telecommunications Commission. This important change placed all regulated communications carriers under the auspices of one administrative agency. The rationale behind this move was based on the belief that a single organization could more effectively handle problems encountered in the industry.

To a large extent, the regulation of telephone service in British Columbia reflects both Commissions mandate to serve the public interest. This responsibility has been interpreted in a manner which makes the provision of a high quality service to as many Canadians as possible a major priority. Whether this objective serves the public interest is not considered in this analysis. However, an impressive penetration level has been achieved through public pricing policy. Over ninety-eight percent of the households in Canada now have some type of telephone service. The following rate case awards demonstrate a tendency to subsidize local residential service by price discrimination in the toll and business markets.

Rate Case Awards

On September 1, 1921, the Company obtained its first general rate increase. This ten percent addition to price generated revenue used to meet operating costs and provide a reasonable return to investors. Since that time, B.C. Telephone Company has received twelve additional general rate increases from the Canadian Transport Commission and the Canadian Radio-television and Telecommunications Commission. The outline below summarizes these rate increases and their effect on the price of different telephone services.

September 21, 1950:

The Commission's decision allowed business and residential exchange rates to be increased by a total of 15.39 percent.

January 8, 1952:

In their final decision, the Commission confirmed an interim toll rate increase of 12.42 percent and a general exchange rate increase of 12.88 percent.

March 24, 1953:

An interim rate schedule representing a 12.2 percent increase in toll services and a 100 percent increase in local coin telephone service was approved. In addition, a 9.95 percent increase in exchange rates was authorized.

July 18, 1958:

An increase of 2.97 percent in exchange and toll rates was approved by the Commission.

December 24, 1958:

Increases in toll and exchange rates of 11.43 percent were authorized to allow the Company to meet its income tax obligations based on a revised accounting procedure.

July 30, 1971:

Effective on September 1, 1971, exchange service rates were increased 2.5 percent while toll rates increased from 5 to 10 percent.

January 16, 1975:

The Commission authorized exchange increases of 4.7 percent for residential and 9.5 percent for business rates effective February 15, 1975. Furthermore, service charges were instituted for several categories of operator handled calls, e.g. person to person.

November 3, 1975:

Residential service rates were increased 15.4 percent effective January 1, 1976. Most other service rates were increased 19.8 percent by the Commission.

May 17, 1977:

The rates for long distance calling within B.C. increased by 10 percent effective May 30, 1977. Weekend discounts which were also authorized set a maximum charge of 35 cents per minute.

January 29, 1981:

Residential exchange rates increased 12.5 percent while business exchange rates increased 15 percent. Long distance rates were increased in a manner which was estimated to increase total revenue by 2 percent. All new rate structures became effective February 2, 1981.

May 3, 1982:

Intra B.C. toll service rates increased an average of 6.3 percent while several service charges increased by 20 to 100 percent effective May 5, 1982.

June 22, 1983:

The Commission authorized increases of 3 percent for both residence and business exchange rates and most other telephone services.[4]

Evidence on toll price elasticities was introduced in the latter three rate cases. Not only were rate applications designed around these estimates, but the awards granted by the Commission explicitly noted their importance to the decision process. Intervenors were characterized by a limited knowledge of long distance demand studies and were therefore unable to participate effectively in this aspect of the public hearings. A basic understanding of the methodology behind such studies can be obtained from published research.

This reliance on elasticity estimates does not mitigate the need for other types of information. The CRTC could also benefit from more

4 Much of the empirical information contained in this section was obtained from B.C. Telephone Company's, Fact Book, June 1981, pp. 3-17.

extensive use of contemporary research. While the Commission's powers enable it to conduct research on the publics behalf as well as require the necessary information from regulated firms, very little progress in this direction has been forthcoming. This burden has traditionally been met by participants in regulatory hearings. Given that most company data is of a confidential nature and unavailable to intervenors, the Commission's decisions could be improved by its constructive use of the full array of data available from the B.C. Telephone Company.

II.2 A Synopsis of Existing Literature

In the pervasive regulatory environment, it is not too surprising that the number of publications bearing on the estimation of long distance telephone demand is quite extensive. Any consequent studies of demand should be founded on this previous research. The articles selected for review here were chosen so they constituted a representative sample of the literature on this subject.[5] Given this limitation, the following abstracts still provide useful information on the theoretical relationship of variables and alternative functional forms of an econometric model.

Luke and Yatrakis (1971)

In a seminal article produced for AT&T Long Lines and the Hawaiian Telephone Company, they developed a toll message demand model for traffic from Hawaii to the continental United States. Their data is quarterly (1961(4) - 1969 (4)), and aggregates residential and business calling. Citing established theory, a double logarithmic form was used for estimation. However, this implicit assumption appears to be more a matter of convenience than a viewpoint justified by previous economic research. The model contains four independent variables: an index representing price, national employment, the number of tourists and a seasonal dummy.

[5]Several other publications on telephone demand are summarized in Lester Taylor's, The Demand for Telephone Service: A Survey and Critique of the Literature, (Cambridge: Ballinger Publishing Company, 1980)

The price variable (P) measures the average charge for long distance calls weighted by the respective volume of calls within rate classes and deflated by the Hawaiian Consumer Price Index. Price changes were lagged fifteen days to account for consumers hypothesized response time. Several macroeconomic variables were tested for significance. Of per capita income, gross national product and employment, the latter (E) was found to obtain the best results. The tourism variable (V) was also statistically significant. A dummy (D) was included after examination of the residuals indicated that the estimated first quarter values differed substantially from the actual values.[6]

Table 2

Double Log Coefficients for Hawaiian to the Continental U.S. Toll Demand

Variable	Total Toll
P/CPI	-1.02 (-3.11)
E	4.03 (6.55)
V	0.16 (2.39)
D	1.14 (4.94)
D.W.	1.261
R^2	.994

Source: Luke and Yatrakis (1971) p. 744.

[6] Standard errors are reported in the Chen and Black (1976) and Rea and Lage (1978) studies. All other terms in brackets are t test statistics.

A stability test of the coefficients was then made by forecasting the number of messages in 1970. The percent deviation of these forecasts from the actual number of messages had a largest absolute deviation in any quarter of 3.3 percent. This short range forecasting achieved impressive results even though the actual values of the 1970 explanatory variables were used. A major contribution of this paper was the interest it sparked among academics. Shortly after its publication, several independent inquiries were made to model the demand for toll telephone services.

Dobell, Taylor, Waverman, Liu and Copeland (1972)

This paper was chosen because it utilizes the Houthakker-Taylor (1970) approach to model toll demand across Canada as well as presenting production and investment models. The data used for the Bell Canada results reported here was an annual time series from 1950 through 1967. Linear stock and flow models were estimated for both the residential and business sectors. The dependent variable was revenue (disaggregated in the residence equation) deflated by a price index. Independent variables included a lagged dependent variable (Q_{t-1}), personal disposable income for Quebec and Ontario (X is per capita in the residence equation) and a toll price index in the residence equation (P). All variables are in terms of 1967 dollars.

Table 3

Coefficients for Bell Canada Long Distance Demand

Variable	Residential	Business
Q_{t-1}	.8674 (2.77)	.8708 (5.74)
ΔX_t	.00117 (1.02)	
X_{t-1}	.00103 (0.65)	
X_t		.00213 (1.59)
ΔP_t	-.0248 (-4.04)	
P_{t-1}	-.00927 (-1.01)	
D.W.	1.95	2.37
R^2	.993	.990

Source: Dobell et al (1972) pp. 178 - 184.

The stock adjustment results were reported because they yielded the best parameter estimates. The absence of a price variable in the business equation contradicts accepted economic theory. Furthermore, the use of the standard Durbin Watson statistic was not appropriate to test for first order serial correlation as a lagged dependent variable was included in the estimated equation. The business equation is just a special case where several coefficients are not significantly different and the functional form collapses to a Koyck model. Short run price and income elasticities were quite inelastic while long run elasticities were very elastic. This probably occurred because the lagged dependent variable contributed most of the explanatory power for both models. The important conclusion revealed in this study was that consumer habit formation strongly influences toll demand.

Carr (1973)

This study uses an econometric model to estimate the toll message demand function for Bell Canada. Using quarterly data from 1949 to 1967, output was defined in terms of the main characteristics of toll messages. These are the percentage of messages at full rate (FUL), the percentage of person to person calls (PP), the average length of messages (D) and the average duration of calls (T). Other included independent variables were the average revenue per long distance message (AR), personal disposable income for Ontario and Quebec (Y), population (POP) and seasonal dummies (S_1, S_2, S_3). Average revenue and personal disposable income were converted into real terms by deflating by the CPI for the residential and coin equations and by an implicit GNP deflator for the business equation.

Table 4

Ordinary Least Square Parameter Estimates of the Explanatory Variables

Variable	Residence	Business	Coin
S_1	-.54 (-3.30)	-.52 (-3.17)	-.07 (-1.84)
S_2	-.22 (-1.53)	.20 (1.36)	.004 (.12)
S_3	.24 (.93)	.24 (1.48)	.30 (6.40)
AR	-6.29 (-4.36)	-1.41 (-.91)	-.22 (-.41)
T	-.16 (-.28)	-.75 (-.61)	-.07 (-.43)
D	.04 (3.74)	-.006 (-.48)	-.009 (3.16)
PP	-.10 (-3.00)	-.06 (3.30)	-.004 (-.57)
FUL	-.03 (-2.48)	-.08 (-1.66)	-.002 (-.48)
Y	.63 (3.73)	.93 (5.77)	.02 (.68)
POP	-.0005 (-.65)	-.003 (-.46)	-.002 (-.03)
D.W.	1.95	1.17	1.37
$\bar{R}^2$	.99	.99	.86

Source: Carr (1973) p. 306.

The price and income elasticities were evaluated at the means of the variables. Business and coin demand were found to be price inelastic while residence demand was price elastic. The income elasticities for residential and business demand were elastic while coin was inelastic. Although these variables display signs consistent with economic theory, many of the other parameter estimates were perverse and not statistically significant. For example, the negative coefficients for population should be positive and are not even mentioned in his analysis. A plausible explanation for some of his other unexpected results which was offered is that the definition of the functional form as a linear combination may not be appropriate. Nonetheless, this paper advances knowledge by eliminating this particular formulation from further consideration.

Waverman (1973)

In this paper, the approach of Dobell et al was slightly modified and improved. The normalization of the dependent variable by the stock of telephones rather than population accounts for the difference in the demand for access compared to the demand for use. In addition, a quality variable was introduced to represent the change in telephone service caused by improved technology. This measure was defined as the percentage of toll calls dialed by an operator. Both stock and flow adjustment models were utilized to explain toll calling for Britain and a log Koyck model for Canada. Since the models specified for Britain contain more information, the rest of this survey will concentrate on three major regressions using the total number of messages as the dependent variable.

The explanatory variables are real per capita consumer expenditure (X), the price of an average long distance call divided by the first class postal rate (P) and the quality variable (D).

Table 5

Flow Adjustment Coefficients for Britain

Variable	Per Capita	Per Capita with Quality	Per Telephone with Quality
Q_{t-1}	1.102 (32.9)	.976 (20.8)	.547 (3.48)
$X_t + X_{t-1}$	-.0008 (.26)	-.0041 (1.57)	.0055 (3.85)
$P_t + P_{t-1}$	-.0059 (1.52)	-.0095 (2.89)	.1347 (5.84)
$D_t + D_{t-1}$		-.01 (3.28)	.274 (2.91)
D.W.	1.45	2.05	1.75
$\bar{R}^2$	.996	.996	.998

Source: Waverman (1973) Appendix Table C.

These results indicate that the adjustement of the dependent variable by the number of telephones improves parameter estimates. In the Dobell model, the consumer response coefficient appeared to be too large and dampened the effects of the other explanatory variables. Thus, the significance of the price and income variables increased using this specification.

Table 6

Stock Adjustment Coefficients for Britain

Variable	Per Capita	Per Capita with Quality	Per Telephone with Quality
Q_{t-1}	1.08 (32.2)	1.02 (17.5)	0.38 (1.62)
X_{t-1}	-.026 (2.69)	-.027 (2.23)	.007 (1.20)
ΔX_t	-.0004 (2.69)	.0002 (1.29)	.0005 (0.42)
P_{t-1}	-.008 (1.15)	-.014 (2.16)	-.279 (2.91)
ΔP_t	-.002 (0.25)	-.005 (0.63)	-.004 (1.04)
D_{t-1}		-.023 (1.91)	-.785 (3.36)
ΔD_t		-.028 (1.36)	-.362 (1.61)
D.W.	-	2.61	2.13
$\bar{R}^2$	-	.996	.998

Source: Waverman (1973) Appendix Table D.

Several elasticities were derived from these equations. The aggregate long run price elasticity for both residential and business customers was inelastic using the flow adjustment model. Waverman postulates that the stock adjustment model is inappropriate due to an implausibly low price elasticity estimate. Income elasticities averaged slightly above unity. Although logarithmic form cannot be used to estimate a stock adjustment model, it can be developed for the flow adjustment model.

