Estimating Demand for Canadian Cable Television Services

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November 2, 2002

Abstract

This paper presents preliminary demand estimates for basic and non-basic cable television services over data drawn from the annual reports of CATV operators from 1990-1996. Parameters of interest include the degree to which subscription levels respond to changes in rates for basic service and to changes in rates for non-basic service. Since a subscription to non-basic service is conditional on subscription to basic, an important question is the extent to which CATV firms selected prices for basic service that were below the CRTC's price caps either to acquire non-basic subscriptions or for other reasons. In addition to revealing features of the historical growth of CATV markets in Canada, the results also inform future policy considerations which inevitably arise from convergence of technologies (such as for telephone or for CATV) for signal transmission.

JEL Classification codes
L5 Regulation and Industrial Policy; L9 Industry Studies: Transportation and Utilities

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The author expresses appreciation of the excellent research assistance provided by Sergio Pulla and acknowledges the support of SSHRC, Ryerson Polytechnic University, and the Department of Economics of the University of New Brunswick, Fredericton.

I. INTRODUCTION

The deregulation of the services of the cable television (CATV) industry has become a pressing issue in the development of the Canadian telecommunications system. Policy initiatives undertaken within the last five years include the relaxation of entry barriers (1997) and a major revision of the regulations (1998) which allow for rate deregulation with entry. Consequently, there is a need to evaluate market conditions and the impact of policies within the complex and changing regulatory environment.

Research into the demand for Canadian cable television services includes: Good (1974), Munasinghe and Corbo (1978), and McFadyen, Hoskins, and Gillen (1980). There is a lack of thorough investigations of demand characteristics in Canada using data more recent than the decade of the 1970's.

Demand estimates for the United States include Mayo and Otsuka (1991) and Rubinovitz (1993). One of the salient issues in this line of research is the determination for basic service of the trend for the price-responsiveness of demand (elasticity). If demand is becoming less price-responsive (less elastic) over time, then failure to maintain close control of prices may become more costly in political terms – since a larger proportion of consumers continue to consume while paying a higher price for the service – although less costly in terms of efficiency – since, if demand is relatively less elastic, deadweight loss is smaller as a larger proportion of lost consumer surplus is simply transferred to the producer when prices rise. Possible policy responses include tighter regulatory controls, or the opening of the industry to competition, and it is the latter course of action which is reflected in recent CRTC decisions.

II. THE CATV INDUSTRY

In 1986, the CRTC codified its procedures into a set of published rules for the CATV industry.[1] These rules required CATV operators to apply for exclusive licences to serve cable television subscribers residing in specified areas. These Licensed Service Areas (LSAs) are then classified by the CRTC based partly on the current subscription level within the LSA and partly on the quality of broadcast reception that is available to the CATV service provider. All types of LSAs and all types of services are subject to the rules on carriage, or signal content. Only basic service in Class 1 and Class 2 LSAs is subject to rate regulation.

The point at which the CRTC evaluates broadcast reception is the head end of the CATV system. The quality of reception of over-the-air broadcasts decreases with the distance between the broadcasting antenna and the receiving antenna (at the head end). It is possible to map out contours of broadcast signal quality; on a flat surface with no obstructions these contours would be circular. If the head end (or, where there is more than one, the head end that receives the majority of the programming services) in a licensed service area is within the Grade B contour of two or fewer broadcast stations, the CRTC exempts the LSA from the rate regulations in Part II.

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[1] For the regulations relevant to this study, see SOR/86-831: *Cable Television Regulations, 1986*, and amendments (*Canada Gazette*).

Regulations differ by type of service: basic service covers the package of local broadcast stations, plus community channels (if any) and any other channels the CATV operator is required or applies to include; pay services are marketed individually or in several packages, usually including movie channels, music channels, and other specialty channels; and extended basic service which is typically a single package that subscribers can add on to their basic service to augment the choice of channels. The CRTC makes the determination of whether a set of channels can be offered in a pay or extended basic package, or whether channels must be part of the basic subscription. Consumers are required to subscribe to the basic service in order to obtain any of the other services.

A cable system is the cable network around one local head end. The head end is the location of the equipment that receives the signals that are sent down the cable to the subscriber. Head end apparatus can include such devices as satellite dishes, large antennas for the reception of over-the-air broadcasts, fibre optic links, video relay equipment, and microwave towers. Within a licensed service area, if it is large enough, there may be more than one cable system, although only one operator. A CATV firm is an operator of one or more cable systems which may be located in one or more LSAs.

For the time period covered by the study the competition to CATV provided by distant broadcast satellite (DBS) was quite limited. Alternate signal sources included those from direct television broadcast (antennas) or from video cassette recorders (VCRs).[2] Thus, with the exception of signals generated by local broadcast stations, the CATV firms were essentially monopoly providers of real-time signals available to Canadians.

The rate restrictions (found in Part II of the regulations) do not apply to "Part III licensees". The restrictions in Part III concern only carriage, *i.e.*, Part III licensees are required to carry certain signals, are required to deliver a particular mix of Canadian and non-Canadian services, and are provided with a list of those services which they are allowed to carry but there is no other explicit economic regulation in this section of the rules.

The distinction between Classes 1 and 2 arises in the rate regulations which place more severe restrictions on rate increases for Class 1 systems than for Class 2 systems.[3] The pricing regulations fix a ceiling for rate increases, allow rate increases related to the amount of investment in capital for the provision of basic service, and permit increases for those systems which are earning returns on net fixed capital that are below a benchmark set by the CRTC.

Thus, small LSAs were subjected only to rules concerning signal content while larger LSAs also had to adhere to rules that restrict permissible price increases. Prices, that is, monthly subscription rates, could be increased to cover inflation (§18(2)), to pay for capital expenditures (§18(6), "CAPEX"), and in cases where the rate of return on net fixed assets falls below a benchmark (§18(8), "Economic

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[2] Regrettably, no information was obtainable on the number of Canadians receiving foreign (US) DBS signals. In addition, VCR penetration rates would be helpful for the analysis but were not readily available at the time of this study.

[3] See Law (1999).

Need”). Prior to 1994, large LSAs were divided into two groups: Class 1 LSAs with more than 6000 subscribers, and Class 2 LSAs with between 2000 and 6000 subscribers.[4] In 1994, the rate regulations pertaining to Class 2 category were relaxed, effectively making 6000 subscribers the new standard boundary between rate regulated and not.

III. MODEL

1. Estimating Equations

Quantity

Following Mayo and Otsuka (1991), a model of the demand for basic service is:

$$\frac{Q_b}{N} = X\alpha_0 + P_b X\alpha_1 + P_p \alpha_2 \tag{1}$$

where Q_b is the number of subscriptions to basic service, N is the number of houses wired for cable in the LSA, X is a vector of demand variables, P_b is the price of basic cable service, P_p is the price of non-basic service and α_0, α_1, and α_2 are vectors of coefficients. The demand for non-basic service is:

$$\frac{Q_p}{N} = \frac{Q_b}{N}\left(X\beta_0 + P_p X\beta_1\right) \tag{2}$$

where β_0 and β_1 are vectors of coefficients, Q_p is the number of subscriptions to non-basic service, and the other variable are as defined above. Equation (1) defines the fraction of potential subscribers who subscribe to basic service. Equation (2) defines the fraction of potential subscribers who subscribe to non-basic service as the product of the proportion of subscribers who have a basic subscription multiplied by the fraction of basic subscribers who choose non-basic service, that is, $(X\beta_0 + P_p X\beta_1)$. [Under this formulation, the price of basic service would enter the demand equation for non-basic service only through an income effect which would be small and, hence, is suppressed here.]

Cost

The CATV operators maximize profits of $\pi = P_b Q_b + P_p Q_p - C(Q_b, Q_p)$. Marginal costs are estimated (simultaneously) from a translog cost function: Γ_b and Γ_p, for basic and non-basic service respectively. To obtain these estimates of marginal cost for the pricing equations (below) we approximate a cost function that corresponds to a production function under standard duality assumptions. A second order logarithmic approximation to an arbitrary twice-differentiable cost function is given by:

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[4] See Law (2002) for more detailed description of the initial class size definitions.

$$\log C = \log \beta_0 + \sum_i \beta_i \log X_i + \tfrac{1}{2}\sum_i \sum_j \beta_{i,j} \log X_i \log X_j + u, \quad (i, j = k, l, m, q, d, h). \tag{3}$$

where u is the error term and where, for variables denoted X_i, P_K is the price of capital, P_L is the price of labour, P_M is the price of "materials", Q is the level of output (subscribers); D is a measure of subscriber density and H is the number of channels.[5] Variables, *e.g.*, Z, are centred around sample means, $\overline{Z}$, to avoid arbitrary scaling problems. The estimated version of Equation (3), is:

$$\log \tilde{C} = a_0 + \sum_i a_i \log \tilde{X}_i + \tfrac{1}{2}\sum_i \sum_j a_{ij} \log \tilde{X}_i \log \tilde{X}_j, \quad \text{where } \tilde{C} = \frac{C}{\overline{C}} \text{ and } \tilde{X}_i = \frac{X_i}{\overline{X}}. \tag{4}$$

Restrictions applied to this function as estimated here include symmetry, "adding-up" constraints, and linear homogeneity in prices.[6] Shephard's lemma provides additional estimating equations, the cost share equations, given by:

$$S_i = a_i + \sum_j a_{ij} \log \tilde{X}_j, \quad (i = k, l, m), \tag{5}$$

where S_K, S_L, and S_M denote the cost shares of capital, labour, and "materials", respectively.[7] A description of the data, definitions of the variables, and expansions of the estimating equations are provided in the Data Appendix. With the exception of S_K, S_L, and S_M, all variables are centred around their respective sample means. The estimates of marginal cost are recovered from a conversion to "decentre" the series. With b_0 an estimate for β_0, b_i an estimate for β_i, and b_{ij} an estimate for β_{ij}, the parameters for the original function may be recovered from the following conversions:

$$b_0 = a_0 - \sum_i a_i \log \overline{X}_i + \frac{1}{2}\sum_i \sum_j a_{ij} \log \overline{X}_i \log \overline{X}_j + \log \overline{C}; \quad b_i = a_i - \sum_j a_{ij} \log \overline{X}_j; \quad b_{ij} = a_{ij}. \tag{6}$$

For the purpose of the current work, costs are assumed to be additively separable in basic and non-basic output. Thus, two versions of the cost system described above are estimated: one for basic and one for non-basic. [This restrictive assumption will be tested and, if appropriate, relaxed in later versions of the paper. In the meantime, the separated versions of the cost functions allow for direct comparison with earlier research on the costs of providing basic cable television service, e.g., Law (1999).]