This study develops econometric models of toll demand for the states of Oregon and Washington. Their data is pooled time series and cross section from the second quarter of 1970 to the fourth quarter of 1975. Three functional forms are specified: simple Koyck, log Koyck and a log Koyck where income and price enter the model linearly. Explanatory variables are the average price of a three minute call (P), per capita national disposable income (Y), a habit formation proxy (Q_{t-1}), seasonal dummies (S_2 - S_4) and a dummy variable (C) used to represent a change in rate charges from three minutes to one minute. The dependent variables were the average number of messages per mainstation.

Table 7

Intrastate Parameter Estimates of Long Distance Telephone Demand

Variable	Koyck	Log Koyck	Adapted Log Koyck
P_{it}	-.157842 (.099563)	-.172038 (.103995)	-.006607 (.004131)
Y_{it}	.005677 (.001793)	.672764 (.224020)	.000242 (.000076)
Q_{it}	.540123 (.094845)	.515582 (.092930)	.508022 (.092972)
C_{it}	2.513340 (.757237)	.111099 (.034309)	.103932 (.030321)
S_{2it}	1.812908 (.397129)	.081669 (.013761)	.081411 (.073668)
S_{3it}	2.080586 (.321746)	.081669 (.013761)	.081411 (.073668)
S_{4it}	-2.247240 (.684327)	-.124496 (.029249)	-.124772 (.029049)
D.W.	2.44	2.39	2.27
R^{-2}	.915	.911	.912

Source: Chen and Black (1976) Appendix Table 1.

Besides reporting the Durbin Watson test statistic, several other less obvious pitfalls are hidden in this report. Perhaps the most important is that no tests were made to see if pooling of the time series and cross section data was reasonable. The authors appear to assume that customers in Oregon and Washington are a homogenous group. Interpretation of the results of the estimated functions is also more than a little tricky. Cross section estimates provide long run elasticities while the time series data will produce short run elasticities. The short and long run price elasticities listed are very inelastic with income elasticities becoming elastic in the long run. These results are inconsistent with a large portion of the existing literature and further suggest that the use of highly aggregated data is inappropriate.

Dreessen (1977)

This study is the orginal attempt at estimating Intra B.C. toll demand. Preliminary investigation was initiated in 1976 in order to provide evidence on elasticities for future rate structure design. A Hildreth-Lu transformation in logrithmic form was used to represent the gradual adjustment of consumers to environmental changes over time and reduce the probability of serially correlated errors. The dependent variable for eighteen disaggregated market segments was minutes per residence or business main station. In addition, the data series consisted of monthly observations from 1972 through 1975. Independent variables were revenue per minute (R/M), real personal disposable income and gross domestic product for B.C. (PDIRESI, GDPRESI), the

Vancouver consumer price index (CPIVAN) and several dummy variables for changes which could be expected to influence long distance telephone demand, e.g. postal strikes, (POSTDUM).[7]

Table 8

B.C. Telephone Company's Own Price Elasticities (0 - 30 Miles)

Segment		Residence	Business
Day	DDD	-.622 (2.34)	.149 (.69)
	SOH	-.493 (2.06)	-.705 (3.0)
	PP	-.282 (2.52)	-.487 (4.7)
Evening	DDD	1.065 (2.58)	1.113 (1.31)
	SOH	-.535 (2.61)	-.420 (1.91)
	PP	-.421 (2.92)	-.521 (3.26)
Late Night	DDD	-2.189 (7.65)	-2.476 (6.10)
	SOH	1.136 (7.65)	.833 (6.10)
	PP	-.045 (.23)	-.710 (3.42)

Source: Dreessen (1977) p. 63.

[7] An explanation of the abbreviations follows: DDD represents direct dialed calling, SOH stands for operator handled calls and PP is equivalent to person to person calls.

Although the results exhibit unrealistic parameter values and the wrong sign on some coefficients, they do demonstrate that disaggregate analysis provides estimated coefficients significantly different from zero. The elasticities do not show any consistent relationships between call classes or the type of call.

Rea and Lage (1978)

The U.S. demand for international telephone, telegraph and telex services is presented in this study. This paper is reviewed because it is one of the few articles which incorporates the price of potential substitutes. Pooled cross section (37 countries) and time series (yearly 1964 - 73) data are used for estimation. The dependent variables are the total number of sent messages modeled in logrithmic Ordinary Least Squares and Generalized Least Squares specifications. The independent variables are the average price of each service (PTP, PTX, PTG) divided by an implicit price deflator for U.S. gross national product (P), total disposable income (DISING) and the value of trade with each country (TRADE).

Table 9
Coefficients for U.S. - International Telephone Demand

Variable	OLS	GLS
TRADE	.357 (0.87)	.520 (0.58)
PTP	-.548 (.159)	-.725 (.156)
PTG	-3.171 (.309)	-2.933 (.300)
DISINC	2.971 (.192)	2.624 (.162)
$\bar{R}^2$	.964	.810

Source: Rea and Lage (1978) p. 370.

The price elasticity for long distance telephone service is inelastic using both methods while the income elasticities seem abnormally high. This is probably due to a failure to adjust both the income and trade variable into real terms. The most significant problem with this report is the authors definition of the price variables as an "unweighted" average of prices across all classes of service.

Bernstein (1980)

The theoretical and empirical evaluation of the demand for B.C. Tel services is presented as a section of this paper. Annual data from 1961 through 1977 was utilized to estimate the toll demand equation. A Box-Cox generalized demand function was derived to test for the appropriate functional form. Double log models without cross price effects provided the best first order approximation. Thereafter, the dependent variable was defined as the number of toll messages (SN). Explanatory variables included the average revenue per message (QN), gross provincial product of British Columbia (Y), the total number of telephones (SL) and a dichotomous dummy variable introduced to represent special events (DUM).

Table 10

Double Log Parameters for B.C. Toll Demand

Variable	Total Toll
QN	-.593 (-6.614)
Y	.972 (3.642)
SL	1.042 (2.842)
DUM	-.095 (-3.091)
R^{-2}	.998

Source: Bernstein (1980) p. 24.

As indicated above, all variables are statistically significant while the average price and income elasticities are both inelastic. Two factors render Bernstein's results rather questionable or inapplicable for decision making. First, the use of only sixteen data points is not sufficient to establish much faith in his results. Furthermore, the aggregation of all long distance call classes into one toll category reduces the number of meaningful uses that could have incorporated these estimates.

Johnston (1982)

This study is the most recent version of the intra B.C. toll demand model. The price elasticities for sixty-six different long distance telephone services are estimated using a log Koyck specification. Minutes per mainstation is the dependent variable. Independent variables were defined as deflated revenue per minute, real per capita personal disposable income, real per capita GDP and dummy variables to account for external shocks, e.g. postal strikes. A monthly data series (1973 - 1981) was developed and then seasonally adjusted using an X-11 procedure. The elasticities presented in this paper provide an easy reference for comparing the results developed later in the estimation section.

Table 11

Short Run Price Elasticities

Segments	Mileage Bands					
	0 - 10	11 - 25	26 - 50	51 - 100	100 - 300	300+
Residence:						
Mon - Fri	-.0315	-.1764	-.1551	-.2264	-.4321	-.746
DDD, Day	(-.59404)	(-2.55)	(-3.34)	(-3.83)	(-4.27)	(-4.92)
Residence						
Mon - Thu	-.9058	-.2720	-.2534	-.3587	-.3223	-.2639
DDD, Eve	(-1.1901)	(-2.66)	(-4.07)	(-4.14)	(-3.80)	(-3.76)
Residence:						
Fri	-.4215	-.7489	-.4325	-.6297	-.6983	-.5222
DDD, Eve	(-3.14)	(-5.36)	(-4.09)	(-5.70)	(-6.54)	(-6.45)
Residence:						
Sat	-.3799	-.0326	-.15847	-.3218	-.5071	-.5720
DDD, Day	(-3.34)	(-.76)	(-2.13)	(-3.39)	(-5.76)	(-6.37)
Residence:						
Sat	-.4365	-.6277	-.3443	-.7678	-.7086	-.5832
DDD, Eve	(-2.41)	(-4.83)	(-3.68)	(-5.84)	(-8.00)	(-7.24)
Residence:						
Sun	-.3635	-.4921	-.4109	-.6202	-.8275	-.86874
DDD, Day & Eve	(-2.84)	(-4.29)	(-4.08)	(-5.35)	(-7.33)	(-7.62)
Residence:						
Mon - Sun	-.5260	-.2851	-.2229	-.3313	-.223	-.6031
DDD, Late Night	(-4.74)	(-2.55)	(-2.23)	(-3.11)	(-2.36)	(-4.83)
Residence:						
Mon - Fri	-.7064	-.2022	-.1783	-.3975	-.2939	-.3146
SOH, Day	(-5.40)	(-3.09)	(-2.89)	(-3.42)	(-2.33)	(-2.54)
Residence:						
Mon - Fri	-1.15	-.3594	-.3148	-.5008	-.3819	-.4725
SOH, Eve	(-7.93)	(-3.63)	(-3.57)	(-4.74)	(-4.33)	(-4.60)
Business:						
Mon - Fri	-.7444	-.1611	-.1622	-.2088	-.1904	-.2309
DDD, Day	(-1.24)	(-2.02)	(3.13)	(-3.70)	(-2.77)	(-3.18)
Business:						
Mon - Fri	-.4734	-.1620	-.0189	-.0149	-.0013	-.0295
SOH, Day	(-4.40)	(-2.79)	(-.35)	(.-23)	(-.02)	(-.38)

Source: Johnston (1982) p. 23.

Table 12

Lagged Dependent Variable Coefficient

Segments	Mileage Bands					
	0 - 10	11 - 25	26 - 50	51 - 100	100 - 300	300+
Residence: Mon - Fri DDD, Day	.8115 (18.64)	.8611 (21.88)	.8773 (27.92)	.8554 (24.72)	.6819 (10.53)	.5992 (8.07)
Residence Mon - Thu DDD, Eve	.7893 (18.02)	.8006 (14.99)	.8237 (22.34)	.7503 (14.87)	.7218 (11.688)	-.7895 (14.285)
Residence: Fri DDD, Eve	.4458 (7.34)	.4082 (5.55)	.5745 (8.84)	.4768 (6.73)	.3642 (4.45)	.3702 (5.35)
Residence: Sat DDD, Day	.5292 (7.37)	.8239 (19.02)	.71047 (12.07)	.6308 (9.90)	.4986 (8.03)	.4115 (6.57)
Residence: Sat DDD, Eve	.3260 (3.76)	.4728 (7.12)	.6571 (11.21)	.3793 (5.14)	.3154 (4.97)	.3393 (5.45)
Residence: Sun DDD, Day & Eve	.5194 (7.47)	.6454 (10.84)	.6484 (10.71)	.5339 (8.14)	.3236 (4.19)	.2936 (3.67)
Residence: Mon - Sun DDD, Late Night	.5060 (6.80)	.7622 (11.87)	.8606 (15.52)	.7971 (14.44)	.7993 (12.44)	.5766 (7.20)
Residence: Mon - Fri SOH, Day	.5611 (8.73)	.8565 (23.34)	.8548 (21.85)	.7742 (14.87)	.7958 (13.59)	.7937 (14.84)
Residence: Mon - Fri SOH, Eve	.4329 (7.13)	.8288 (18.69)	.7471 (13.74)	.6290 (9.88)	.6342 (8.69)	.5778 (7.20)
Business: Mon - Fri DDD, Day	.7433 (16.74)	.7721 (13.48)	.7815 (15.85)	.7267 (14.35)	.7608 (12.58)	.7649 (13.12)
Business: Mon - Fri SOH, Day	.4551 (6.09)	.6411 (10.06)	.7766 (13.59)	.7875 (15.37)	.8861 (20.25)	.8884 (17.51)

Source: Johnston (1982) p. 24.

Several conclusions can be drawn from this analysis. Price elasticities increase with the length of haul and business segments are more inelastic than residential sectors. The disaggregation of toll traffic by class and mileage zone also appears to provide reasonable results. Problems with her paper include the unrealistic use of per capita GDP in the business segments and a data base which was inaccurate and in most cases required revison back to 1976.

In general, this selective review of the literature yields some important information. For example, price and income elasticities tend to be inelastic in the short run and become more elastic in the long run. This conclusion is consistent with economic theory and will be used to partially gauge the validity of this study's results. Other observations which were identified and are incorporated later include: 1) seasonally adjusting real economic data provided superior estimates, and 2) adjusting the dependent variable by the number of telephones accounted for the network externality and improved parameter estimates. For these reasons, a similar definition of variables appears to be desirable from an empirical standpoint.

The majority of publications also specify some form of a dynamic demand structure. Reading summaries and articles on thirty-eight different telephone demand inquiries showed that twenty-seven of these papers used either the flow adjustment or Koyck specifications to model the dynamic nature of telephone demand. In addition, a large number of articles provided evidence to the effect that a non-linear functional form produced the most robust results. The economic foundations upon which all these studies were based is discussed in the next section to obtain a more complete picture of the appropriate methodology for toll telephone demand analysis.

III. MODELLING INTRA B.C. TOLL DEMAND

III.1 Theoretical Relationships of Variables

Long distance telephone services can be distinguished by the time of call, the customer class, the method used to gain access to the network (whether directly dialed or operator assisted) and the length of haul (distance of a call). Based on these characteristics, twelve market segments and seven mileage zones were identified. The next step involved in estimating the demand for all these different toll services required a definition of the quantity to be explained. Several studies use the number of messages as the dependent variable. However, this measure of volume fails to consider the length of a conversation. Since the average duration of a call will have a significant impact on revenue, this paper uses minutes per main station to capture the effects of explanatory variables.[8]

Willingness to pay for telephone services will depend on several economic variables. A change in any of these observations would be reflected in a corresponding increase or decrease in the quantity demanded. In addition, the fundamentally different nature of business and residential long distance demand requires two separate demand specifications. Economic doctrine suggests the following relationships among variables.