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[5] Additional details on the specification, characteristics, and performance of the cost model in the context of the Canadian CATV industry are available in Law (1997).

[6] For a discussion of some properties of translogarithmic cost functions and derivations of share equations see Berndt (1991), or see Fuss and Waverman (1978) who also provide a derivation of the revenue-share equation used here.

[7] Shephard's lemma implies $L = \dfrac{\partial C}{\partial P_L}$ in the case of labour, for example. Re-writing this expression yields $L\dfrac{P_L}{C} = \dfrac{\partial C}{\partial P_L}\dfrac{P_L}{C}$ or $S_L = \dfrac{\partial \log C}{\partial \log P_L}$ which is the cost share equation for labour.

Prices

The pricing equations are derived from the first-order conditions of the firm's profit-maximization problem. There are several different ways to incorporate the information from the solution to the maximization problem into the estimation procedure.

The first method is to solve the first-order equations for the prices of the two goods, , P_b and P_p, and add an error term for estimation. The price equations are then:

$$P_b = \Gamma_b - \left(\frac{1}{NX\alpha_1}\right) Q_b Y\delta_b - \left(P_p - \Gamma_p\right)\left(X\beta_0 + P_p X\beta_1\right) \tag{7}$$

and

$$P_p = \Gamma_p - \left(\frac{1}{Q_b X\beta_1}\right) Q_p Y\delta_p - \left(P_b - \Gamma_b\right)\left(\frac{N\alpha_2}{Q_b X\beta_1}\right) \tag{8}$$

Under this formulation of the model, the effects of regulation on prices are included through the functions $Y\delta_b$ and $Y\delta_p$, where $0 \le Y\delta_b \le 1$ and $0 \le Y\delta_p \le 1$. While there is no explicit regulation of non-basic prices, we can nonetheless explore the impact of carriage regulations through these parameters: $Y\delta_b = Y\delta_p = 1$ implies monopoly pricing and $Y\delta_b = Y\delta_p = 0$ implies marginal-cost pricing. These functions are similar to the market power indexes proposed by Bresnahan (1982) and have been estimated for Canadian CATV for 1985 – 1991 in Law (1999).

Alternatively, the pricing information can be incorporated into the cost system through a "revenue share equation" which is similar to the cost share expressions in Equation (5). Following the presentation in Law (1999), this procedure also relies on the first order condition for profit maximization in which the firm equates some constrained function of marginal revenue to marginal cost:

$$f(MR) = \frac{\partial F(PQ)}{\partial Q} = \frac{P}{g} = \frac{\partial C}{\partial Q}. \tag{9}$$

The precise functions F and f of revenue and marginal revenue from the constrained optimization problem are unknown but their form is not required for estimation.[8] Assuming profit maximization, the lower bound for g is determined by its value in a competitive equilibrium; the upper bound corresponds to the value from a monopoly equilibrium, *i.e.*,

$$1 \le g \le \frac{\varepsilon}{\varepsilon + 1}, \text{ where } \varepsilon = \frac{\partial Q}{\partial P}\frac{P}{Q}. \tag{11}$$

With S_R the ratio of total revenue to total cost, the definition of g can be re-written:

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[8] The constraints embodied in F and f arise from the CRTC pricing regulations.

$$g = \frac{P}{\left(\frac{\partial C}{\partial Q}\right)} \Rightarrow \frac{PQ}{\frac{C}{Q}Q} = \left(\frac{1}{C}\frac{\partial C}{\partial Q}Q\right)g \Rightarrow \frac{PQ}{C} = \left(\frac{\partial \log C}{\partial \log Q}\right)g, \tag{13}$$

which yields the "revenue share" equation:

$$S_R = \left(\frac{\partial \log C}{\partial \log Q}\right)g. \tag{15}$$

For two outputs, this construction must be modified to reflect the possibility that a change in the price of one output will affect the profitability (or first-order condition for) the other output. The resulting equations are:

$$S_{R,b} = \left(\frac{\partial \log C_b}{\partial \log Q_b}\right)g_b - \frac{P_p Q_b}{C_b}\left(X\beta_0 + X\beta_1 P_p\right)\frac{g_b}{g_p}. \tag{16}$$

and

$$S_{R,p} = \left(\frac{\partial \log C_p}{\partial \log Q_p}\right)g_p - \frac{P_b Q_p}{C_p}\left(\frac{X\alpha_2 X\beta_1}{Q_b}\right)\frac{g_p}{g_b}. \tag{17}$$

2. Estimation Procedures

Using either method, there are ten estimating equations. The demand equations (1) and (2), the cost functions which include versions of (4) and (5) for basic and for non-basic, and the pricing equations, (7) and (8), or the revenue-share equations, (16) and (17), are estimated simultaneously, along with the conversion in equation (6) using three-stage least squares weighted estimation.

Transformations, or weights, for the cost function equations have been discussed above. Equations (1) and (2) require weighting since residual errors for theses equations are heteroskedastic. [Discussion drawn from Mayo & Otsuka (1991).]