[8] In a regulatory environment prices can be taken as exogenously determined and the minutes per main station would equal demand where excess capacity exists.

Prices

Given a change in telephone toll price, the quantity of service consumed would be expected to change in the opposite direction. This view is based on the assumption that long distance calling is either a normal or inferior good. The only exception which could occur is in a situation where some particular service is regarded by consumers as a status symbol.

To the extent that convenient substitutes are available, demand for minutes of long distance calling will be more elastic. Residential customers might consider letters, telegrams and meetings in the park viable substitutes. On the other hand, business organizations may find it difficult to operate with verbal committments alone. It is conceivable that they consider telephone service as a complement to their daily operations. Therefore, the price of any goods closely related to toll calls can be expected to have a direct impact on the quantity of service purchased.

Income

An increase in personal income would produce an immediate positive influence on the duration of phone conversations. Of course, this assumes that current rather than permanent income determines the number of toll minutes consumed. If the alternative hypothesis is accepted, lagged values of income which decline geometrically over time are included in the econometric model. Either approach seems reasonable. Previous estimation by many independent researchers has shown this variable to consistently obtain the expected sign and have a statistically significant coefficient using both methods.[9]

Preferences

Personal preferences form largely from habit. Therefore, it appears likely that the length of calls made next month will be at least partially determined by peoples consumption of telephone service this month. Perhaps of equal importance is the nature of the adjustment process. Buyers of telecommunication services seldom have perfect information on which to make quick decisions. Furthermore, once information does become avaiable the marginal costs of altering their current behavior increase with the speed of adjustment.

Population

Growth in the population of B.C. will also indirectly influence toll telephone demand. Assuming people would still purchase access to the telephone network even if only local service were available, the demand for access and long distance calling can be modeled separately.

[9] The income for business organizations may be represented in a similar manner. Given that the goal of firms is profit maximization, the number of minutes of toll calls used as an input to the production process will be directly related to some aggregate measure of business activity.

Then the demand for toll service will be an increasing function of the number of individuals which have already gained access to the network. Taylor (1980) explicitly recognizes this phenomenon and refers to it as a network externality. The more people that can be reached through the telephone system, all other things being held equal, the greater will be the demand for long distance services. It is appropriate at this point to mention the call externality. On every occassion when someone receives a telephone call, the opportunity cost of the time spent in conversation versus the satisfaction gained (lost) represents a positive or negative call externality. Throughout the rest of this analysis it is assumed the parties involved internalize the latter external effect. A simple explanation of how this might occur would be the rotation of calls between individuals.

General Considerations

Seasonality will affect the demand for long distance services. Holidays such as the New Year, Easter and Christmas clearly demonstrate regular seasonal trends in the residential sectors. Business demand shows a seasonal component with regard to the number of working days in weeks and months. A wide variety of dichotomous shocks have also been shown to have an impact on the dependent variable in almost every study estimating the demand for telephone services. Any such exogenous variables which can be identified certainly must be included to avoid misspecification of the demand for toll service.

The models developed by previous authors seldom estimate a simultaneous system of equations. In a normal market where price is determined by demand and supply considerations it would be incorrect to evaluate price as a pre-determined variable. However, British Columbia Telephone Company rates are set by the Canadian Radio-television and Telecommunications Commission and do not reflect the quantity of service provided. The supply of long distance capacity generally exceeds the demand for use in all market segments. Therefore, since peak capacity is greater than toll demand at the regulated price, a supply constraint need not be included in the econometric model.

Choosing between a static or dynamic framework of analysis should be linked to some reasonable behavioral assumption. Specifying the static model suggests that an alteration of an explanatory variable results in the immediate and complete response of the dependent variable in that time period alone. This restriction does not seem appropriate since the consequences of an exogenous change will be felt in later periods for reasons already discussed. Then the dynamic structure of demand, where the dependent variable is a function of its own lagged value, is the most realistic model specification.

III.2 Dynamic Models and Functional Form

There are three basic dynamic econometric models used throughout the literature. These are the Koyck, Stock Adjustment and Flow adjustment specifications. Each model is presented here with regard to its implicit assumptions and estimating form.

Koyck Model

The impact of an explanatory variable will be distributed over a number of time periods in the geometrically distributed lag model in which a series of lagged explanatory variables account for the time adjustment process. The weights of the lagged explanatory variables are assumed to be positive and decline geometrically over time, i.e.

3.2.1) $Q_t = \alpha + B\,(X + wX_{t-1} + w^2\, X_{t-2} + \ldots) + E_t$ $\quad 0<w<1$

While the effect of X on Q_t extends indefinitely into the past, the coefficients decline in a fixed proportion so that beyond a reasonable period the effect becomes negligible. By lagging equation 3.2.1 one period and multiplying by w:

3.2.2) $wQ_{t-1} = w\alpha + B(wX_{t-1} + w^2X_{t-1} + \ldots) + wE_{t-1}$

Subtracting equation 3.2.2 from 3.2.1 results in the Koyck model:

3.2.3) $Q_t = \alpha(1-w) + BX_t + wQ_{t-1} + (E_t - wE_{t-1})$

By using the geometric lag the Koyck transformation produces an estimating relationship that contains the independent variables in terms of their current values and the lagged value of the dependent variable.[10] Without using the Koyck model it is often very difficult to model this adjustment process because too many degrees of freedom are lost or the lagged values of explanatory variables are collinear with one other. The long run response of this specification with respect to an independent variable is simply the coefficient B times the sum of the lag weights or equivalently B/(1-w). This model postulates that individuals and firms adjust gradually to changes in economic conditions. Technological constraints or increasing costs of adjustment are often associated with durable goods. However, the distinction between demand for access and the demand for use can explain this phenomenon with regard to telephone service. In the short run customers would probably adjust their number of calling minutes based on the existing number of telephones. In the long run, the actual number of telephones will change affecting the total number of toll minutes purchased. Furthermore, habit formation will also cause inertia to affect the demand for long distance calling.

[10] Pindyck and Rubinfeld, Econometric Models and Economic Forecasts, (New York: McGraw-Hill, 1976) pp. 232 - 238.

Stock Adjustment Model

The Stock Adjustment model assumes that demand (Q_t) is dependent upon the current stock of the commodity (S_t), i.e.

3.2.4) $Q_t = \alpha + BS_t + \gamma X_t + E_t$

and

3.2.5) $\dot{S}_t = Q_t + \delta S_t$

Other current factors (X_t) also influence demand while past values are already incorporated in S_t. In any given time period, the actual value of Q_t may not adjust completely to the desired level. Since physical inventories of telephone minutes are impossible to observe, the second equation eliminates the variable by relating the change in the stock variable to current consumption and depreciation. The final estimating form of this equation, as described by H-T (1970) is:[11]

3.2.6) $Q_t = \gamma_0 + \gamma_1 Q_{t-1} + \gamma_2 \Delta X_t + \gamma_3 X_{t-1} + U_t$

This equation is approximately the same as the Koyck model if $\gamma_2 = \gamma_3$. However, the two models make different assumptions

[11]See Houthakker and Taylor for continuous time derivation in <u>Consumer Demand in the United States : Analysis and Projections</u>, (Cambridge: Harvard University Press, 1970) pp. 13 - 17.

about the error structure. In the Stock Adjustment model the error term is represented by a moving average process.

Flow Adjustment Model

The flow adjustment specification relies on a slightly different assumption of behavior. Rather than adjusting stocks of goods, consumers try to achieve some desired consumption level of a commodity. This model appears fundamentally more correct than the stock adjustment model because it does not use depreciation in its functional form. In the case of toll service demand, this requirement seems unjustified and theoretically unreasonable. The final estimation structure of the model is:

3.2.7) $Q_t = b_0 + b_1 Q_{t-1} + b_2(X_t + X_{t-1}) + E_t$

The decision to use logarithmic or linear notation can be based on the information provided in previous articles on the estimation of telecommunications demand. Several authors have addressed this question. For example, Corbo and Munasinghe choose logarithmic functions because they "possess the advantage that the magnitudes of the variables are considerably reduced, so that the assumption of equal variance of the random errors for each observation (homoscedasticity) is more plausible."[12] In addition, Bernstein has shown in his model of

[12] Corbo and Munasinghe, "The Demand for International Telecommunications Services and their Policy Implications", Telecommunications Journal, September 1978, p. 496.

British Columbia Telephone Company long distance demand that a double log specification without cross price effects provides the best first order approximation. Other authors have chosen the logarithmic form on the basis of a superior explained variation statistic. Since the log specification seems to be the generally accepted formulation of established theory, it will be used exclusively throughout this study.

An advantage in using this method is the elasticities can be interpreted directly from the regression equation, i.e.

3.2.8) $\delta \log Q / \delta \log X = X/Q \cdot \delta Q / \delta X$

Thus, log-linear functions assume the constant elasticity of Q with respect to X where;

3.2.8) $\log Q_t = a_o + a_1 \log Q_{t-1} + a_2 \log X_t + \ldots + E_t.$

However, it should be noted that the implicit assumption of constant elasticities is convenient and not necessarily justified by economic theory. Elasticities should vary across periods with movements along and shifts of demand curves. Whether this assumption is correct will be the subject of further investigation later in this paper.

III.3 Estimation Problems

Autocorrelation

An issue associated with the estimation of a dynamic model is the problem of serially correlated errors. When the error terms in a model that includes a lagged dependent variable are autocorrelated the coefficient estimates will be biased, inconsistent and inefficient. Most studies give insufficient attention to this problem and often report the standard Durbin Watson test statistic. However, when a lagged dependent variable is contained in the equation this test is inappropriate because it will be biased against finding either negative or positive first order autocorrelation. Durbin (1970) has shown that the h - statistic holds for large samples and can be used instead to test for serial correlation. This statistic is defined as:

3.3.1) $$h = \left(1 - \frac{D.W.}{2}\right)\sqrt{\frac{N}{1 - N[\mathrm{Var}(\hat{\beta})]}}$$

where D.W. = the standard Durbin Watson statistic

N = the sample size

$\mathrm{Var}(\hat{\beta})$ = the estimated variance of the coefficient of the lagged dependent variable.

Since the h statistic is distributed normally with unit variance the test for autocorrelation can be performed using the normal distribution.

Multicolinearity

Multicolinearity can also cause estimation problems. When two or more explanatory variables are highly correlated it becomes impossible to identify and interpret the separate effects of their coefficients on the endogenous variable. If the collinearity is caused by a fixed structural relationship, the least important variable may be dropped from the equation while the other captures the effect of the omitted variable. For example, if income is correlated with promotion expenditures, advertising rather than income should be dropped from the model. A moving regression will be used to test for multicolinearity because given its presence, the estimated coefficients will be sensitive to data ommissions and additions. Specifically, one quarter of the observations will be dropped and another added starting with the first five year sample period.

III.4 Model Specification

The economic theory of long distance telephone demand and the majority of research conducted by individuals in the past suggest the following model specifications. In addition, the data requirements of British Columbia Telephone Company necessarily resulted in these functional forms. Its computer reprice program, which was developed after several years of effort, requires four basic inputs. These include a data base, forecast, rate schedule and price elasticities. The data base is updated monthly by MIS; the forecast is generated by Forecasting; the rate schedule is determined by Product Management and the components of the long run price elasticities are supplied by the Costs, Prices and Economics department. The Canadian Radio-television and Telecommunications Commission uses the information provided by this model to evaluate rate increase applications and the effect of price changes on the Company's revenue.[13]

Data characteristics which are considered essential are:

i) price, income, main stations and a lagged endogenous variable,

ii) all economic variables be converted into real terms,[14]

iii) the data series be adjusted for seasonality and exogenous shocks.

13 Canadian Radio-television and Telecommunications Commission, Telephone Decision CRTC 81-3, January 1981, p. 72.

14 It should be noted explicitly that this adjustment assumes the absence of money illusion.

The residential equations which were estimated are:

Log Koyck

3.4.1) $\log(MIN_t/RESTA_t) = b_o + b_1\log(MIN_{t-1}/RESTA_{t-1}) +$
$b_2\log[NPDIBC_t/(POPBC_t \times CPIVAN_t)] +$
$b_3\log[REV_t/(MIN_t \times CPIVAN_t)] +$
$b_4PS_t + b_5TS_t + b_6DUM_t + E_t$

Flow Adjustment (Log)

3.4.2) $\log(MIN_t/RESTA_t) = b_o + b_1\log(MIN_{t-1}/RESTA_{t-1}) +$
$b_2[\log(NPDIBC_t/(POPBC_t \times CPIVAN_t)) +$
$\log(NPDIBC_{t-1}/(POPBC_{t-1} \times CPIVAN_{t-1}))] +$
$b_3[\log(REV_t/(MIN_t \times CPIVAN_t) +$
$\log(REV_{t-1}/(MIN_{t-1} \times CPIVAN_{t-1}))] +$
$b_4PS_t + b_5TS_t + b_6DUM_t + E_t$

The business equations which were estimated are:

Log Koyck

3.4.3) $\log(MIN_t/BUSTA_t) = b_o + b_1\log(MIN_{t-1}/BUSTA_{t-1}) +$
$b_2\log(RGDPBC_t/PGDPBC_t) +$
$b_3\log[REV_t/(MIN_t \times PGDPBC_t)] +$
$b_4PS_t + b_5TS_t + b_6DUM_t + E_t$

Flow Adjustment (Log)

3.4.4) $\log MIN_t/BUSTA_t = b_o + b_1 \log(MIN_{t-1}/BUSTA_{t-1}) +$
$b_2[\log(RGDPBC_t/PGDPBC_t) +$
$\log(RGDPBC_{t-1}/PGDPBC_{t-1})] +$
$b_3 [\log(REV_t/(MIN_t \times PGDPBC_t)) +$
$\log(REV_{t-1}/(MIN_{t-1} \times PGDPBC_{t-1}))] +$
$b_4 PS_t + b_5 TS_t + b_6 DUM_t + E_t$

Where MIN/RESTA = minutes per residential main station,

MIN/BUSTA = minutes per business main station,

NPDIBC = nominal personal disposbale income for British Columbia

RGDPBC = real gross provincial product for B.C.