Define penetration rates $PR_b = Q_b/N$ and $PR_p = Q_p/N$. The weights used are:

$$W_b = \left(\frac{N}{PR_b\left(1 - PR_b\right)}\right)^{1/2} \text{ and } W_p = \left(\frac{N}{PR_p\left(1 - PR_p\right)}\right)^{1/2} \tag{18}$$

since the penetration rates can be seen as probabilities that a potential customer in the market area is an actual subscriber. With population probabilities π_b and π_p, such that $\pi_b \simeq PR_b$ and $\pi_p \simeq PR_p$, the sample probabilities will have the following distributions:

$$\frac{Q_b}{N} = PR_b \sim N\left(\pi_b, \frac{\pi_b\left(1 - \pi_b\right)}{N}\right) \text{ and } \frac{Q_p}{N} = PR_p \sim N\left(\pi_p, \frac{\pi_p\left(1 - \pi_p\right)}{N}\right). \tag{19}$$

The weights are then used to scale the dependent and independent variables in Equations (1) and (2), following the minimum chi-square method presented above, which was developed by Amemiya (1976) and specified for simultaneous equation estimation by Maddala (1983).

3. The Data

The CRTC-LSA-Response dataset used for this study covers the period 1990 through 1996. These data were augmented with information from Statistics Canada for income and demographic characteristics. A more complete description of each variable is presented in the Appendix.

IV. RESULTS

The following lists lay out the parameters of interest for the study.

REGIONS

ATL	Newfoundland, Nova Scotia, Prince Edward Island, New Brunswick
PQ	Quebec
ONT	Ontario
PRAI	Manitoba, Saskatchewan, Alberta
NWST	British Columbia and the Territories

ELASTICITIES

EB	own-price elasticity for basic service
EP	own-price elasticity for pay (or discretionary) service
EBLP	cross-price elasticity: response of basic service subscriptions to changes in price of pay service
EPLB	cross-price elasticity: response of pay service subscriptions to changes in price of basic service
EBINC	income elasticity for basic service
EPINC	income elasticity for pay service
SYMMETRY	test statistic for symmetry

MEASURES OF COST STRUCTURE, MARKET POWER, AND PERFORMANCE

MUB	inverse cost-output elasticity for basic service, μ_b, returns to scale for basic service
MUP	inverse cost-output elasticity for pay service, μ_p returns to scale for pay service
COMPETB	test for marginal cost (competitive) pricing for basic service
COMPETP	test for marginal cost (competitive) pricing for pay service
CRSB	test for constant returns to scale in basic service, $\mu_b - 1$,
CRSP	test for constant returns to scale in pay service, $\mu_p - 1$,
IB	Bresnahan index of market power for basic service

PACRATB	price to average cost ratio for basic service
ZIPB	test for breakeven pricing (price to average cost ratio different from 1) for basic service
PMCRATB	price to marginal cost ratio for basic service
MONB	test for unconstrained monopoly pricing for basic service
LAMBDAB	Ramsey-Boiteux multiplier for basic service
IP	Bresnahan index of market power for pay service
PACRATP	price to average cost ratio for pay service
ZIPP	test for breakeven pricing (price to average cost ratio different from 1) for pay service
PMCRATP	price to marginal cost ratio for pay service

1. Price Elasticities

Price elasticities for all regions and all years are presented in the tables at the end of the document. Most of the tables in the text immediately below present the elasticities for Ontario, as an example.

Symmetry

Symmetry is not expected to hold in this case since a subscription to discretionary service is conditional on a subscription to basic service. The test statistic used is given by:

$$e_{B,P} - \left(\frac{e_B e_P}{e_{P,B}}\right)$$

where $e_{B,P} = \frac{\partial Q_B}{\partial P_P}\frac{P_P}{Q_B}$, $e_B = \frac{\partial Q_B}{\partial P_B}\frac{P_B}{Q_B}$, $e_P = \frac{\partial Q_P}{\partial P_P}\frac{P_P}{Q_P}$, and $e_{P,B} = \frac{\partial Q_P}{\partial P_B}\frac{P_B}{Q_P}$.

The test suggests that in the regions for the years marked X in the table below, symmetry cannot be rejected, but for the remaining 23 of the 35 cells (5 regions x 7 years), symmetry is rejected at the five percent level, that is, the test statistic is significantly different from zero. ($p < 0.05$).

Symmetry Test Statistic

	Atlantic	Quebec	Ontario	Prairies	NorthWest
1990			X	X	
1991		X	X		
1992	X	X	X		
1993		X	X		
1994					
1995			X	X	X
1996					

Own-price elasticity, basic service, e_b

ONTARIO	Parameter Estimate	Standard Error	t-statistic		P-value
1990	-.157128	.070270	-2.23605	*	[.025]
1991	-.090377	.392158	-.230461		[.818]
1992	-.433808	.325299	-1.33357		[.182]
1993	-.630487	.237773	-2.65163	**	[.008]
1994	-.600679	.167012	-3.59663	**	[.000]
1995	-.165140	.253576	-.651244		[.515]
1996	-.464305	.174410	-2.66215	**	[.008]

The own-price elasticities for basic service from this model are considerably lower than those reported in earlier studies. From Law (1997):

> Rubinovitz (1993) estimates an elasticity of e = -1.46 for the American demand for cable television services in 1984 and -1.45 in 1991. A re-estimation of the Rubinovitz model over the data from the CRTC for 1989 – 1991, augmented with channel information from Mediastats, and provincial per capita incomes and VCR penetration rates from Statistics Canada, confirms these values: e = -1.5 in 1989, slightly less elastic in 1990 and 1991 [with values of -1.42 for 1990 and -1.43 for 1991].[9]

One explanation for the finding of very inelastic demand in this study is that the model structure yields estimates of short run demand.[10] Although it seems clear that the annual data employed here captures long run decisions on the part of the CATV with regard to production (see Law and Nolan (1999)), it could be the case that one year is not sufficient to capture long run decisions on he demand side. Either firms may take longer than one year to alter their subscription pricing patterns – and recall that these firms are regulated and must secure approval from the CRTC for pricing increases – or consumers take more than one year, on average, to respond to price signals by, for example, switching to DBS systems away from CATV service. Installation of the dish for DBS reception may have been a more daunting prospect in the mid 1990s than it is now.