POPBC = population of B.C.,

CPIVAN = Vancouver consumer price index,

PGDPBC = implicit GDP deflator for B.C.

REV = total revenue,

PS = postal strikes,

TS = telephone strikes,

DUM = a dummy variable for structural changes, and

E = an error term with classical properties.

The results of the logrithmic Koyck model are reported here. This decision was made based on the superior performance of the model with regard to the signs and significance of coefficients.

IV. EMPIRICAL RESULTS

IV.1 Definition of Variables

In the previous section, the variables which should theoretically influence the demand for long distance telephone services were presented. Although some variables proved to be important in explaining the dependent variable, others were only of minor significance. However, all variables which could be identified were kept in the model to avoid misspecification of the demand for toll services. The following discussion of the source of the telephone data is included here for convenience and clarity.

The Toll Sample Array (TSA) file accumulates the monthly number of messages, minutes, revenue and average miles for five classifications of telephone calls placed in British Columbia. These categories are: 1) Alberta, 2) Trans Canada, 3) U.S., 4) Intra-B.C. and 5) Overseas. This data base is then further broken down by the time, type and originating class of telephone calls. Of course, the variables contained in this study are defined only in terms of the information contained in the Intra-B.C. segments.[15] An explanation of the derivation of these variables is presented in the rest of this section.

15 Complete documentation of all these variables and the procedures used to obtain them can be found in the appendix.

Quantity

Monthly minutes per main station is the dependent variable analyzed in this study. Minutes as the measure of volume will be the same quantity in all periods and have a direct relationship with the price variable. This occurs because consumer's costs are duration sensitive. Alternative choices for the dependent variable fail to meet either one or both of these criteria. The network externality is treated explicitly by normalizing minutes by the number of main stations. Besides allowing disaggregate analysis, this procedure is implicitly the same as adjusting each of the independent variables by the size of the telephone system. Since the definition of the stock of telephones differs between the residential and business sectors, their components are described separately. Residence main stations include individual, multi party, foreign exchange and toll stations. The number of business main stations is composed of Centrex, PBX, PABX, Measured, Watts, extension, multi-party and individual lines. In addition, disaggregation by the distance of calls was accomplished to account for the fact that prices are also sensitive to the length of haul. Based on these distinctions, the demand for the dependent variable was estimated for several call categories.

Price

Real revenue per minute was used as a measure of price. Total revenue was disaggregated by mileage zone and the type of call to obtain figures corresponding to the toll services estimated. Moreover, using the Vancouver consumer price index as a deflator implicitly considers the price of related goods. The ommission of actual price indexes for potential substitues and complements was unavoidable because such data was not available. Although some measure of price must be included in the estimation of the demand for service, the average real revenue per minute includes both surcharge and duration components. This implies consumers do not distinguish between these separate prices and only react to the aggregate information provided in their phone bill.

Income

Two different income variables were used to estimate the demand for toll services. For the residence equations per capita personal disposal income was employed. Since per capita income is derived from aggregate information it can be somewhat misleading. For example, average income levels in Victoria and Vancouver differ from those experienced in rural areas. This variable was used, however, because the telephone data does not distinguish between the origins of separate calls. Estimation using this explanatory variable implicitly assumes the existence of an average individual.

In the business segments, Real Gross Domestic Product for B.C. was used as an income variable. Since this measure incorporates the value of products produced in British Columbia it provides an aggregate view of business income. Further disaggregation was not attempted because the representation of an average business did not appear reasonable or necessary.

Dummy Variables

Several independent variables were included in the model for exogenous shocks. These dichotomous variables (o or 1) represented postal strikes, B.C. Telephone Company strikes and a structural change in the rate schedule. Normally, postal service is not considered a substitute for toll service. This assumption is based on the different characteristics of a phone call and a letter. The latter requires a significant amount of preparation and is essentially one way communication. However, during a postal strike toll services are a reasonable substitute and as such would exert a postitive influence on long distance telephone demand. On the other hand, a negative impact on the number of minutes per main station could be expected during a B.C. Telephone Company strike. Strikes at Okanagan Telephone Company were included in this variable by assigning them a value associated with its percentage volume of B.C. Telephone Company's total output. The evening discount was changed from 6:00 p.m. - 11:00 p.m. to 5:00 p.m. - 11:00 p.m. in January 1975. This resulted in an increase in evening volume and a corresponding decrease in day traffic. Therefore, months after January 1975 were assigned a value of zero while those preceding this date were given a value of one.

Seasonal Adjustments

As discussed earlier, seasonality and trading day variations should effect the demand for long distance services. A preliminary test using dummy variables did indeed show a significant relationship for both these phenomenon. For this reason, appropriate adjustments were made on all the economic variables using the Census Bureau X-II method.

IV.2 Estimation

The log Koyck model described previously was used to determine the demand for 84 toll services within British Columbia. Zellner estimation was also utilized on some segments to improve the efficiency of parameter estimates by accounting for the correlation of error terms across equations.[16] In the business day and late night residence segments Ordinary Least Squares regression was applied to obtain unbiased and consistent results. The following six groups were identified for the purposes of this study.

Group	Segment	Market
1	1 - 3	Residence : Week
2	4 - 6	Residence : Week End
3	7	Residence : Late Night
4	8 - 9	Residence : Operator Handled
5	10	Business : Day
6	11 - 12	Business : Operator Handled

16 This correlation occurs due to the fact that a low prediction in one service market guarantees an overestimate in another call category. The sum of the dependent variables must equal the total number of observations before segmentation. See Zellner in "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", Journal of the American Statistical Association, vol. 57 (1962) pp. 348 - 368.

Appendix Tables 14 through 17 provide a summary of the short run paramenter estimates of the price elasticities and lagged endogenous variables for two different sample periods. The first two tables cover the entire data base (1973 - 1982) while the last two encompass the second half of the sample (1978 - 1982). A comparison of these results will be made with regard to their summary statistics and the revenue implications of the elasticity estimates.

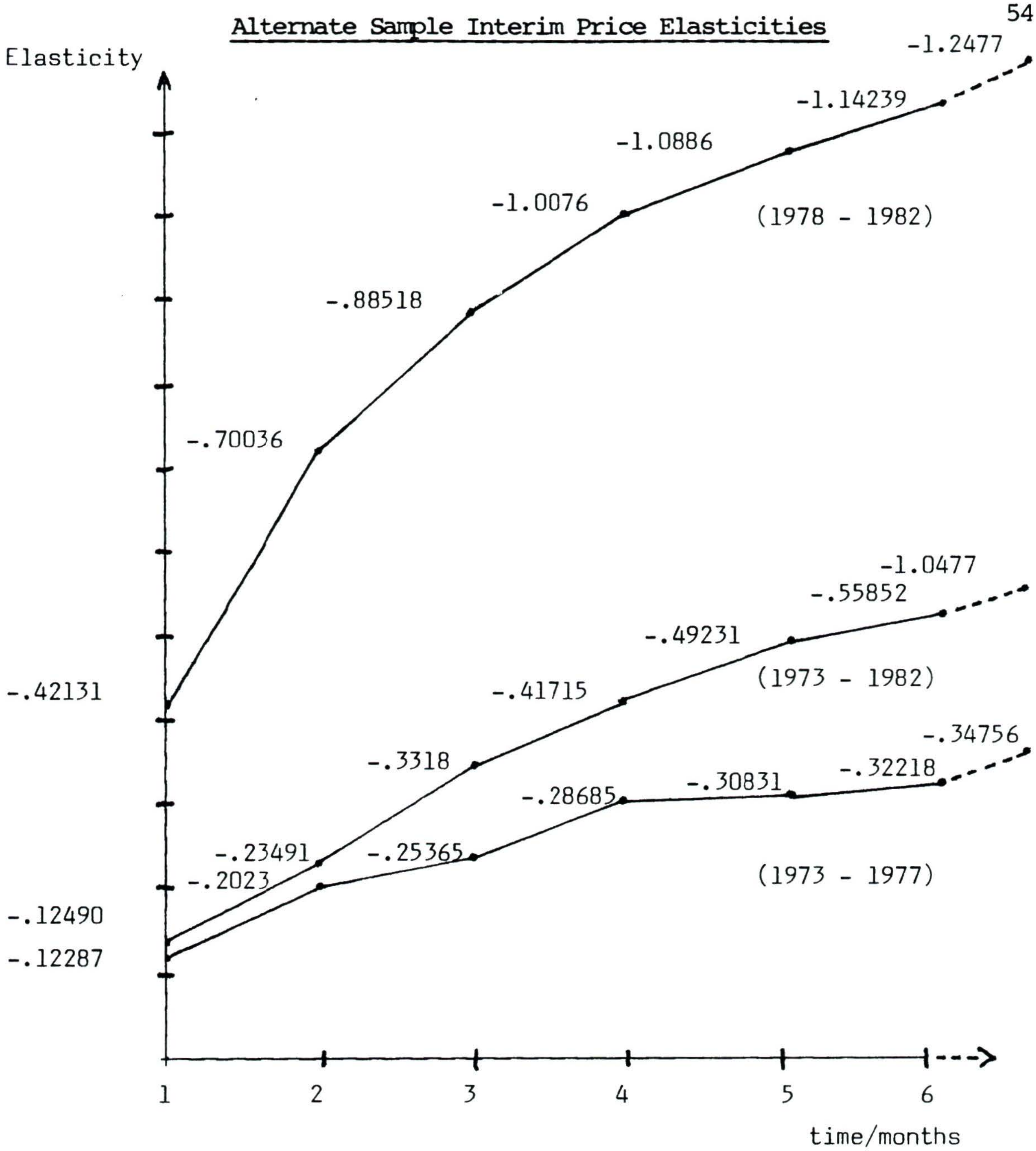
Summary Statistics Review

The coefficients of determination, R^2, varied between a low value of .61 to a high of .99. Thus, the explained variation statistics indicate this functional format provides a good representation of the dependent variables variation which can be explained by the independent variables for both estimation periods. Coefficients of the price variable possess the expected sign in seventy-six of the market sectors contained in the entire sample. However, only fifty-nine cells are significant at a five percent level of confidence. Of those which are insignificant, most occurred in the business and operator handled segments. The lagged dependent variable coefficients are significant in all cells and consistently exhibit the correct sign. As for the short sample, six of the eighty-four price coefficients demonstrated perverse signs which were insignificant. Seven lagged endogenous variables also do not conform with prior expectations while thirty-two sectors are insignificant. These results were concentrated in the residential segments.

The Durbin h-test for serial correlation had mixed results. In forty five percent of the estimated sectors the alternative hypothesis of first order serial correlation could not be rejected. This problem was most severe in the estimation of the entire sample period. Corrections were not attempted due to the nature of the information this study must provide for B.C. Telephone Company's toll reprice model, e.g. short run price elasticities and the coefficients of the lagged dependent variables. However, an iterative search procedure can be used to estimate the serial correlation coefficient in the Koyck model and choose the value which minimizes the error sum of squares. Then the transformed equation can be estimated using Generalized Least Squares regression.[17] Besides being quite expensive, this method results in the loss of an interpretable coefficient for the lagged dependent variable.

In most of the sectors, plots of the residuals exhibited random patterns and led to the conclusion that hetroscedasticity was not a serious problem. A general pattern, however, emerged from the results of the moving regression. The estimated coefficients were relatively stable but the price elasticities showed a persistent trend to become more elastic as the adjustment period shortened. For example, consider a major revenue generating sector in the business day segment, mileage zone 51 - 100. The following graph illustrates the price elasticities of three sample periods.

[17] For a discussion of the estimation of distributed lag models under several assumptions about the error process refer to Zellner and Geisel, "Analysis of Distributed Lag Models with Applications to Consumption Function Estimation." Econometrica, vol. 38 (November 1970) pp. 865 - 887.



Gradually over time the level of toll minutes purchased adjusts to a new consumption level if long distance rates are changed. This modification will occur due to the coefficient on the lagged dependent variable. The combined effects of this parameter and the short run price elasticity determine the impact on revenue of any price alterations. In the first month, the new quantity reflects only the short run price elasticity. However, in consecutive periods the consumer response factor with the short run price elasticity influence the number of calling minutes in an exponentially increasing manner. By depicting this phenomenon graphically, the revenue implications of alternative elasticities can be directly compared.