[9] Law (1997) Text p.262 and Results p.291.

[10] I am grateful to Vaughan Dickson for this observation.

Own-price elasticity, non-basic service, e_p

ONTARIO	Parameter Estimate	Standard Error	t-statistic		P-value
1990	.041656	.808292E-02	5.15364	**	[.000]
1991	-.515171	.127225	-4.04929	**	[.000]
1992	-.116704	.032934	-3.54354	**	[.000]
1993	-.168016	.051990	-3.23169	**	[.001]
1994	-.059866	.013423	-4.46009	**	[.000]
1995	-.293748	.055327	-5.30931	**	[.000]
1996	-1.10947	.361154	-3.07203	**	[.002]

As for basic subscriptions, estimates of the elasticity of demand would suggest little responsiveness of discretionary subscriptions to price, although there is some suggestion from the estimates from the last year of the sample period that this commodity is passing from inelastic to elastic demand.

Cross-price elasticity, basic subscriptions, non-basic price, $e_{b,p}$

ONTARIO	Parameter Estimate	Standard Error	t-statistic		P-value
1990	-.460352E-03	.223170E-03	-2.06279	*	[.039]
1991	-.016319	.014359	-1.13652		[.256]
1992	-.488207E-02	.231380E-02	-2.10998	*	[.035]
1993	-.172372E-02	.996161E-03	-1.73036		[.084]
1994	.498165E-04	.329679E-03	.151106		[.880]
1995	-.905233E-02	.675986E-02	-1.33913		[.181]
1996	-.011716	.012940	-.905399		[.365]

The price of non-basic services does not seem to be a significant determinant of the number of basic subscriptions in Ontario. To the extent that the cross-price elasticity is statistically significant, its estimate is economically of little import: a one percent rate hike for discretionary services would be is predicted to reduce basic subscriptions by only a fraction of a percent.

Cross-price elasticity, non-basic subscriptions, basic price, $e_{p,b}$

ONTARIO	Parameter Estimate	Standard Error	t-statistic		P-value
1990	-.101734	.046418	-2.19170	*	[.028]
1991	-.024918	.110112	-.226301		[.821]
1992	-.017029	.033338	-.510813		[.609]
1993	-.019205	.039979	-.480390		[.631]
1994	-.137032	.044112	-3.10647	**	[.002]
1995	.014965	.022776	.657045		[.511]
1996	.376175	.219204	1.71609		[.086]

Non-basic subscriptions do not seem to be very heavily influenced by the price of basic service.

2. Income Elasticities

Income elasticity, basic service, $e_{b,Y}$

ONTARIO	Parameter Estimate	Standard Error	t-statistic		P-value
1990	-.153765	.101502	-1.51491		[.130]
1991	-.892078	.445393	-2.00290	*	[.045]
1992	-.420968	.766073	-.549514		[.583]
1993	.752309	.322256	2.33451	*	[.020]
1994	.416880	.293074	1.42244		[.155]
1995	.370887	.313113	1.18451		[.236]
1996	.410382	.245308	1.67292		[.094]

From the estimates, income is not a statistically significant determinant of the number of basic subscriptions. One explanation for this observation is the high penetration rates already achieved by basic cable television service, often over 90% in many LSAs. Although not much store can be placed in these estimates, it is of passing interest that the sign of the income elasticity changes from negative to positive at about the time that the Canadian economy was beginning to recover from the recession of the early 1990s.

Income elasticity, non-basic service, $e_{p,Y}$

ONTARIO	Parameter Estimate	Standard Error	t-statistic		P-value
1990	-.315513	.149903	-2.10478	*	[.035]
1991	-.456454	.246001	-1.85550		[.064]
1992	.046494	.063895	.727659		[.467]
1993	.060164	.040670	1.47933		[.139]
1994	.051971	.070681	.735286		[.462]
1995	-.033892	.040954	-.827551		[.408]
1996	-.416116	.282854	-1.47113		[.141]

Similarly, changes in average per capita income in a LSA appear not to affect the number of subscriptions to non-basic service. For the early 1990s the estimates for this income elasticity follow the same pattern of sign change as did that for basic service. By the mid-1990s, however, the estimates return to being negative.

IV. DISCUSSION

Two fundamental pieces of evidence remain to be introduced. The first is the degree to which rates charged by the CATV firms for basic service in rate-regulated LSAs fell below the allowable maximum rates set by the CRTC.

Results from the following regression equation would be expected to display $\phi_1 = 1$ if firms were constrained by the regulated prices, $\text{RATE}_n = \phi_1 \text{APRATE}_n + \xi_n$, for each cable operation, n, where RATE is the actual rate charged for a direct subscription in the n^{th} LSA and APRATE is the rate approved by the CRTC. ϕ_1 provides an estimate of the average ratio of the rates charged to the allowable rates. Note that higher than allowable rates can occur either through the averaging process that generated annual returns data or through the actual rates charged being slightly higher than the capped rates.

Average ratio of Direct Rate / Approved Rate for Class 1 and 2 LSAs

Year	Ratio	Standard Error
1990	1.10971	.062200
1991	1.04869	.00557864
1992	1.04233	.00474460
1993	1.03766	.00461669
1994	1.04240	.00442681
1995	1.03582	.00719895
1996	1.05255	.00592165

There appears to be weak evidence to support the contention that firms are systematically underpricing basic cable service, relative to the permissible rate structure, in order to secure additional subscriptions for non-basic service. The estimates of the relevant elasticities do not suggest that such a strategy would be successful. And the proportion of rate-regulated (Class 1 and Class 2) LSAs in which the direct rates are less than the approved rates is less than one third and generally less than one fifth of the LSAs.

Proportion of Class 1 and 2 LSAs with Direct Rates less than Approved Rates for Basic Service

1990	29.2%
1991	12.3%
1992	17.2%
1993	16.8%
1994	17.4%
1995	18.7%
1996	13.8%

The second piece of evidence concerns the marginal efficiency cost of allowing the CATV firms to price above marginal cost. See the notes following the text for a derivation of the Ramsey-Boiteux multiplier. The R-B multiplier, the parameter λ, measures the marginal value to a regulator, who is assumed to be concerned with maximizing the sum of surplus, of reducing the profits to the firm from some constrained level $B > 0$, or the marginal efficiency cost of not reducing B.

λ_b, Marginal Efficiency Cost, Ramsey-Boiteux Multiplier (Classes 1 and 2 only, Basic Service)

CANADA	Parameter Estimate	Standard Error	t-statistic		P-value
1990	-.040079	.055912	-.716835		[.473]
1991	.044560	.061817	.720834		[.471]
1992	**.081388**	.036846	2.20885	*	[.027]
1993	-.016982	.230988	-.073517		[.941]
1994	**.195378**	.094168	2.07479	*	[.038]
1995	.267770	.163628	1.63646		[.102]
1996	.057093	.048828	1.16927		[.242]

Given the generally low estimates of the own-price elasticity for basic service, the resulting estimates of λ_b suggest that rates could be higher without much efficiency loss, although the subscribing public would be unlikely to be pleased at the resulting transfer of consumer surplus to firms.

VI. CONCLUDING NOTES

Elasticities of demand appear to be much lower than earlier estimates would suggest.

There is only weak evidence that CATV firms systematically underpriced rate-regulated basic service to secure subscriptions to non-basic service which is not rate-regulated.

Estimates of the Ramsey-Boiteux multiplier, that provide an estimate of the marginal efficiency cost of not constraining basic rates more closely, suggest that little efficiency loss would have occurred from higher rates. This suggests that the CRTC was not allowing rates to climb "too high" in terms of efficiency loss from the exercise of market power, Instead it suggests that there was considerable room to allow rates to move still higher, although this would be unpopular with subscribers who would be unhappy with higher rates, especially those who felt that since program choice had been excessively restricted for the purpose of emphasizing Canadian content purposes.

There is some suggestion that some cross-subsidization of basic service from non-basic revenues occurred through the CRTC's rate regulation although a firmer conclusion on this point will need to await further research.

To the extent that there is cross-subsidization, this would suggest that the CRTC valued groups of consumers differently: subscribers with basic service alone likely received higher weighting in the CRTC welfare calculation than those with basic and non-basic service. A future research project would be to estimate the degree of this discrimination, to uncover the regulator's social welfare weights [Ross (1984)].

Notes on Marginal Efficiency Cost[11]

Although the CRTC does not use Ramsey-Boiteux pricing to determine allowable rates for basic service, the Ramsey-Boiteux (R-B hereafter) structure allows assessment of the impact of regulation on the constrained maximization of surplus, in the absence of transfers from a regulatory authority.[12] If the regulator seeks to maximize the sum of consumer and producer surplus, subject to the constraint that the producer receives at least B (typically $B = 0$), the regulator's problem is to set a price, P, to maximize:

$$L = \int_{P}^{\infty} Q(P)dP + PQ(P) - C(Q(P)) + \lambda[PQ(P) - C(Q(P)) - B], \tag{22}$$

with first-order conditions:

$$\frac{\partial L}{\partial \lambda} = 0, \text{ or, } PQ(P) - C(Q(P)) = B; \text{ and} \tag{24}$$

$$\frac{\partial L}{\partial P} = 0 = -Q(P) + Q(P) + P\frac{\partial Q}{\partial P} - \frac{\partial C}{\partial Q}\frac{\partial Q}{\partial P} + \lambda\left[Q(P) + P\frac{\partial Q}{\partial P} - \frac{\partial C}{\partial Q}\frac{\partial Q}{\partial P}\right], \text{ or,} \tag{26}$$

$$\frac{P - \frac{\partial C}{\partial Q}}{P} = -\frac{1}{\varepsilon}\frac{\lambda}{1+\lambda}.$$

From this solution, we get the familiar result that the proportional mark-up of price over marginal cost should be a function of the demand elasticity and the multiplier from the constrained maximization problem. The multiplier reflects the cost to the objective function of raising the allowable profit level of the producer, since:

$$\frac{\partial L}{\partial B} = -\lambda, \tag{28}$$

Given $B = 0$, we can compare this cost to the social benefit of avoiding distortionary (non-lump-sum) tax revenues by allowing the distortionary (non-marginal-cost) pricing required to meet the balanced budget for the producer.[13]

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[11] Discussion drawn from Law (1999).

[12] See Laffont and Tirole (1993, 30-32).

[13] Assuming that the constraint is binding (and the demand function is well-behaved), the constraint is sufficient to determine a unique solution to the maximization problem. The first order condition in Equation (26) yields the relationship between the price-marginal cost ratio, g, and the Ramsey-Boiteux multiplier, λ, shown in Equation (32).

Intuitively, the government has the option of subsidizing the firm by paying its costs less any revenues and then taxing society, to pay for the subsidies, with some distortionary tax system. One dollar raised in taxes costs society $1 + \theta$ dollars. If the government chooses instead to allow distortionary pricing, the efficiency cost of the distortion should be no higher than θ, the cost of raising public funds. To see this, consider the maximization problem of the government's regulatory authority attempting to maximize surplus while ensuring that the producer breaks even with a subsidy. The social cost of raising each dollar of the subsidy is $1 + \theta$. Since the producer receives exactly $B = 0$, by construction, the problem is:

$$\max_P \left\{ \int_P^{\infty} Q(P)dP - (1+\theta)[(C(Q(P)) - PQ(P)] \right\}, \tag{30}$$

which is exactly the problem for which the multiplier was λ, although in general $\theta \neq \lambda$.

The parameter λ measures the marginal value to the regulator's objective function of reducing the profits to the firm from some level $B > 0$, or the marginal efficiency cost of not reducing B.[14] Thus, if we are to retain pricing regulation, at the very least, λ should be less than θ. Where conditions of constant returns to scale obtain, marginal-cost pricing is feasible (and equivalent to $B = 0$) and we might hope to see λ near zero.[15]

The Ramsey-Boiteux solution for the price-marginal cost ratio yields another interpretation of the parameter g. Under R-B pricing:

$$g = \frac{1}{1 + \left(\frac{1}{\varepsilon}\right)\left(\frac{\lambda}{1+\lambda}\right)}, \quad \text{or,} \quad \lambda = \frac{-\varepsilon(g-1)}{\varepsilon(g-1) + g}. \tag{32}$$

An estimate of the marginal efficiency cost, λ, can be derived, then, from an estimate of the own-price elasticity of demand, ε, and an estimate of the ratio of price to marginal cost, g.

Examples of values for the R-B multiplier are provided in the table below.

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[14] It is not unreasonable to suppose that λ increases monotonically with increasing B. There could be discontinuities if discriminatory pricing or non-linear tariffs were used but, with the exception of installation fees, prices within each LSA are uniform rates.

[15] Note that the subsidy scheme presumes that public funds would be used to compensate a CATV firm for losses incurred from marginal-cost pricing if marginal cost falls below average cost. In practice, this approach may not be desirable on equity grounds since the set of taxpayers may not correspond exactly to the set of CATV consumers. Another common subsidy scheme is cross-subsidization. The focus of CRTC rate regulation of CATV is on rates for basic service. Some degree of cross-subsidization from discretionary services to basic services might allow the CRTC to constrain basic prices to marginal cost. For an example of cross-subsidization in a network industry, consider the telephone industry: some providers of telephone services have claimed that long distance tolls subsidized local service to such an extent that local rates were below marginal cost. Estimating the extent to which cross-subsidization is possible represents an interesting task for future research.

Ramsey-Boiteux multiplier (λ) for 3 values of elasticity

Year	*g*	Elasticity			Year	*g*	Elasticity		
		-1.50	-1.25	-1.00			-1.50	-1.25	-1.00
		All LSAs					Part 3 LSAs		
1985	1.34	**0.61**	0.46	0.34	1985	1.14	**0.23**	0.18	0.14
1986	1.39	**0.73**	0.54	0.39	1986	1.25	**0.43**	0.33	0.25
1987	1.38	**0.70**	0.52	0.38	1987	1.18	**0.30**	0.24	0.18
1988	1.40	**0.75**	0.56	0.40	1988	1.25	**0.43**	0.33	0.25
1989	1.38	**0.70**	0.52	0.38	1989	1.31	**0.55**	0.42	0.31
1990	1.29	**0.51**	0.39	0.29	1990	1.20	**0.33**	0.26	0.20
1991	1.34	**0.61**	0.46	0.34	1991	1.32	**0.57**	0.43	0.32
		Class 1 LSAs					Single-LSA Firms		
1985	1.19	**0.31**	0.25	0.19	1985	1.43	**0.82**	0.60	0.43
1986	1.26	**0.45**	0.35	0.26	1986	1.36	**0.66**	0.49	0.36
1987	1.28	**0.49**	0.38	0.28	1987	1.41	**0.77**	0.57	0.41
1988	1.28	**0.49**	0.38	0.28	1988	1.52	**1.05**	0.75	0.52
1989	1.35	**0.64**	0.48	0.35	1989	1.46	**0.90**	0.65	0.46
1990	1.15	**0.24**	0.19	0.15	1990	1.35	**0.64**	0.48	0.35
1991	1.15	**0.24**	0.19	0.15	1991	1.43	**0.82**	0.60	0.43
		Class 2 LSAs					Multi-LSA Firms		
1985	1.32	**0.57**	0.43	0.32	1985	1.43	**0.83**	0.61	0.43
1986	1.34	**0.61**	0.46	0.34	1986	1.53	**1.08**	0.76	0.53
1987	1.34	**0.61**	0.46	0.34	1987	1.50	**1.00**	0.71	0.50
1988	1.42	**0.80**	0.59	0.42	1988	1.49	**0.97**	0.70	0.49
1989	1.37	**0.68**	0.51	0.37	1989	1.40	**0.75**	0.56	0.40
1990	1.33	**0.59**	0.45	0.33	1990	1.30	**0.53**	0.41	0.30
1991	1.20	**0.33**	0.26	0.20	1991	1.38	**0.70**	0.52	0.38

Table drawn from Law (1997), p.272

Data Appendix

Table A1
Selected Descriptive Statistics for Basic Service, All LSAs, 1996

Variable	Mean	Std Dev	Minimum	Maximum
Direct Subscribers, Q_1	18069.19	51991.18	67	667567
Indirect Subscribers, Q_2	1427.15	5379.54	1	71296
Channels, H	23.59	6.00	8	42
Total Cost, C	4420724.38	14190300	8681.35	174814000
Price of Capital, P_K	0.31578	0.095772	0.12027	1.59437
Price of Labor, P_L	44056.20	22403.30	2556.00	261285.00
Cost Share of Labor, S_L	0.22724	0.091340	0.014374	0.65398
Cost Share of Capital, S_K	0.30461	0.12703	0.00051516	0.80442
Total Kilometres of cable	451.37634	914.76813	3.3600	11310.10
Houses Passed (wired for cable)	25029.1	80806.5	165	1159781
Density Measure	0.022213	0.037673	0.0050119	0.13641

Number of Observations: 358

Output and Revenue
Output has several dimensions: subscriptions to basic service, Q_B, the (unduplicated) number of recipients of pay service, Q_P, and the numbers of channels in each tier of service, H_B and H_P. For basic service, the subscription level is the "equivalent total" number of subscribers, calculated as the number of direct subscribers to basic service inflated by the ratio of total revenue, from both direct and indirect subscribers, to revenue from direct subscribers. The number of subscribers is adjusted to revalue indirect subscribers (*e.g.*, in apartment buildings where cable services are part of the rent) to be comparable to direct subscribers. Basic revenue is the total revenue from basic service, including revenues from direct subscribers, indirect subscribers, and installation fees. Revenue for pay services includes all fees paid for discretionary services, including rental of decoding equipment.

Cable Length and Density
D = density measure. LSAs comprising relatively larger territories require more cable; LSAs which are relatively more sparsely populated require more cable per subscriber. To control for variations in density, we use subscriber sparsity (inverse density) measured by the kilometers of cable per wired household.

Capital inputs
P_K = price of capital. The level of net assets is as calculated by the CRTC: the historical cost of those assets less accumulated depreciation. The rental price of capital is the sum of depreciation and financing rates. The depreciation rate is obtained directly from the CRTC database. The financing rate used here is given by: i, the "risk free" interest rate (the average of monthly ten-year-plus bond rates for a year ending in August),[16] plus a risk premium, $\gamma\beta$, where γ is the market risk premium and β is the systematic risk factor.[17] The assumption required for this value for the risk premium is either that the firms are 100% equity-financed, or, equivalently, that the required rate of return on equity is equal to the required rate of return on debt. The risk premium used is 0.042 from market risk of 7% and β of 0.6.

Labour and other inputs
Operating expenses, non-capital-related costs, are salaries plus expenditures on "materials". P_L = price of labor. To derive the price of labor, salaries are divided by the number of staff employed within the LSA. P_M = price of "materials". The cost of "materials" is the sum of costs of other inputs in operating expenses other than labor and the price of materials is proxied by the Industrial Product Price Index.[18]

Costs
Total costs, C = operating expenses + depreciation + $((i + \gamma\beta)$*(net assets), where operating expenses are total expenses less programming expenses and the other components are as defined above under capital inputs. An assumption maintained for this study is that costs are additively separable by output, *i.e.*, considering basic service alone, without including the provision of non-basic services, does not introduce excessive bias.

Income and demographics
Average per capita income and the fraction of the population between the ages of 20 and 50 for each district corresponding as closely as possible to the LSA were obtained for the years 1991 and1996. 1991 was a census year. Linear interpolation and extrapolation was used to generate values for other years.

Off-air Competition
The extent to which signals are available off-air, via standard broadcast, is expected to influence demand. A comparative variable, COMP, was constructed as follows:

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[16] Source: Statistics Canada, CANSIM database, series B14003, Government of Canada bond yields.

[17] Patterson (1990) estimates an unlevered β_u for basic service in Canada of 0.6.

[18] Source is Statistics Canada, CANSIM database, series D694193, IPPI, all industries, excluding food and beverage industries, average of 12 months ending August 31, with a base year of 1986.

$$COMP = \log\left(\frac{1 + H_B}{1 + 0.9\left(1 - \gamma\right)H_B + 0.6\gamma H_B}\right)$$

where γ is the proportion of basic signals that are 'distant' as defined by the CRTC and the Copyright Board of Canada (for the purpose of calculating liability for distant signal retransmission royalties). Such signals presumably are of lower quality received on a broadcast basis.

Other variables
Dummy variables for *Region* were used: Atlantic (Newfoundland, Nova Scotia, Prince Edward Island and New Brunswick); Quebec; Ontario; Prairies (Manitoba, Saskatchewan, and Alberta) and NorthWest (British Columbia and the Territories).

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