Revenue Implications

Even though the long run elasticities for the entire sample (1973 - 1982) and the last five year sample (1978 - 1982) are both elastic, their short term effects could be very different. Often product managers are faced with the problem of generating additional revenue in the immediate future. Estimation across the entire sample period suggests this need could be met by raising the toll price in this segment. However, using the alternate sample indicates customers will react much sooner and total revenue would remain basically the same. If the first five years data is used to estimate the price elasticity of demand, (1973 - 1977), the resulting parameter is inelastic in the long run and revenue would increase.

The above findings appear to indicate that the sample period covers a transitionary phase in consumer behavior. Whether this is just a temporary adjustment due to economic conditions or a permanent alteration in the demand for toll services can only be investigated with the addition of future observations in the data base.[18] A plausible cause of a shift in demand could be the recent recession. Then the inclusion of information after this period would allow the investigation of the extent and magnitude of any changes in consumer preferences. Specifically, a shift in business demand is reasonable from the stand point of changing economic climate and firms generally superior information on which to make decisions. Rapid adjustment of profit maximizing enterprises to new conditions would not be very surprising.

Shifts of demand are not necessarily the only factor which could cause increasing elasticities. The assumption of constant elasticities may not be valid and would therefore result in an incorrect model specification.[19] Consumers might be more sensitive to a price change at a higher price level. For example, a higher price elastiticity for operator handled calls could reflect a movement along the demand curve. This behaviour would simply take into account the rather extreme price increase in the surcharge component. Since 1978 the surcharge rate has increased from 35¢ to $2.00 for person to person calls and from 35¢ to $1.00 for other types of operator handled messages.

[18] The problem of specifying a model where structural change occurs gradually over a known transition period is discussed by Beach in "An alternative approach to the specification of structural transition functions", The Canadian Journal of Economics (February 1977) pp. 133 - 141.

[19] Unfortunately, the investigation of alternative functional forms is outside the scope of this study.

Structural Test

To further investigate whether there has been a change in the underlying structure of long distance telephone demand, a Chow test of the null hypothesis of identical demand equations was performed by using observations associated with different sample periods. Table 18 in the Appendix illustrates the results of the Chow test. An F statistic is provided in the far right column. Seventy-seven percent of the sectors show a significant difference between the restricted and unrestricted error sum of squares. This effect was concentrated in the business and operator handled segments.

Long Run Price Elasticities

The long run price elasticities for these segments were calculated from the information contained in the sample period from 1978 through 1982. This was done for the following reasons. First, a higher proportion of the estimated coefficients had the correct sign and were statistically significant than those in the entire sample. A wider range of data variation also makes the later estimation period reasonable. In 1981, the business income series, real GDP, decreased for the first time in the entire sample period. As indicated earlier, the elasticity estimates appear to increase over time. Thus, estimates using the second sample period seem more appropriate.

Where significant differences have been identified, the conclusions presented are based on theoretical expectations. Estimates of the long run price elasticities of demand are contained in Appendix Table 19. When the short run coefficients were perverse and not statistically different from zero they have been assigned that value for the reprice model's purposes. Although a zero price elasticity does not correctly represent consumer response to price changes, it is certainly more justified than assigning some arbitrary value.

IV.3 Price Elasticity Applications

Relationship to Previous Research

The estimated long run price elasticities differ from the results of previous research in two areas. First, most authors have found elasticities become more elastic with the distance of calls. Such a consistent pattern is not visible in any of the market segments estimated in this paper. Price changes may provide a plausible explanation for this result. Rate increases for long distance traffic have been proportionally higher for smaller distances in the past several years. For example, from 1980 to 1982 message rates for the shortest mileage band jumped over thirteen percent while those in the furthest zones increased only three percent. B.C. Telephone Company has obviously been using the elasticity estimates generated by earlier internal research to meet additional revenue requirements from inelastic market sectors which were identified. This application of price elasticities demonstrates that the reprice model can be used as a tool for planning new rate schedules.

Another point of divergence in the long run price elasticities can be seen in the business segment. Business demand for toll service was less elastic than residential demand in prior company studies. This finding cannot be verified based on the calculated elasticities in Table 19 of the Appendix. A change in the income variable could have caused this result. Nominal and real gross domestic product for B.C. required substantial revisions from the estimates utilized in earlier internal research. As a consequence, the implicit GDP deflator was altered. This changed the relative value of the price variable when it was adjusted into real terms.

Reprice Model

The model basically takes the previous years minute data and prices it under a new rate structure. Then the elasticities and market forecasts are applied to obtain the associated new revenue. However, there are several problem areas which should be noted. The average revenue per minute includes both duration and surcharge components. Since the average number of miles in a certain call category often changes across observations, the duration charge which is based on mileage will vary. Then the surcharge can cause the implicit price to change when there has not been any alteration in the rate structure. Plots of the price variable confirm this effect. In fact, as the mileage bands became wider, with a greater realm for variability, the implicit price oscillated randomly. Another more subtle observation can be made with regard to how the model is used. The intention behind the development of the reprice model was to use its output as a guide for maximizing profit. This goal cannot be achieved without some knowledge of the cost structure of message toll services. Even if the results of this study had not been hindered by estimation problems, policy statements could not have been made on anything but revenue maximization unless the costs of different services were available.

The cummulative effects of the price elasticities produced in this report are summarized by the reprice model. By including the recent recessionary period in the data base, the elasticities for business and operator handled traffic were found to be elastic on average. The impact of these results on revenue are illustrated in the following table which uses the three percent rate award and the seven percent sales tax.

Table 13

Cummulative Impact of Elasticities on Revenue

	1983 July - December	1984
Residence:		
Price change	10.4%	10.4%
Received Revenue	2.3%	- .2%
Received Revenue net of tax	-4.4%	- 5.9%
Business:		
Price change	10.8%	10.8%
Received Revenue	-1.0%	- 4.3%
Received Revenue net of tax	-7.5%	- 9.6%
Total:		
Price change	10.6%	10.6%
Received Revenue	.9%	- 1.9%
Received Revenue net of tax	-5.7%	- 7.5%

A major difference between this result and Table 1 of the introduction can be seen in the business group. Because general pricing strategy would shift dramatically using this new information, a linear hypothesis test was conducted on the coefficients of the lagged dependent variables and the short run price elasticities in the business day segment. Minus one is the critical value of an elasticity used for revenue maximization. Therefore, the null hypothesis was

$$H_o : \beta - w = -1.$$

In all cases but the shortest mileage zone, the calculated F statistic confirms that the long run elasticity was significantly greater than unitary elastic. On average, positive increments in revenue could not be achieved by raising all business toll prices.

It must be stressed that this analysis isolates the price effect and holds all other determinants of demand constant. A corresponding increase in income would cause approximately twice the revenue change in the opposite direction due to its very elastic positive coefficients.

V. CONCLUSION

The objective of this paper has been to produce and evaluate estimates of the price elasticities of demand for eighty-four toll services. Detailed market segmentation provides an effective tool for rate structure design. For this reason, the information produced by the model used in this study can be useful to decision makers at British Columbia Telephone Company. The market segments included in the data base make up approximately eighty-two percent of the revenue and toll volume for intra B.C. calling. However, the reprice model should be modified so it can accept a more flexible form of input. This would allow the exploration of alternative functional forms which could alleviate the problems encountered in estimation and provide more robust results. Another improvement could be made in the data used to estimate the model. The implicity defined prices could be replaced with an index of the price for each type of call which separates the toll and surcharge components. This would eliminate the correspondence between the surcharge component of the price variable and the distance of calls. Normalizing revenue per minute by the average mileage of calls could also rectify this problem.

A log Koyck specification, using Zellner's Seemingly Unrelated Regression technique, was used to model the dependent variable minutes per main station. Evidence was obtained which led to the conclusion that this functional form fitted the data better than the flow adjustment model. In most cases, the results of estimation are reasonable. The majority of equations passed standard statistical tests for hetroscedasticity, autocorrelation and multicollinearity. The general tendencies exhibited by the calculated elasticities are also in line with a priori theoretical expectations. Demand for long distance calls appears to be inelastic in the short run while in the long run it becomes elastic for almost all call categories. A comparison with the estimates of previous internal research showed the most recent business elasticities have increased in magnitude. This result is probably due to the wider variability in the business income series caused by the recession. The better data incorporated in the model should therefore provide richer information on the nature of long distance telephone demand.

There are some qualifications of the parameter estimates which should be considered. Lag times of over three years in some sectors of the reprice model confirm autocorrelation is a problem in several market segments. More than a six period lag time for most consumer adjustments seems unreasonable. The assumption of constant elasticities is also questionable and would reduce the efficiency of parameter estimates if it was found to be invalid. Furthermore, fundamental changes in demand have been identified by a Chow test. Additional research will be necessary to determine whether this phenomenon is permanent or not. However, one policy implication for British Columbia Telephone Company still remains clear. Proposing real toll rate increases in the near future would not be in the Company's best interest from a revenue maximizing perspective.

On the other hand, the CRTC should certainly reevaluate its position on how telecommunication costs are allocated. As technology, consumer preferences and the competitive environment change, further cross subsidization of local residential service by toll markets will be unfeasible. A recognition that the public interest could be better served by marginal cost pricing would not require a new definition of the Commission's objectives. To the contrary, this pricing policy is consistent with the economic criteria for maximizing consumer welfare. Although separating the joint costs of production poses some technical problems, this strategy can be accomplished with assistance from the B.C. Telephone Company. Such user service costing would provide an efficient alternative for allocating this scarce resource.

BIBLIOGRAPHY

Athanassious, Stylianos K. "Statistical Analysis of Demand for Telecommunications Services in Greece." Telecommunciations Journal (April 1974): 244 - 253.

B.C. Telephone Company. Fact Book June 1981.

Beach, Charlie M. "An Alternative Approach to the Specification of Structural Transition Functions." The Canadian Journal of Economics (February 1977): 131 - 141.

Bell Canada. "Econometric Models of Demand for Selected Bell Canada Services." Response to CRTC Interrogatory Bell 03 April 80 - 809 1980.

Bernstein, Jeffrey I. "A Corporate Econometric Model of the British Columbia Telephone Company." forthcoming in O. Anderson (ed.) Public Utilities North Holland, 1980.

Carr, Jack. "Demand and Cost: An Empirical Study of Bell Telephone in Canada." Telecommunications for Canada (H. English, ed.) Methuen: Agincourt, 1973.

Chen, Albert M. and Black, R.J. "The Demand for Long Distance Telephone Service: A Case Study." General Telephone Company of the Northwest Inc., May 1976.

Corbo, Vittorio and Mohan, Munasinghe "The Demand for International Telecommuncations Services and their Policy Implications." Telecommunications Journal (September 1978): 493 - 503.

Cracknell, David. "Econometric Models of Inland Trunk Calls." Telecommunications Journal (September 1978): 482 - 486.

Craver, R.F. "An Estimate of the Price Elasticity of Demand for International Telecommunications." Telecommunications Journal (November, 1976): 671 - 675.

CRTC. Telecom Decision CRTC 81-3 Ottawa, 29 January 1981.

CRTC. Telecom Decision CRTC 82-8 Ottawa, 22 June 1983.

Davis, B., Caccappoli, G.J., and Chaudry, M.A. "An Econometric Planning Model for American Telephone and Telegraph Company." The Bell Journal of Economics and Management Science (Spring 1973): 19 - 56.

Dobell, A.R., Taylor, L.P., Waverman, L., Liu, T.H., and Copeland, M.D. "Telephone Communications in Canada: Demand Production and Investment Decisions." The Bell Journal of Economics and Management Science (Spring 1972): 175 - 219.

Dreessen, Erwin. "The Demand for Intra-B.C. Toll Calling." B.C. Telephone Company, July 1977.

Dreessen, Erwin. "Aggregate Demand for L - D Intra Provincial Calling: Estimates and Forecasts, 1971 - 1977." B.C. Telephone Company, June 1978.

Dreessen, Erwin. "Elasticity Is ... A disaggregate analysis of Intra-B.C. toll calling, 1973 - 1978." B.C. Telephone Company, September 1979.

Durbin J. "Testing for Serial Correlation in Least Squares Regressions when Some of the Regressors are Lagged Dependent Variables." Econometrica (May 1970): 410 - 421.

Fontenay, A., Gorham, D., Lee, M. and Manning, G. "Stochastic Demand for a Continium of Goods and Services." B.C. Telephone Company, December 1982.

Houthakker, Hendrik S. and Taylor, Lester D. Consumer Demand in the United States: Analysis and Projections Cambridge: Harvard University Press, 1970.

Johnston, J. "Intra B.C. Toll Tariffs from 1973 to 1982." B.C. Telephone Company, 9 November 1982.

Johnston, J. "Re-Estimation of the Intra-B.C. Toll Demand Model." B.C. Telephone Company, June 1982.

Khadem, R. "An Econometric Study of the Demand for TransCanada Long Distance Telephone Service." TransCanada Special Studies, June 1973.

Lago, Armando M. "Demand Forecasting Models of International Telecommunications and their Policy Implications." Journal of Industrial Economics (November 1970):

Luke, C.H. and Yatrakis, P.G. "A Computer-Based Econometric Model of Demand for Telephone Communications Between Hawaii and the United States Mainland." Telecommunications Journal (November 1971): 743 - 746.

Naleszkiewicz, Wladimir. "International Telecommunications - Testing a Forecasting Model of Demand." Telecommunications Journal (September 1970): 635 - 638.

Piekaar, E. "The Intra B.C. Demand Model - Further Developments." B.C. Telephone Company, 1980.

Pindyck, R.S. and Rubinfeld, D.L. Econometric Models and Economic Forecasts New York: McGraw-Hill, 1976.

Rea, J. and Lage G.M. "Estimates of Demand Elasticities for International Telecommunications Services." Journal of Industrial Economics (June 1978): 363 - 381.

Rohlfs, Jeffrey. "A Theory of Interdependent Demand for a Communications Service." The Bell Journal of Economics and Management Science (Spring 1974): 16 - 37.

Squire, Lyn. "Some Aspects of Optimal Pricing for Telecommunicaitons." The Bell Journal of Economics and Management Science (Autumn 1973): 515 - 525.

Taylor, Lester D. Telecommunication Demand: A Survey and Critique Cambridge: Ballinger Publishing Company, 1980.

"Deluge of Legislation Creates Bedlam in House." Vancouver (B.C.) The Sun (22 June, 1983): A2.

Theil, Henri. Applied Economic Forecasting Amsterdam: North Holland, 1966.

Ware, H.G. and Siddons, M.R. Memorandum B.C. Telephone Company, 12 July 1983.

Waverman, Leonard. "The Demand for Trunk Telephone Services in Great Britain: the Significance of Quality Change." Institute for the Quantitative Analysis of Social and Economic Policy: University of Toronto Working Paper 7308, December 1973.

Yatrakis, P.G. "Determinants of the Demand for International Telecommunications." Telecommunications Journal (December 1972): 732 - 746.

Zellner Arnold. "An Efficient Method of Estimating Seemingly Unrelated Regression and Tests for Aggregation Bias." Journal of the American Statistical Association vol. 57 (1962): 348 - 368.

Zellner, A., and Geisel, M. "Analysis of Distributed Lag Models with Applications to Consumption Function Estimation." Econometrica vol. 38 (November 1970): 865 - 888.

APPENDIX A

Econmon File for 1982
(12 observations, 6 variables)

YYMM	POPBC	RGDPBC	NPDIBC	PGDPBC	CPIVAN
8201	2771.3	1283.2	2385.8	2.697	2.543
8202	2774.3	1281.0	2403.5	2.713	2.558
8203	2776.0	1288.5	2460.4	2.719	2.576
8204	2777.2	1255.0	2466.2	2.732	2.593
8205	2781.1	1287.0	2490.3	2.759	2.629
8206	2784.0	1289.2	2531.7	2.770	2.644
8207	2785.9	1263.9	2351.7	2.790	2.657
8208	2788.0	1261.8	2193.3	2.821	2.677
8209	2790.2	1220.0	2459.8	2.836	2.687
8210	2792.4	1284.7	2477.8	2.859	2.700
8211	2794.0	1260.5	2448.1	2.879	2.711
8212	2795.6	1249.5	2362.4	2.868	2.705

YYMM - Year and month of observation.

POPBC - Monthly population of B. C. (in thousands) was derived from the quarterly population of B. C. (Matrix Series D11). The monthly patterns of population growth of persons over age 15, Cansim Matrix 2096 Series D769174 (men) and Series D769181 (women) were applied in the following manner.

1) Add series D769174 and D769181.
2) Calculate the quarterly change in the series, e.g. $\Delta = P_{8204} - P_{8201}$.
3) Calculate the monthly change within each quarter, e.g. $\partial = P_{8202} - P_{8201}$.
4) Calculate the proportion of each month's change to the change in that quarter, i.e. ∂/Δ
5) Using the quarterly series (note: observations are the first month of quarter) calculate the difference from quarter to quarter, e.g. $D = P_{82II} - P_{82I}$.
6) Multiply D by ∂/Δ to get the increase over the previous month; then add this figure to the last months observation, e.g.

	1) D769174	+ D769181	=	Sum	2) Δ	3) ∂	4) ∂ / Δ
P8201	1027	1065	=	2092	-	-	-
P8202	1030	1067	=	2097		5	.5000
P8203	1031	1069	=	2100		3	.3000
P8204	1032	1070	=	2102	10	2	.2000
P8205	1034	1072	=	2106		4	.4444
P8206	1035	1074	=	2109		3	.3333
P8207	1036	1075	=	2111	9	2	.2222
P8208	1037	1076	=	2113		2	.3333
P8209	1038	1077	=	2115		2	.3333
P8210	1039	1078	=	2117	6	2	.3333
P8211	1039	1079	=	2118		1	.2000
P8212	1040	1079	=	2119		1	.2000
P8301	1041	1081	=	2122	5	3	.6000

5) Series D11		D
P82I	- 2771.3	-
P82II	- 2777.2	5.9
P82III	- 2785.9	8.7
P82IV	- 2792.4	6.5
P83I	- 2800.5	8.1

6) POPBC - monthly

8201	- 2771.3	8207	- 2785.9
8202	- 2774.3	8208	- 2788.0
8203	- 2776.0	8209	- 2790.2
8204	- 2777.2	8210	- 2792.4
8205	- 2781.1	8211	- 2794.0
8206	- 2784.0	8212	- 2795.6

RGDPBC - Real gross domestic product of B. C. at market prices (in millions of $1971) was obtained in an annual series from the Central Statistics Bureau prior to 1979. A quarterly series from 1979 through 1982 was obtained from the Costs, Prices and Economics department of B. C. Telephone Company. Both series were redistributed using the monthly patterns of employment for persons over age 15 in B. C. The source of the latter information is Cansim matrix 2096, series D769176 (men) and D769183 (women). This was accomplished by the following procedure.

1) Add series D769176 and D769183.
2) Total these monthly observations to obtain quarterly aggregates.
3) Divide the monthly observations by the appropriate quarter.
4) Multiply this ratio times the quarterly real gross domestic product for monthly observations.

	1) D769176	+ D769183 =		Empi	2) $\sum_{i=1}^{3}$ Empi	3) Empi / $\sum_{i=1}^{3}$ Empi
E8201	697	497	=	1194		.33305
E8202	700	492	=	1192	3585	.33250
E8203	697	502	=	1199		.33445
E8204	691	485	=	1176		.32758
E8205	705	501	=	1206	3590	.33593
E8206	704	504	=	1208		.33649
E8207	705	502	=	1207		.33556
E8208	706	499	=	1205	3597	.33500
E8209	679	486	=	1165		.32388
E8210	675	493	=	1168		.33855
E8211	662	484	=	1146	3450	.33217
E8212	655	481	=	1136		.32926

4) QRGDP x Empi/ $\sum_{i=1}^{3}$ Empi = Mon. RGDPBC

QRGDP	Mon. RGDPBC
	1283.2
3852.7	1281.0
	1288.5
	1255.0
3831.2	1287.0
	1289.2
	1263.9
3766.7	1261.8
	1220.0
	1284.7
3794.7	1260.5
	1249.5

NPDIBC - Nominal personal disposable income in B. C. (millions of dollars). Prior to 1979, annual figures were obtained from table 3 of the B. C. Economic Accounts, June 1980, as the difference between total personal expenditure and current transfers to government. An annual series from 1979 through 1982 was obtained from Roger Purdy of the Central Statistics Bureau. Both series were redistributed on a monthly basis using Wages and Salaries in B. C. from Cansim matrix 1791 Series D5235. This derivation required the repetition of a procedure similar to that utilized to develop the monthly real gross domestic product of B. C., i.e.

1) D5235 = Y_i		2) $\sum_{i=1}^{12} Y_i$	3) $Y_i / \sum_{i=1}^{12} Y_i$	4) xPDI	= Mon.NPDIBC
Y8201	1877465		.0821803		= 2385.8
Y8202	1891403		.0827904		= 2403.5
Y8203	1936185		.0847506		= 2460.4
Y8204	1940788		.0849520		= 2466.2
Y8205	1959697		.0857797		= 2490.3
Y8206	1992303	22845690	.0872070	29031	= 2531.7
Y8207	1850630		.0810057		= 2351.7
Y8208	1726037		.0755520		= 2193.3
Y8209	1935730		.0847306		= 2459.8
Y8210	1949860		.0853491		= 2477.8
Y8211	1926545		.0843286		= 2448.1
Y8212	1859047		.0813741		= 2362.4

PGDPBC - Implicit GDP deflator for B. C. (1971 =1.00). An annual series, prior to 1979, was derived from information supplied by the B. C. Central Statistics Bureau as the ratio of current dollar GDP to constant dollar GDP. A quarterly series from 1979 through 1982 was generated by the Costs, Prices and Economics Department of B. C. Telephone Company. Both series were redistributed on a monthly basis using the same method developed to allocate population. The Vancouver CPI was utilized for monthly distribution.

CPIVAN - Consumer Price Index for Vancouver (1971 = 1.00). Monthly series taken from Cansim matrix 7030 series D488500.

Telsa File for 1982
(12 observations, 3 variables)

TM	BUSTA	RESTA
109	601047	1011586
110	603094	1012787
111	602063	1014589
112	600381	1014619
113	597597	1014451
114	594856	1014667
115	592160	1014489
116	589062	1014942
117	586059	1020779
118	583194	1023876
119	580568	1026393
120	578897	1027918

TM - Total number of observations.

BUSTA - Business main stations in B. C. were taken from Telephone Data, Form DP186 (column 4 line 39 minus lines 9 and 18).

RESTA - Residence main stations in B. C. were taken from Telephone Data, Form DP186 (column 4 line 27).

Dumymon File for 1982
(12 observations, 11 variables)

YYMM	PS	PSWD	OKTS	OKTSWD	BCTS	BCTSWD	MNWD	MNSUN	MNBD	MNDAY
8201	0	0	0	0	0	0	21	5	20.0	31
8202	0	0	0	0	0	0	20	4	20.0	28
8203	0	0	0	0	0	0	23	4	22.0	31
8204	0	0	0	0	0	0	22	4	20.0	30
8205	0	0	0	0	0	0	21	5	20.0	31
8206	0	0	0	0	0	0	22	4	22.0	30
8207	0	0	0	0	0	0	22	4	21.0	31
8208	0	0	0	0	0	0	22	5	21.0	31
8209	0	0	0	0	0	0	22	4	21.0	30
8210	0	0	0	0	0	0	21	5	20.0	31
8211	0	0	0	0	0	0	22	4	21.0	30
8212	0	0	0	0	0	0	23	4	20.0	31

YYMM - Year and month of observation.

PS - 1 if Postal strike in that month, 0 otherwise.

PSWD - Postal strike weekdays/weekdays in month.

OKTS - 1 if Okanagan Telephone strike in that month, 0 otherwise.

OKTSWD - Okanagan Telephone strike weekdays/weekdays in month.

BCTS - 1 if B. C. Telephone strike in that month, 0 otherwise.

BCTSWD - B. C. Telephone strike weekdays/weekdays in month.

MNWD - Number of weekdays in that month.

MNSUN - Number of Sundays in a given month.

MNBD - Number of business days in a month.

MNDAY - Total number of days in a month.

SEGOIMON File, Mileage Zone A-G, for Jan. 1982
(1 observation , 23 variables)

TM	YYMM		MSG*01	MIN*01	REV*01
109	8201		4260 1432	17531 5866	3470 1069
A = 0 - 10 miles			5692	23397	4539
			34590 12107	138020 52295	35430 12226
B = 11 - 25 miles			46697	190315	47656
			31405 10933	129151 50298	48317 16756
C = 26 - 50 miles			42338	179449	65073
			21401 8126	99655 43364	47321 18039
D = 51 - 100 miles			29527	143019	65360
			9919 3751	51802 23445	27316 10561
E = 101 - 175 miles			13670	75247	37877
			7053 2834	41041 19561	24076 9648
F = 176 - 300 miles			9887	60602	33724
			7764 2803	43055 20628	28212 11201
G = 300 + miles			10567	63683	39413

TM - Number of observation.

YYMM - Year and month of observation.

MSG*01 - Sent paid messages by mileage zone.

MIN*01 - Total minutes of call duration by mileage zone.

REV*01 - Total revenue by mileage zone.

Superwylber XIIPTSA was used to extract raw data from the Toll Sample Arrays (TSA). A time series for messages, minutes and revenue was requested by customer class and the type of call. This information directly corresponds to twelve market segment files, i.e.

Residential Mon. - Fri. Direct Dialing, Day	SEG01MON
Residential Mon. - Thur. Direct Dialing, Eve.	SEG02MON
Residential Friday Direct Dialing, Eve.	SEG03MON
Residential Saturday Direct Dialing, Day	SEG04MON
Residential Saturday Direct Dialing, Eve.	SEG05MON
Residential Sunday Direct Dialing, Day & Eve.	SEG06MON
Residential Mon. - Sun. Direct Dialing, Late Night	SEG07MON
Residential Mon. - Fri. Operator Handled, Day	SEG08MON
Residential Mon. - Fri. Operator Handled, Eve.	SEG09MON
Business Mon. - Fri. Direct Dialing, Day	SEG10MON
Business Mon. - Fri. Operator Handled, Day	SEG11MON
Business Mon. - Fri. Person to Person, Day	SEG12MON

The procedure was accessed by typing XIITSA in superwylber. 78 Execution occurred when the following XIIPTSA parameters were entered. In the SEGO1MON example, direct dialing and equivalent calling between 8 a.m. and 6 p.m. required some data manipulation. This was accomplished by combining the appropriate information in jobs SEGO1A2 and SEGO1B2.

FORM DP.9031 (Rev. 4-72)

DATA ENTRY TRANSMITTAL

Jobname	Call X11TSA	Job No.		PAGE OF
Card Name		Electro No. ☐ 5081, other		Colour/Stripe
Corner Cut	Return Job to:		Dept.	
Address		Tel. No.		Date

DATE From YY MM	DATE To YY MM	SETTL	REPORT	MILEAGE L	MILEAGE H	DUR'N L	DUR'N H	CUST L	CUST H	BILL L	BILL H	TYPE L	TYPE H	TIME OF WK L	TIME OF WK H	SERIES MESS	SERIES MIN	SERIES REV	SERIES AVG MI	ODDS + ENDS EAS	ODDS + ENDS RADIO	ODDS + ENDS 2nd	ODDS + ENDS SYS OFF	X11 PRT	X11 PLOM	X11 TAR	SCALE	OWN COMMENTS (DO NOT INPUT) Job Name
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	3	3	1	1	1	1	0	0	0	0	9			10	SEG01A2
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	9	9	1	1	1	1	0	0	0	0	9			10	SEG01B2
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-4	-5	1	1	1	1	0	0	0	0	9			10	SEG02A2
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-10	-11	1	1	1	1	0	0	0	0	9			10	SEG03A2
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	15	15	1	1	1	1	0	0	0	0	9			10	SEG04A2
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-16	-17	1	1	1	1	0	0	0	0	9			10	SEG05A2
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-21	-23	1	1	1	1	0	0	0	0	9			10	SEG06
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-1	-2	1	1	1	1	0	0	0	0	9			10	SEG07B
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-12	-14	1	1	1	1	0	0	0	0	9			10	SEG07CF
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-6	-8	1	1	1	1	0	0	0	0	9			10	SEG07AD
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	-18	-20	1	1	1	1	0	0	0	0	9			10	SEG07EH
7301	8212	4	1	1	7	0	0	1	1	1	4	1	3	24	24	1	1	1	1	0	0	0	0	9			10	SEG07G
7301	8212	4	1	1	7	0	0	2	2	1	4	1	3	3	3	1	1	1	1	0	0	0	0	9			10	SEG10A2
7301	8212	4	1	1	7	0	0	2	2	1	4	1	3	9	9	1	1	1	1	0	0	0	0	9			10	SEG10B2

TO FILE AND OUTPUT:

1) FET T NAME JOB# DDN JOBLOG CLR DEF
2) L 'CC='
3) FET T NAME JOB# DDN FT06F001 CLR DEF
4) SAVE INTO NAME
5) PRINT JOB#
6) CLR TEMPS

TABLE 14

Entire Sample Period Short Run Price Elasticities

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Fri. DDD, Day	.020214 (.377)	-.23446 (-3.44)	-.21268 (-4.52)	-.31469 (-5.16)	-.48627 (-6.31)	-.48459 (-6.69)	-.72804 (-6.68)
Residence: Mon. - Thur. DDD, Eve.	-.064946 (-.832)	-.44932 (-5.04)	-.30138 (-5.21)	-.42721 (-5.73)	-.47512 (-7.90)	-.30107 (-5.05)	-.27171 (-4.52)
Residence: Fri. DDD, Eve.	-.19430 (-1.26)	-.67513 (-5.36)	-.55446 (-5.71)	-.56439 (-6.23)	-.69236 (-8.04)	-.61919 (7.61)	-.47725 (-6.29)
Residence: Sat. DDD, Day	-.49594 (-3.77)	-.12864 (-2.51)	-.28589 (-3.48)	-.48744 (-4.89)	-.59747 (-6.51)	-.61873 (-6.88)	-.64100 (-7.01)
Residence: Sat. DDD, Eve.	-.23507 (-1.32)	-.56549 (-4.38)	-.41465 (-4.96)	-.74280 (-6.85)	-.74081 (-9.66)	-.75650 (-9.77)	-.57709 (-8.49)
Residence: Sun. DDD, Day & Eve.	-.17757 (-1.46)	-.55452 (-5.17)	-.45631 (-5.13)	-.68322 (-6.91)	-.78116 (-9.48)	-.71778 (-8.64)	-.74330 (-8.75)

Entire Sample Period Short Run Price Elasticities (Continued)

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Sun. DDD, Late Night	-.48549 (-4.21)	0.080522 (.89)	-.00083829 (-.013)	-.075502 (-1.14)	-.0015927 (-.04)	-.053161 (-1.08)	-.097257 (-1.75)
Residence: Mon. - Fri. SOH, Day	-.14509 (-1.28)	-0.068538 (-1.22)	-0.092824 (-1.57)	-.39522 (-3.80)	-.95331 (-8.48)	-.88432 (-8.31)	-.84162 (-7.76)
Residence: Mon. - Fri. SOH, Eve.	-.53345 (-3.69)	-.21080 (-2.66)	-.26571 (-3.48)	-.41586 (-4.87)	-.37485 (-5.32)	-.42025 (-6.5)	-.47699 (-6.32)
Business: Mon. - Fri. DDD, Day	-.0066981 (-.0108)	-.18279 (-2.39)	-.098865 (-1.96)	-.12490 (-2.1644)	-.084855 (-1.02)	-.076917 (-.85)	-.20782 (-1.98)
Business: Mon. - Fri. SOH, Day	-.66660 (-7.19)	-.13895 (-2.42)	.022824 (.44)	.066146 (1.61)	-.0.0054895 (-0.06)	.050290 (.44)	.092671 (.77)
Business: Mon. - Fri. PP, Day	-1.2743 (-7.04)	-.46489 (-3.88)	-.16323 (-1.35)	-.12791 (-1.06)	-.043124 (-.26)	.12808 (.87)	.10641 (.59)

TABLE 15

Entire Sample Period Lagged Dependent Variable Coefficients

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 176	176 - 300	300+
Residence: Mon. - Fri. DDD, Day	.77568 (15.56)	.8006 (18.27)	.79631 (21.51)	.74688 (18.08)	.49232 (7.02)	.48218 (7.35)	.49713 (7.22)
Residence: Mon. - Thur. DDD, Eve.	.73565 (16.45)	.65868 (12.56)	.74467 (17.94)	.63420 (11.26)	.44969 (7.16)	.62836 (9.90)	.70695 (12.87)
Residence: Fri. DDD, Eve.	.46801 (6.42)	.43446 (5.88)	.4652 (6.20)	.42707 (5.49)	.16221 (1.81)	.27319 (3.26)	.43587 (5.63)
Residence: Sat. DDD, Day	.51421 (7.42)	.74928 (15.38)	.67399 (9.93)	.59142 (8.09)	.45841 (6.04)	.45665 (6.50)	.42345 (6.02)
Residence: Sat. DDD, Eve.	.35657 (4.29)	.45598 (6.28)	.53797 (8.15)	.30637 (3.86)	.14526 (2.02)	.16376 (2.22)	.32001 (4.88)
Residence: Sun. DDD, Day & Eve.	.51037 (6.72)	.56960 (9.37)	.57990 (9.00)	.41462 (5.76)	.18402 (2.43)	.23251 (2.89)	.26069 (3.35)

Entire Sample Period Lagged Dependent Variable Coefficients (Continued)

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Sun. DDD, Late Night	.45026 (5.84)	.84414 (14.04)	.81380 (11.81)	.80436 (12.39)	.84485 (13.17)	.75556 (11.34)	.76690 (11.14)
Residence: Mon. - Fri. SOH, Day	.64062 (9.41)	.91747 (30.97)	.90927 (29.65)	.78148 (18.14)	.40092 (6.33)	.3307 (4.86)	.45105 (7.30)
Residence: Mon. - Fri. SOH, Eve.	.60739 (8.99)	.88692 (28.84)	.78457 (17.74)	.62853 (10.61)	.55129 (8.18)	.43555 (6.08)	.46808 (6.56)
Business: Mon. - Fri. DDD, Day	.90307 (18.70)	.81695 (14.24)	.90560 (22.88)	.88079 (21.13)	.93700 (25.07)	.92332 (24.76)	.91102 (21.70)
Business: Mon. - Fri. SOH, Day	.27534 (3.60)	.74429 (12.42)	.93298 (22.17)	.92798 (23.69)	.96702 (27.90)	.95957 (28.48)	.95779 (25.97)
Business: Mon. - Fri. PP, Day	.19299 (2.50)	.73603 (15.78)	.76435 (17.62)	.81618 (19.63)	.77604 (15.69)	.76995 (15.11)	.67040 (11.394)

TABLE 16
Short Run Price Elasticities for 1978 - 1982

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Fri. DDD, Day	-.47364 (-2.56)	-.60551 (-3.91)	-.65871 (-5.40)	-1.0421 (-6.15)	-.55253 (-5.29)	-.72078 (-7.68)	-.85465 (-4.85)
Residence: Mon. - Thur. DDD, Eve.	-.85684 (-4.03)	-.75579 (-4.88)	-.53502 (-4.39)	-.63805 (-5.22)	-.46512 (-5.60)	-.46100 (-5.20)	-.38499 (-4.42)
Residence: Fri. DDD, Eve.	-1.8079 (-5.81)	-1.1548 (-6.23)	-.78896 (-5.70)	-.72724 (-5.64)	-.76025 (-6.15)	-1.2835 (-8.89)	-.90995 (-6.07)
Residence Sat. DDD, Day	-.73723 (-3.81)	-1.1109 (-6.58)	-1.2208 (-6.44)	-1.2884 (-5.33)	-.78893 (-3.57)	-1.637 (-5.73)	-1.9253 (-6.06)
Residence: Sat. DDD, Eve.	-1.7955 (-5.81)	-1.4689 (-7.67)	-.87416 (-6.23)	-1.1552 (-6.82)	-.90741 (-7.86)	-1.0298 -6.69	-1.1449 (-6.89)
Residence: Sun. DDD, Day & Eve.	-1.1996 (-5.54)	-1.2000 (-7.21)	-1.0104 (-7.19)	-1.1656 (-8.22)	-.78795 (-7.49)	-.845 (-7.60)	-.87643 (-7.31)

Short Run Price Elasticities for 1978 - 1982 (Continued)

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Sun. DDD, Late Night	-1.0057 (-5.68)	.12471 (1.00)	.063228 (.67)	.02116 (.22)	.091018 (1.62)	.048030 (.61)	-.026566 (-.38)
Residence: Mon. - Fri. SOH, Day	-.47439 (-2.06)	-.29837 (-2.24)	-.70566 (-4.81)	-.86039 (-4.78)	-1.0581 (-8.72)	-.96964 (-7.36)	-.79844 (-6.35)
Residence: Mon. - Fri. SOH, Eve.	-.85763 (-4.10)	-.48645 (-3.43)	-.48369 (-3.99)	-.51958 (-4.80)	-.42904 (-5.04)	-.40287 (-5.50)	-.44887 (-5.15)
Business: Mon. - Fri. DDD, Day	-.21583 (-2.02)	-.34744 (-2.95)	-.36797 (-3.23)	-.42131 (-3.60)	-.79966 (-3.69)	-1.0077 (-4.51)	-.80818 (-3.89)
Bsuiness: Mon. - Fri. SOH, Day	-.97119 (-8.05)	-.57493 (-6.08)	-.72731 (-6.24)	-.80239 (-8.15)	-.7794 (-6.18)	-.60616 (-3.66)	-.44453 (-3.23)
Business: Mon. - Fri. PP, Day	-1.4352 (-5.69)	-.85649 (-6.71)	-.40993 (-2.39)	-.3624 (-2.25)	-.43134 (-2.08)	-.11220 (-.71)	0.093086 (.41)

TABLE 17

Lagged Dependent Variable Coefficients for 1978 - 1982

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Fri. DDD, Day	.49986 (5.02)	.51603 (4.81)	.363 (3.44)	.17671 (1.41)	.33956 (3.01)	0.070266 (.66)	.35889 (2.99)
Residence: Mon. - Thur. DDD, Eve.	.36762 (3.70)	.42453 (4.04)	.51747 (4.92)	.42396 (4.13)	.41669 (4.39)	.35301 (3.14)	.54924 (6.09)
Residence: Fri. DDD, Eve.	-.1945 (-1.52)	0.06078 (.49)	.19543 (1.60)	.15901 (1.24)	0.03166 (.24)	-.23553 (-1.82)	.22057 (1.92)
Residence: Sat. DDD, Day	.37676 (3.59)	.19611 (1.85)	.060280 (.45)	.12391 (.79)	.39927 (2.48)	-.16316 (-0.1)	-.067705 (-.42)
Residence: Sat. DDD, Eve.	.036466 (.33)	-.12525 (-1.04)	0.095288 (.77)	-0.04867 (-.37)	-0.051133 (-.43)	.013197 (.1)	.11289 (.95)
Residence: Sun. DDD, Day & Eve.	.18677 (1.72)	.20494 (2.08)	.10229 (.89)	-0.03572 (-.29)	.069812 (.61)	-.01598 (-0.09)	.098507 (.84)

Lagged Dependent Variable Coefficients for 1978 - 1982 (Continued)

	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
Residence: Mon. - Sun. DDD, Late Night	.13849 (1.23)	.91544 (12.56)	.79047 (7.40)	.73173 (6.84)	.85828 (9.46)	.59866 (4.96)	.71715 (6.95)
Residence: Mon. - Fri. SOH, Day	.637 (6.52)	.86798 (21.36)	.68591 (12.96)	.54007 (7.33)	.23592 (3.04)	.12258 (1.25)	.37126 (4.26)
Residence: Mon. - Fri. SOH, Eve.	.52381 (6.32)	.79339 (19.95)	.6412 (9.23)	.51023 (6.62)	.45988 (5.50)	.40948 (4.65)	.36449 (3.64)
Business: Mon. - Fri. DDD, Day	.73394 (7.50)	.65844 (6.59)	.72831 (8.44)	.66234 (6.97)	.60864 (5.76)	.35856 (2.83)	.60682 (5.68)
Business: Mon. - Fri. SOH, Day	.071212 (.74)	.33913 (4.15)	.38935 (4.37)	.20901 (2.49)	.54727 (7.87)	.56074 (5.90)	.67983 (9.07)
Business: Mon. - Fri. PP, Day	.067514 (.63)	.13038 (1.50)	.31961 (4.09)	.30302 (3.64)	.19507 (2.10)	.32548 (3.36)	.25422 (2.91)

TABLE 18 Chow Test

Zone	ESS_R	ESS_1	ESS_2	$ESS_{UR} = ESS_1 + ESS_2$	$(ESS_R - ESS_{UR})$	K	N+M-2K	$\frac{ESS_R - ESS_{UR}}{K}$	$\frac{ESS_{UR}}{N+M-2K}$	$\frac{(ESS_R - ESS_{UR})/K}{ESS_{UR}/(N+M-2K)}$
Segment 1										
1	.24151	.062821	.13652	.199341	.042169	7	106	.0060241428	.0018805754	3.203351103
2	0.094994	.041906	.040077	.081983	.013011			.0018587142	.00077342452	2.40633
3	.10206	.048278	.032858	.081136	.020924			.0029891428	.00076543396	3.90516
4	.12980	.059098	.044750	.103848	.025952			.0037074285	.000979698	3.784255
5	.25959	.12856	.094851	.223411	.036179			.0051684285	.0021076509	2.45222
6	.34244	.17601	.10383	.27984	.0626			.0089428571	.00264	3.387446
7	.47540	.18902	.23892	.42794	.04746			.00678	.0040371698	1.67939
Segment 2										
1	.44297	.15742	.18494	.34236	.10061			.014372857	.0032298113	4.45
2	.16577	.088207	.049675	.137882	.027886			.003984	.0013007735	3.0627942
3	.087956	.039011	.030735	.069746	.01821			.0026014285	.00065798113	3.953652
4	.10520	.055983	.037558	.093541	.011659			.0016655714	.00088246226	1.8874138
5	.14426	.059021	.064867	.123888	.01538			.0021971428	.0011687547	1.8799
6	.21825	.12076	.073187	.193947	.024303			.0034718571	.0018296886	1.8975
7	.22929	.12719	.083607	.210797	.018493			.0026418571	.0019886509	1.328
Segment 3										
1	1.5929	.40875	.61405	1.0228	.5701			.081442857	0.0096490566	8.4405
2	.39078	.17510	.14087	.31597	.07481			.010687142	0.002980849	3.58526
3	.29169	.12653	.10529	.23182	.05987			.0085528571	.0021869811	3.91
4	.24105	.099574	.10136	.200934	.040116			.057308571	.0018956037	30.232
5	.44953	.17898	.21765	.39663	.0529			.0075571428	.0037417924	2.01966
6	.49686	.25157	.14279	.39436	.1025			.014642857	.0037203773	3.9
7	.82529	.45805	.19313	.65116	.17413			.024875714	0.0061430188	4.0494

Chow Test (Continued)

Zone	ESS_R	ESS_1	ESS_2	$ESS_{UR} = ESS_1 + ESS_2$	$(ESS_R - ESS_{UR})$	INCL. DEPND V.V. K	N+M-2K	$\frac{ESS_R - ESS_{UR}}{K}$	$\frac{ESS_{UR}}{N+M-2K}$	$\frac{(ESS_R - ESS_{UR})/K}{ESS_{UR}/(N+M-2K)}$
Segment 4										
1	.54538	.16726	.18064	.3479	.19748	7	106	.028211428	.0032820754	8.5956
2	.26197	.10075	.093459	.194205	.067765			.0096807142	.0018321226	5.28388
3	.41264	.15240	.14107	.29347	.11917			.017024285	.0027685849	6.14909
4	.74085	.32388	.25049	.57437	.16648			.023782857	.0054185849	4.389127676
5	1.4579	.79817	.44063	1.2386	.2191			.0313	.011686792	2.678237
6	1.9403	1.1543	.51310	1.6674	.2729			.038985714	.015730188	2.4785
7	3.2861	1.7466	.76892	2.51552	.77058			.110082857	.02373132	4.638716
Segment 5										
1	2.0874	.84776	.64492	1.49268	.59472			.08496	.014081886	6.03328
2	.48701	.16368	.16220	.32588	.16113			.023018571	.0030743396	7.4873
3	.24609	.090554	.10558	.196134	.05475			.0078214285	.0018503207	4.22706775
4	.47097	.17717	.21664	.39381	.07716			.011022857	.0037151886	2.966971
5	.61236	.34170	.22200	.5637	.04866			.0069514285	.0053179245	1.387169
6	.80010	.45897	.27232	.73129	.06881			.00983	.0068989622	1.42485
7	1.0401	.58118	.32430	.90548	.13462			.019231426	.0085422641	2.25132656
Segment 6										
1	1.0859	.36407	.31199	.67606	.40984			.058548571	.0063779245	9.179879
2	.27370	.12043	.091330	.21176	.06194			.0088485714	.0019977358	4.4293
3	.23591	.10207	.076936	.179006	.056904			.0081291428	.0016887358	4.813746
4	.26376	.12901	.065240	.19425	.06951			0.00993	.0018325471	5.41868776
5	.45254	.24479	.11232	.35711	.09543			0.013632857	.0033689622	4.0466
6	.42228	.23191	.090443	.322353	.099927			.014275285	.003041066	4.69417
7	.48155	.26203	.13326	.39529	0.08626			.012322857	.0037291509	3.304468

Chow Test (Continued)

Zone	ESS_R	ESS_1	ESS_2	$ESS_{UR} = ESS_1 + ESS_2$	$(ESS_R - ESS_{UR})$	K	N+M-2K	$\frac{ESS_R - ESS_{UR}}{K}$	$\frac{ESS_{UR}}{N+M-2K}$	$\frac{(ESS_R - ESS_{UR})/K}{ESS_{UR}/(N+M-2K)}$
Segment 7										
1	1.8865	.73649	.51719	1.25368	.63282	7	106	.090402857	.011827169	7.6437
2	.7491	.27792	.36777	.64568	.10341			.014772857	.006091415	2.4252
3	.44248	.14117	.28587	.42704	.01544			.0022057142	.0040286792	.5475
4	.40155	.10291	.26789	.3708	.03075			.0043928571	.0034981132	1.2558
5	.48711	.19744	.23260	.43004	.05707			.0081528571	.0040569811	2.0096
6	.50356	.13451	.32009	.4546	.04896			.0069942857	.0042886792	1.6308
7	.39015	.16916	.17159	.34075	.0494			.0070571428	.0032146226	2.1953
Segment 8										
1	2.7981	.38116	1.7148	2.09596	.70214			.1003057	.0197732	5.0728
2	.40376	.13633	.19802	.33435	.06941			.00991571	.04776429	0.2076
3	.37428	.10981	.12579	.2356	.13868			.01981143	.00222264	8.9135
4	.55201	.15777	.21103	.3688	.18321			.02617286	.003479245	7.5226
5	.43162	.22428	.086753	.311033	.120587			.01722671	.002934274	5.9833
6	.63835	.25549	.22774	.48323	.15512			.02216	.0045587735	4.86096
7	.62424	.29788	.16138	.45926	.16498			.0235686	.00433264	5.4398
Segment 9										
1	5.443	1.2134	2.3304	3.5438	1.8992			.27131429	.03343208	8.1154
2	.56652	.19492	.24057	.43549	.13103			.01871856	.0041083962	4.556
3	.51146	.18587	.19828	.38415	.12731			.018187142	.0036240566	5.018
4	.37244	.13380	.16827	.30207	.07037			.01005286	.0028497169	3.5277
5	.40260	.18257	.14196	.32453	.07807			.01115286	.003061604	3.6428
6	.46969	.20829	.14286	.35115	.11854			.01693429	.003312736	5.1119
7	.68137	.25293	.20389	.45682	.22455			.03207857	.004309623	7.4435

Chow Test (Continued)

Zone	ESS_R	ESS_1	ESS_2	$ESS_{UR} = ESS_1+ESS_2$	$(ESS_R - ESS_{UR})$	K	N+M-2K	$\frac{ESS_R-ESS_{UR}}{K}$	$\frac{ESS_{UR}}{N+M-2K}$	$\frac{(ESS_R-ESS_{UR})/K}{ESS_{UR}/(N+M-2K)}$
Segment 10										
1	.27911	.10410	.13154	.23564	.04347	7	106	.00621	.0022230188	2.7935
2	.17400	.075415	.064708	.140123	.033877			.00483957	.001321915	3.661
3	.11573	.051661	.041702	.093363	.022367			.003195286	.000880783	3.6278
4	.13437	.060541	.048986	.110401	.023969			.00342414	.001041518	3.3851
5	.15640	.079207	.044040	.123244	.033156			.00473657	.001162679	4.0738
6	.18789	.079098	.061817	.140915	.046975			.0067107	.001329387	5.0479
7	.20196	.096173	.055423	.151596	.050364			.00719486	.001430151	5.0308
Segment 11										
1	1.265	.43807	.51881	.95688	.30812			.04401742	.0090271698	4.8761
2	.38627	.10629	.13018	.23647	.1498			.0214	.002230849	9.5927
3	.33667	.14938	.083555	.232935	.103735			.014819285	.0021975	6.7437
4	.34235	.12796	.072576	.200536	.141814			.020259142	.001891849	10.7086
5	.35790	.22703	.069271	.296301	.061595			.008799285	.0027952924	3.1479
6	.46782	.23141	.12278	.35419	.11363			.016232857	.003341415	4.8581
7	.58613	.40158	.10929	.51087	.07526			.010751428	.0048195283	2.2308
Segment 12										
1	12.284	2.6072	7.5705	10.1777	2.1063			.3009	.096016037	3.1339
2	1.7145	.34112	.61834	.95946	.75504			.107862857	.0090515074	11.9166
3	.99404	.22893	.43434	.66327	.33077			.047252857	.0062572641	7.5517
4	.78884	.13915	.33415	.4733	.31554			.045077142	.0044650943	10.9545
5	.98814	.19798	.45971	.65769	.33045			.047207142	.0062046226	7.6084
6	.71269	.34365	.25039	.59404	.11865			.01695	.0056041509	3.0245
7	1.2811	.33901	.50243	.84144	.4397			.062814285	.0079381132	7.9129

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TABLE 19

LONG-RUN PRICE ELASTICITIES

Segment	0 - 10	11 - 25	26 - 50	51 - 100	101 - 175	176 - 300	300+
1	0	-1.1758	-1.0441	-1.2432	- .95783	- .93583	-1.4478
2	-2.4568	-1.3164	-1.1804	-1.1679	- .86337	- .81011	- .92718
3	- .36523	-1.1938	-1.0368	- .98509	- .82641	- .85193	- .84599
4	-1.0209	- .51308	- .87694	-1.193	-1.1032	-1.1387	-1.1118
5	- .36534	-1.0395	- .89745	-1.0709	- .86671	- .90464	- .84867
6	- .36266	-1.2884	-1.0862	-1.1671	- .95733	- .93523	-1.0054
7	- .88313	0	- .0045005	- .38592	- .010261	- .21748	- .41723
8	-1.3069	-2.26	-2.2467	-1.8707	-1.3848	-1.1051	-1.2699
9	-1.801	-2.3544	-1.3481	-1.0609	- .79434	- .68223	- .70631
10	- .81121	-1.0172	-1.3544	-1.2477	-2.0433	-1.5710	-2.0555
11	-1.0457	- .86996	-1.191	-1.0156	-1.7216	-1.38	-1.3884
12	-1.5391	- .98490	- .60249	- .51996	- .53587	- .16634	0

VITA

Surname: BOZMAN Given Names: SCOTT

Place of Birth: Raton, New Mexico Date of Birth: October 23, 1956

Educational Institutions Attended, with Dates of Entering and Leaving:

UNIVERSITY OF IDAHO, MOSCOW, IDAHO 1978 to 1980

UNIVERSITY OF VICTORIA, VICTORIA, B. C. 1982 to 1983

____ to ____

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

B.Sc. (Dean Honour List) 1980 University of Idaho

Honors and Awards:

Philips, Hager and North Ltd. Bursary, 1982

Publications: