A Demand Model of Physician Membership in the American College of Radiology

by

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(ABSTRACT)

The strength and affluence of an association is related to the size of its membership and its share of those eligible for membership. Associations, therefore, have an incentive not only to recruit new members, but also retain those who already belong. However, less is known about the exogenous economic factors that influence an individual's membership decision.

Using time-series data from 1977 to 1992 and linear regression techniques, this thesis identifies and measures the economic factors important to the physician membership percentage of the American College of Radiology. The results of this thesis will provide the leadership of the American College of Radiology useful insight into the impact certain variables have on the membership.

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Table of Contents

Table of Contents

List of Illustrations

List of Tables

I. INTRODUCTION AND OVERVIEW

A. Importance of thesis to the ACR

The strength of an association is measured, in part, by the size of its membership and the market share of those eligible for membership it commands. Since its founding in 1923 by twenty physicians, the American College of Radiology (ACR) has grown to nearly 29,000 members. During this time, the ACR has become the principle socioeconomic medical association for radiologists (physicians who specialize in the diagnostic and therapeutic use of x-rays) in the United States.

The number of members belonging to an association determines its financial viability. Dues from dues paying members account for over a third of the ACR's total revenue. Total revenue, in turn, is spent providing benefits to members. It follows then, a well financed organization can bestow more benefits to its members than can one with lesser earnings. The more benefits members receive from belonging to an association, the more likely they are going to remain a member and pay dues.

The political clout of an association is dependent, somewhat, on the size of its constituency. One needs only to look as far as the American Association of Retired Persons, the National Educational Association, and, in medicine, the American Medical Association for examples of large organizations with effective lobbying efforts. The effectiveness of these organizations rests with their ability to mobilize large numbers of individuals on a particular subject and deliver their concerns to the targeted audience. In the past, radiologists under the direction of the ACR have participated in letter writing campaigns and other grass-roots efforts in an attempt to make lawmakers, etc. aware of

their interests. As a counter example, some unions have seen the size of its membership fall and their power wane as a result.

Not only is the number of members important to the success of an association, but so is its share of those eligible for membership. Organizations with large market shares can speak as the "true voice" of their constituencies. Conversely, individuals represented by numerous factions may find their message diluted and their efforts ineffective.

It is important, based on the aforementioned reasons, for the leadership of the ACR to know how administrative actions, such as dues changes, will be perceived by the general membership. This analysis will provide the ACR leadership with a model for assessing the role that dues play in the membership decision. Armed with such a model, the ACR leadership will be able to forecast beforehand how members will react to a dues change and plan accordingly.

B. Structure of the ACR

Membership. Diagnostic radiologists, radiation oncologists (i.e. therapeutic radiologists), nuclear medicine specialists, and radiation physicists are eligible for membership in the ACR. (Unless otherwise stated, the remainder of this report will use the term "radiologist(s)" to represent both diagnostic radiologists, nuclear medicine physicians, and radiation oncologists.) Regardless of radiologic specialty, candidates for membership must have passed their oral and written examinations given by either the American Board of Radiology (ABR), the American Osteopathic Board of Radiology (AOBR), or the Royal College of Physicians and Surgeons of Canada (RCPSC)[1]. Radiologists or physicists who have passed their examinations are considered board certified. Alternatively, a physician in full-time practice of nuclear medicine or ultrasound are also eligible for

membership provided they have been certified by a member of the American Board of Medical Specialties or its Canadian equivalent[2].

There are four general membership categories for radiologists and radiologic physicists. The first category is Active Membership. Active members of the ACR are radiologists or physicists in full-time practice of radiology or radiologic physics and certified by one of the aforementioned Boards. Associate members (established in 1982), the second type of membership in the ACR, are radiologists or physicists, without board certification. Radiologists or physicists who have accomplished significant scientific research in their respective field, performed outstanding services as a teacher, or served significantly organized medicine may be selected to become a Fellow of the ACR. Fellows are Active members, although separated for special distinction. The final general membership type, Members-in-Training, consists of those radiologists or physicists who are students in a residency program.

Besides the four general types of membership, four other categories exist: (1) Retired members or fellows, (2) Corresponding Members, (3) Fellow Emeritus, and (4) Honorary Fellows. Retired members is the largest of the remaining categories consisting of radiologists or physicists who are no longer in active practice. Although most ACR members are either from the United States or Canada, radiologists and physicists from other countries may also belong to the ACR as a Corresponding member. The remaining categories are small, specific designations. In all, there are twelve membership classifications in the ACR.

Dues. Nearly sixty percent of ACR members pay annual dues. Dues paying members consist of the Active, Fellow, Associate, and Corresponding membership categories.

Student and retired members, conversely, are exempt from dues payment. Prior to 1980, the ACR had a single dues fee for all dues paying members. In 1980, a three tier pricing mechanism was enacted. Members in their first year of practice after residency or further training (fellowship) typically received a twenty percent discount from the full dues rate. (In 1988, first year members paid sixty-seven percent of the full dues amount.) Members in their second year of ACR membership typically had a ten percent discount (twenty-two percent in 1988). By their third year, new members paid the full dues amount. The ACR's dues structure for new members, therefore, results in a step-wise escalation in dues. Such a progression, it was hoped, would entice residents and non-members to join. Furthermore, the step-wise progression is somewhat commensurate with income. Radiologists in their first year of practice have lower incomes, generally, than more experienced radiologists. However, once a radiologist becomes a full-partner in their group (usually after two to three years), they receive a greater share of the group's revenue. In 1990, the ACR further altered its recruitment policy towards graduating radiologists by automatically granting them ACR member status. Introductory members, as this group is known, receive one year's membership free. After this year, they pay dues based on the step-wise progression already discussed.

State Chapters. As a requirement for ACR membership, ACR by-laws stipulate that members must also join the ACR state chapter in which they practice[3]. State chapter dues vary widely from none to $350.00, with most under $100.00. Most state chapters charge a single dues fee without student or new member discounts. Many states, however, offer a discount for physicists.

II. MATERIALS AND METHODS

A. Data

Number of Radiologists and Board Certification. The explanatory variable in this analysis is the percentage of those radiologists who are eligible for membership actually belong to the ACR (i.e. ACR membership rate). [Physicists were later excluded from the analysis because data for such variables as income, total number of physicists, etc. which were available for radiologists were not available for physicists.] The AMA's Physician Masterfile provided the information for the denominator of the ACR membership ratio (e.g. the total number of radiologists in the U.S., the total number of radiologists with board certification). The Physician Masterfile is widely acknowledged as the most comprehensive database of physician-related information. It contains general demographic information (e.g. sex, birth date) as well as professional and educational information (e.g. board certification, medical specialty) for all U.S. physicians. In addition, the Masterfile is continually updated as new information is obtained on physicians.[4]

A major source of information for the Masterfile is the record of Physicians' Professional Activities (PPA) questionnaire. Between 1969 and 1985, the PPA survey was mailed to each physician every four years. Since 1985, the PPA survey has been administered as a rotating census where approximately one-third of all physicians are surveyed each year. Sixty thousand additional physicians are surveyed through monthly supplemental mailings for address changes, etc.[5]

The Masterfile's data on board certification has two categories of certification relative to a physician's specialty: (1) Certified by Corresponding Board, and (2) Certified by Non-corresponding Board. A physician who is certified by a corresponding board means that he/she passed the board of his/her specialty. On the other hand, physicians who are

certified by boards outside of their specialty are considered to be certified by a non-corresponding board.[6] The American Board of Radiology (ABR) and the American Board of Nuclear Medicine (ABNM) are the primary certifying bodies for radiologists in the U.S. (To repeat a point made earlier, certification by either the ABR or ABNM makes the physician eligible for ACR Active membership.) The ABR certifies physicians in radiology, diagnostic radiology, radiation oncology, and nuclear radiology. The ABNM certifies mostly physicians in nuclear medicine. Therefore, a physician who practices radiology and is certified by the ABR would be classified by the AMA as being certified by a corresponding board. Alternatively, a physician who practices radiology and is certified by the ABNM would be designated as being a non-corresponding board diplomate. In addition, physicians may possess numerous certifications from both corresponding and non-corresponding boards. Therefore, in order to capture the total number of radiologists, radiation oncologists, and nuclear medicine physicians with board certification, the corresponding and non-corresponding board categories for these physicians were aggregated. (See Table 1.) [The use of the board certification data in such a manner will, unavoidably, include some radiologists, etc. listed as being certified by a non-corresponding board, but whose board is not recognized by the ACR for membership (e.g. a radiologist who is board certified by the American Board of Internal Medicine).] The AMA's information on board certification excludes retired physicians and physicians who are permanently or temporarily out of practice.

Table 1: Radiologists by Specialty and Board Certification Status

Specialty and Board Certification Status	1981	1982	1983	1984	1986	1987	1989	1990	1992
Diagnostic Radiology - Corresponding Board only †	4589	5512	6204	6828	8047	8726	9824	10406	11447
Diagnostic Radiology - Corresponding Board and Other Boards †	429	484	520	570	657	726	806	837	895
Diagnostic Radiology - Noncorresponding Board †	N/R	150	213	189	210	224	224	223	256
Diagnostic Radiology - Not Board Certified	2030	2501	3795	3758	3973	4194	4133	3946	4655
Diagnostic Radiology - Total *	7048	8647	10732	11345	12887	13870	14987	15412	17253
Nuclear Medicine - Corresponding Board only †	N/R	370	367	383	416	405	425	442	423
Nuclear Medicine - Corresponding Board and Other Boards †	N/R	499	518	538	560	538	551	553	560
Nuclear Medicine - Noncorresponding Board †	N/R	144	148	172	173	149	142	132	131
Nuclear Medicine - Not Board Certified	N/R	143	109	202	203	223	221	213	258
Nuclear Medicine - Total *	N/R	1156	1142	1295	1352	1315	1339	1340	1372
Radiology - Corresponding Board only †	8452	7086	7001	6918	6750	6365	6336	6197	5907
Radiology - Corresponding Board and Other Boards †	1286	798	804	807	818	801	816	790	784
Radiology - Noncorresponding Board †	N/R	222	197	191	185	179	187	194	216
Radiology - Not Board Certified	1915	1630	1032	1192	1004	1000	1184	1311	941
Radiology - Total *	11653	9736	9034	9108	8757	8345	8523	8492	7848
Radiation Oncology - Corresponding Board only †	1192	1242	1306	1380	1512	N/R	1823	1860	1987
Radiation Oncology - Corresponding Board and Other Boards †	82	95	103	108	122	N/R	171	181	207
Radiation Oncology - Noncorresponding Board †	N/R	36	43	43	51	1822	62	72	67
Radiation Oncology - Not Board Certified	307	371	443	523	587	642	686	708	752
Radiation Oncology - Total *	1581	1744	1895	2054	2272	2464	2742	2821	3013
† : Categories used to define the total number of radiologists with board certification (denominator of RATCERT)									
* : Total number of radiologists without consideration of board certification (denominator of RATIOALL)									
N/R: Not Reported									
Source: Physician Characteristics and Distribution, AMA									

Although the Masterfile is continually updated by the PPA survey, the survey's findings are not always made available; as a result, gaps exist in the database (1984, 1985, 1991). Furthermore, the date used for reporting the information was not consistent. The AMA's report date from 1980 - 1988 was December 31, and January 1 ever since. For consistency purposes, all statistics were made effective as of January 1. An assumption was, therefore, made that the data did not differ from December 31 to January 1; a subsequent conversation with AMA staff upheld this assumption.[7]

ACR Membership Statistics. The ACR's membership reports were used to gather the number of physicians who belonged to the ACR in any given year. (See Table 2.) These reports are generated two or three times a year (typically January, June, and September) for presentation to the ACR's Board of Chancellors (the governing body of the ACR). Whenever possible, the January reports were obtained for the analysis. The use of the January 1, ACR membership reports coincides with most of the AMA's data. However, for 1984, the membership statistics were generated on January 6. The difference between January 6 and January 1 was not significant; therefore, the information was used as if it was effective as of January 1, 1984. Physicists, corresponding members, and non-dues paying members (e.g. residents and retired members) were excluded from the membership counts used in this study.

ACR Dues. For the sixteen years spanning this study, the membership dues charged by the ACR were collected. (See Table 3.) During this time, dues changed four times (1978, 1980, 1985, 1988). In 1977, the ACR charged its dues paying members $125.00; by 1992, dues had risen to $475.00. Dues changes (typically an increase, although the reverse is possible) are not unanticipated. The new dues rate is implemented on January 1.

However, the decision to raise dues is made months before at the ACR's Annual Meeting in September. The policy actions made at the ACR's Annual Meeting are published in the ACR's newsletter in the months following the meeting. Therefore, members have plenty of lead-time before the increase in order to decide whether or not to remain a member.

Members' reaction to nominal and real changes in dues are tested in the model. Nominal dues (i.e. the stated dues amount in a given year) is converted into real dues though the use of the Consumer Price Index - urban consumers (CPI-U), with 1977 as the base (i.e. 1977 constant dollars). To calculate real dues using 1977 as the base, the nominal dues are multiplied by the ratio of $CPI\text{-}U_{1977}/CPI\text{-}U_i$, where i = 1977 - 1992.[8] (See Table 4.)

Radiologists' Net Income. Statistics on radiologist's income are provided courtesy of the AMA's Socioeconomic Monitoring System (SMS) survey. The SMS survey originated in 1981 in response to a need for socioeconomic information on medical practice. Conducted via telephone, sampled physicians respond to a set of fixed, "core" questions which permit trend analysis. In some years, supplemental questions are also asked on issues relevant in a particular year.[9]

The sample universe for the SMS survey consists of 6000 physicians taken at random from the AMA Physicians' Masterfile. Before the selected physicians are contacted, the representativeness of the sample to the general physician population is ensured. Approximately 4000 physicians respond to the SMS survey each year. (The AMA has a minimum response rate of 60 percent.)[10]

Income, as defined by the AMA's SMS, is pre-tax net income (i.e. gross income less expenses).[11] Two measures of income (mean and median) are used in the regression in

order to test which has more explanatory power. (See Table 5.) Real mean and median income were derived using the same approach taken for real dues.

ACR Member Benefits. The benefits ACR members accrue are an important factor in deciding whether or not to belong to the ACR. However, it was beyond the scope of this study to attempt to directly measure the value members place on ACR services. Rather, ACR annual operating expenses (less revenue earned from government grants and contracts) were used as a proxy of the value members placed on belonging to the ACR. (See Table 6.) The underlying rationale for this proxy is that many of the member benefits, both tangible and intangible, have quantifiable costs. There are accountable costs in terms of personnel, printing, travel, etc. of providing such benefits as: educational services, legal advice, government lobbying, publications, etc. Instead of using the actual expense figures, they are converted into a ratio with 1977 as the base. Real benefits were also estimate using the method described for real dues.

This proxy is probably far from being a perfect measure of ACR member benefits. Besides not measuring the "worth" members place on services offered by the ACR, this proxy fails to represent the psychological benefits of membership (e.g. self-identification with a profession).[12] In addition, the literature reports that association membership may positively affect income.[13] Furthermore, the proxy assumes that expenses are spent efficiently. Wastefulness would overestimate costs and, therefore, inflate perceived benefits.

Table 2: ACR Membership Statistics

Year	Active Members	Fellows of the ACR	Associate Members
1977	9174	1558	
1978	9924	1619	
1979	10492	1711	
1980	10728	1804	
1981	11379	1884	
1982	11411	1882	30
1983	11662	1948	58
1984	11870	1947	108
1985	12387	1949	163
1986	12446	1881	184
1987	12493	1872	196
1988	12861	1895	219
1989	12512	1855	203
1990	12881	1815	217
1991	13450	1842	274
1992	13909	1849	270

Table 3: ACR Dues History 1977 - 1992

Year	ACR Dues Amount		
	First Year ($)	Second Year ($)	Third Year (Full Amount) ($)
1977			125.00
1978			175.00
1979			175.00
1980	200.00	225.00	250.00
1981	200.00	225.00	250.00
1982	200.00	225.00	250.00
1983	200.00	225.00	250.00
1984	200.00	225.00	250.00
1985	260.00	300.00	325.00
1986	260.00	300.00	325.00
1987	260.00	300.00	325.00
1988	320.00	370.00	475.00
1989	320.00	370.00	475.00
1990	320.00	370.00	475.00
1991	320.00	370.00	475.00
1992	320.00	370.00	475.00
Italics indicates year in which dues changed			

Table 4: Real Dues (Base 1977)

Year	Consumer Price Index (Urban Consumers)	Real Dues ($)
1977	60.6	125.00
1978	65.2	162.65
1979	72.6	146.07
1980	82.4	183.86
1981	90.9	166.67
1982	96.5	156.99
1983	99.6	152.11
1984	103.9	145.81
1985	107.6	183.04
1986	109.6	179.70
1987	113.6	173.37
1988	118.3	243.32
1989	124.0	232.14
1990	130.7	220.24
1991	136.2	211.34
1992	140.3	205.17

Table 5: Radiologists' Pre-tax Net Income 1977 - 1992

Year	Mean		Median	
	Nominal ($)	Real (Base-1977) ($)	Nominal ($)	Real (Base-1977) ($)
1977	76,700	76,700	72,000	72,000
1978	81,300	75,564	80,000	74,356
1979	95,800	79,965	85,000	70,950
1980	*103,656*	*76,232*	*92,140*	*67,763*
1981	108,000	72,000	105,000	70,000
1982	133,300	83,710	120,000	75,358
1983	144,300	87,797	128,000	77,880
1984	139,700	81,480	122,000	71,157
1985	144,300	81,269	135,000	76,032
1986	168,800	93,333	155,000	85,703
1987	180,700	96,395	170,000	90,687
1988	188,500	96,560	158,000	80,937
1989	210,500	102,873	180,000	87,968
1990	219,400	101,726	200,000	92,731
1991	229,800	102,246	223,000	99,220
1992	*248,644*	*107,397*	*241,732*	*104,412*

Italics: Estimate based on compounded annual growth rate 1977-1991 (8.2% mean, 8.4% median)

Table 6: ACR Operating Expenses (less revenue from government grants and contracts)

Year	Nominal Operating Expense Ratio (base 1977)	Real Operating Expense Ratio (base 1977)
1977	1.00	1.00
1978	1.07	0.99
1979	1.24	1.03
1980	1.36	1.00
1981	1.72	1.15
1982	1.68	1.05
1983	*1.97*	*1.20*
1984	*2.09*	*1.22*
1985	2.54	1.43
1986	2.33	1.29
1987	2.44	1.30
1988	2.99	1.53
1989	2.80	1.37
1990	3.34	1.55
1991	3.62	1.61
1992	4.07	1.74
Italics: Estimates based on growth between 1982 and 1985		

State Chapter Dues. As stated in the introduction, radiologists, etc. who join the ACR are required to belong to their local state ACR chapter. To test how members react to changes in state dues, a variable representing state dues was added to the model. Unfortunately, the records of state dues are incomplete. Furthermore, unlike the ACR which implements dues changes on January 1, some states change their dues throughout the year. At best, state chapter dues for all states were available for 1984, and 1988 - 1992. (See Table 7.) Some degree of gap-filling was possible for approximately half of the state chapters for the period of 1984 - 1992. If a state had same dues in 1988 as it did in 1984, an assumption was made that the dues remained the same during the 1984 - 1988 time period. This technique was also applied during the span from 1988 to 1992 because of variability in report dates. If a state chapter's dues were not the same in 1984 and 1988 and there was no other dues data available, the space was left blank. In the end, mean chapter dues for twenty-five chapters for the years from 1984 to 1992 were obtained and used in the analysis.

Frequency of Dues Changes. Members' tolerance to the frequency of dues changes was evaluated through a variable which counts the number of years between dues modifications, with the count restarted after each dues change. (See Table 8.) The assumption underlying this variable is that members may react differently to frequent dues changes as opposed to seldom changes. More specifically, a member may be less inclined to remain a member if the ACR changes dues frequently. Conversely, a member may be more tolerant of a dues increase if dues had not changed over several years. In addition the magnitude of the dues increases have been relatively constant (mean = 39.75%, range 30% - 46%) for the four instances where dues were raised. The consistency of the magnitude of dues increase, therefore, should allow this variable to detect members' sensitivity without concern to the size of the increase.

Table 7: ACR State Chapter Dues 1984-1992

	State Chapter Dues ($)								
State Chapter	1984	1985	1986	1987	1988	1989	1990	1991	1992
Alabama	45	45	45	45	45	45	45	45	45
Alaska	20	20	20	20	20	20	20	20	20
California	100	100	100	100	100	125	125	125	125
Delaware	20	20	20	20	20	20	20	20	20
Georgia	25	25	25	25	25	25	25	25	25
Hawaii	15	15	15	15	15	75	75	75	75
Idaho	0	0	0	0	0	0	0	0	0
Kansas	70	70	70	70	70	70	70	70	70
Kentucky	25	25	25	25	25	50	50	50	50
Louisiana	30	30	30	30	30	30	30	30	30
Maine	35	35	35	35	35	200	200	200	200
Maryland	100	100	100	100	100	100	100	100	100
Massachusetts	125	125	125	125	150	150	150	150	150
Missouri	50	50	50	50	50	50	50	50	50
Nevada	0	0	0	0	0	0	0	20	20
New Hampshire	50	50	50	50	50	50	50	50	75
New Mexico	20	20	20	20	20	50	50	50	50
New York	125	125	125	125	175	175	175	175	175
North Carolina	40	40	40	40	40	40	40	40	60
North Dakota	0	0	0	0	0	0	0	0	0
Rhode Island	200	200	200	200	200	200	200	200	200
South Dakota	0	0	0	0	0	0	0	0	0
Utah	30	30	30	30	30	30	30	30	30
Virginia	55	55	55	55	55	55	55	85	85
Wisconsin	50	50	50	50	50	50	50	50	50
Unweighted Average	49.2	49.2	49.2	49.2	52.2	64.4	64.4	66.4	68.2

Table 8: Interval From Last Dues Change

Year	Interval From Last Dues Change (Years)
1977	1
1978	0
1979	1
1980	0
1981	1
1982	2
1983	3
1984	4
1985	0
1986	1
1987	2
1988	0
1989	1
1990	2
1991	3
1992	4
Italics: Year in which dues changed	

B. Methods

Dependent Variable. The dependent variable, the percent of radiologists who are ACR members, can be expressed two different ways depending on board certification status. A general approach to the ratio would be to use all radiologists regardless of whether or not they are board certified (RATIOALL). The ratio's numerator (ACR members) would be the sum of the ACR's Active, Fellow, and Associate membership categories. The denominator would the total number of physicians who are self-designated as a "radiologist" (a diagnostic radiologist, a radiologist, a radiation oncologist, or a nuclear medicine physician). Such a ratio is possible because the ACR accepts non-certified radiologists as Associate members. Since the Associate member category is small (approximately two percent), it can be omitted. If Associate members are excluded, a second narrower ratio results (RATCERT), one which includes only board certified physicians. In this case, the numerator is the sum of the ACR's Active and Fellow membership categories. The denominator would be those radiologists, etc. with board certification (corresponding, non-corresponding, or both). Physician with non-corresponding boards were included because a radiologists may be certified by the ABNM and, therefore, would be eligible for membership. The ratios would also include some Canadian members.

Regression Model. The graph (Chart 1) depicting the two competing definitions of the percent of eligible members who join the ACR demonstrates that regardless of which definition is finally chosen, a conventional linear structural model conforms best to the

data-points. Therefore, the proposed structural model may be written as:

$$Y = b_0 + b_1X_1 + b_2X_2 + ...b_{12}X_{12} + e$$

where: b_0 is the constant term

b_i is the coefficient on each independent variable X_i

e is the disturbance term

In order to determine which definition of the ACR membership percentage was the most appropriate, the twelve independent variables were regressed against each definition. (See Table 9 for list of variables.) The definition which achieves the highest R^2 and the most statistically significant coefficients (by t-ratios) would advance for further analysis. Once the best definition was identified the independent variables were regressed individually, in pairs, and in threes so that the variables with the most explanatory power could be ascertained. Many attempts to use more than three explanatory variables were unsuccessful because of the small sample size.

Classic Linear Regression Assumptions. Any statistical inferences drawn from the regressions will not be valid unless certain assumptions are met. The classical assumptions require:

1. The mean of the disturbance is zero ($E[e_i] = 0$, for all i),
2. The disturbance term exhibits constant variance (i.e. homoscedastic),
3. The disturbance term has zero covariance (i.e. non-autocorrelation),
4. The explanatory variables are non-stochastic,
5. The explanatory variables have no multicollinearity,
6. The disturbance term is normally distributed [$e_i \sim N(0, \sigma^2)$], and
7. The model is free of specification error (i.e. How good/correct is the model?).

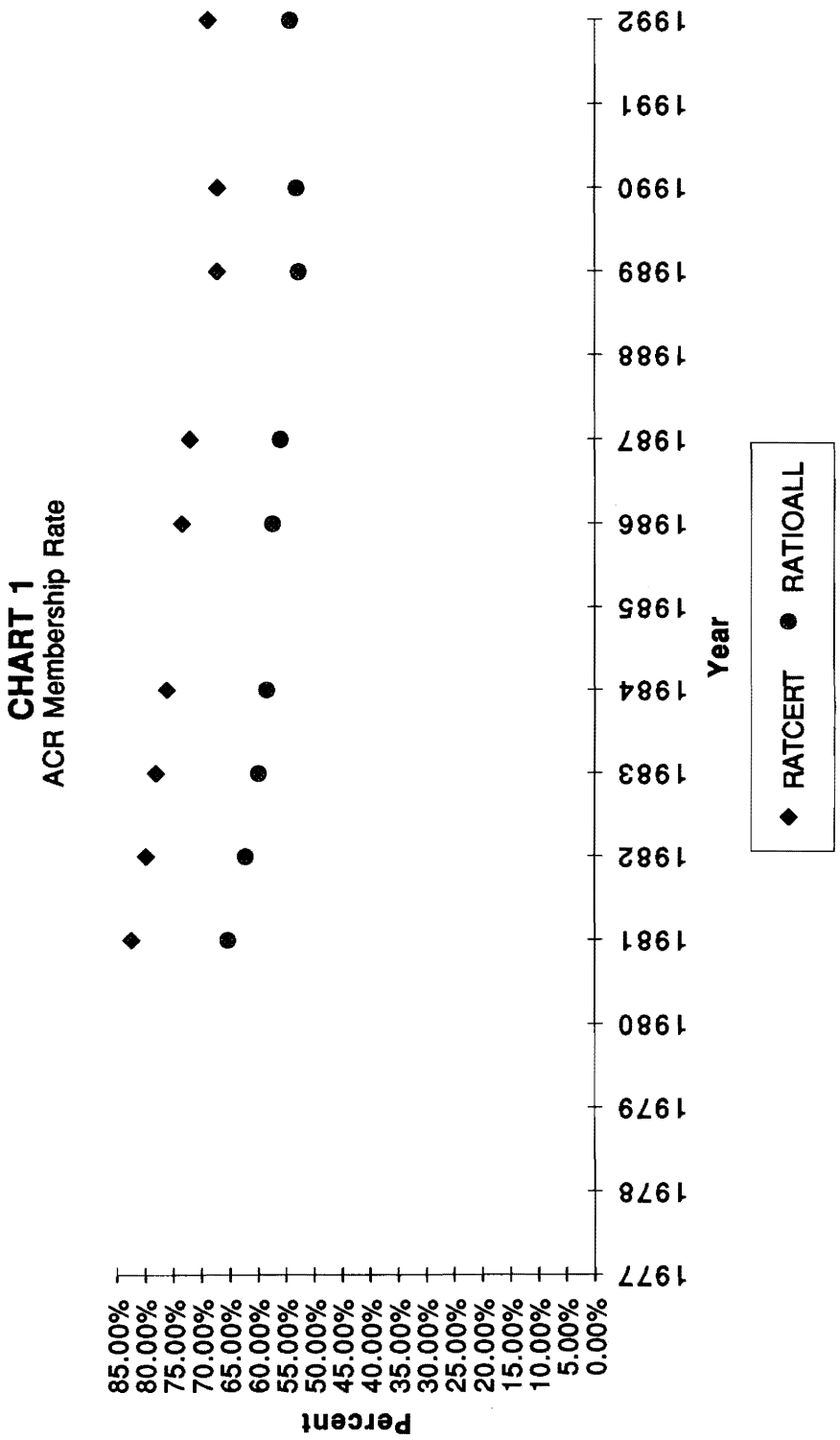
CHART 1
ACR Membership Rate
Percent
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
1977
1978
1979
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1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
Year
RATCERT
RATIOALL

Table 9: List of Independent Variables

Independent Variables	Definition
NOMDUES	Nominal dues (1977-1992)
REALDUES	Real dues (base=1977)
NMNINC	Nominal mean net income
RMNINC	Real mean net income (base=1977)
NMDINC	Nominal median net income
RMDINC	Real median net income (base=1977)
BENEFITS	Nominal ACR operating expenses (base=1977)
RBENEFIT	Real ACR operating expenses (base=1977)
STATE	Nominal mean state chapter dues (based on 25 states with complete dues histories 1984-1992)
LASTCHNG	Time interval between dues changes
TIME	A counting variable
FWDDUES	Next year's nominal dues brought forward to current year

Since the purpose of the model is estimation rather than prediction and the intercept term is of little consequence, three (1, 4, 6) of the seven assumptions can be relaxed without biasing the estimates of the coefficients.[14] Therefore, once the primary explanatory variables are identified, tests must be conducted for the presence of autocorrelation, heteroscedasticity, multicollinearity, and specification error.

Autocorrelation. The presence of autocorrelation is detected by graphing the disturbance term versus a time-trend variable.[15] If the graph uncovers autocorrelation or is inconclusive, then a Durbin-Watson *d* test is performed. Proven autocorrelation may be corrected by transforming the data using the optimal r and the maximum-likelihood and Prais-Winsten technique. Autocorrelation corrective measures may introduce some variability in the final coefficients for small samples.[16] Several methods, therefore, were performed in order to assure at the results were not dependent on the test used.

Heteroscedasticity. Like for autocorrelation, a graphical screen will first be used to detect heteroscedasticity. The graph plots the square of the residual versus the predicted values of the dependent variable.[17] If heteroscedasticity is present in significant amounts or the graph is inconclusive, then each variable will be evaluated by a more exacting statistical test (e.g. Park test, Goldfeld-Quandt test). Goldfeld and Quandt, however, argue that the disturbance term in the Park test may be, itself, heteroscedastic.[18] For this reason, if the Park test identifies a variables as being potentially heteroscedastic, then a confirmatory Goldfeld-Quandt test will follow.

Multicollinearity. The presence of multicollinearity will be assessed first by comparing the R^2 to the significance levels of the coefficients.[19] If a high R^2 is accompanied by insignificant coefficients, then multicollinearity may be present. If this screen is positive or

inconclusive, regressions of the independent variables to one another will be performed in order to determine whether or not they have any significant explanatory power.

Specification Error. Once the model has been developed and tried, its relevance t the dependent variable can be assessed by reviewing the adjusted R^2, the coefficients (in terms of both sign and significance), and the Durbin-Watson statistic.[20] A high adjusted R^2 and significant coefficients with the expected signs are typical of a model that adequately describes the dependent variable.

Log-Log Model. The sensitivity of the ACR's membership percentage to percent changes in the independent variables can be determined through ordinary least square regression featuring the natural logs of the dependent and independent variables. Such a model (known as the log-log model) can be written as follows:

$$\ln Y = a0 + b_i \ln X_i + e_i, \text{ where}$$

$$a0 = \log \text{ (constant)}$$

$$b_i = \text{slope coefficient of } X_i$$

$$e_i = \text{disturbance term}$$

The coefficients measure the percentage change in Y with respect to a percentage change in X_i (i.e. elasticity of Y to X). However, as with the earlier model, the assumptions of the classic linear model must be met by the log-log model.

III. RESULTS

Regression Model

Ordinary Least Squares: The ordinary least squares (OLS) regressions of the twelve independent variables against both proposed dependent variables revealed that the ACR membership rate expressed in terms of board certification (RATCERT) was superior to the all radiologist definition (RATIOALL); although, the difference between the two definitions was not large. The regressions using RATCERT as the dependent variable achieved a higher R^2 and better statistically significant coefficients than did RATIOALL. (See Table 10.) This finding is not surprising since the main difference between RATCERT and RATIOALL is the inclusion/exclusion of Associate members, which represents only two percent of the total membership.

Having concluded that RATCERT was the more appropriate dependent variable, the independent variables were regressed against it so that those independent variables with the greatest explanatory power could be identified. The independent variables were regressed individually and in combinations of two and three. The iteration which achieved the highest R^2 while having significant coefficients by the t-test was chosen as the final model. From the regressions, therefore, nominal dues (NOMDUES), next year's dues this year (FWDDUES), and state chapter dues (STATE) emerged as the best combination of independent variables. (See Table 11.) The regression based on these three variables resulted in a nearly perfect fit (R^2 = .99993) to RATCERT's data-points. Furthermore, the adjusted R^2 remained equally high (adjusted R^2 = .99972). The coefficients on two of the three variables (NOMDUES and FWDDUES) were significant at a .05 level. (STATE was found not to be statistically significant using OLS, but later proved to be significant after correcting for autocorrelation.)

Table 10: Regressions of RATCERT and RATIOALL Against Independent Variables (Constant included in each regression)

	Dependent Variable: RATCERT			Dependent Variable: RATIOALL		
	b	t-Ratio	P-value	b	t-Ratio	P-value
NOMDUES	-.501E-03	-6.463	.00035	-.355E-03	-4.552	.00263
REALDUES	-.155E-02	-4.232	.00388	-.107E-02	-3.190	.01528
NMNINC	-.115E-05	-7.296	.00016	-.846E-06	-5.802	.00066
RMNINC	-.461E-05	-7.453	.00014	-.346E-05	-6.667	.00029
NMDINC	-.112E-05	-4.964	.00163	-.812E-06	-4.132	.00439
RMDINC	-420E-05	-4.130	.00441	-304E-05	-3.573	.00906
BENEFITS	-.605E-01	-4.216	.00395	-.437E-01	-3.595	.00897
RBENEFIT	-.210	-3.597	.00877	-.151	-3.144	.01629
STATE	-355E-02	-3.715	.02056	-.222E-02	-3.537	.02409
LASTCHNG	-.267E-02	-.150	.88462	-.482E-02	-.360	.72965
TIME	-.142E-01	-8.457	.00006	-.104E-01	-6.448	.00035
FWDDUES	-497E-03	-5.813	.00114	-.372E-03	-4.955	.00256

Table 11: RATCERT Ordinary Least Squares

Dependent variable: RATCERT			
	R^2 = .99993	ADJ R^2= .99972	DW= 2.50
	SSE = .0007	F(3,1)= 4739.2037	
	b	t-Ratio	P-value
CONSTANT	.864	207.046	.00307
NOMDUES	-.367E-03	-29.213	.02178
FWDDUES	-.939E-04	-14.937	.04256
STATE	.423E-03	3.130	.19686

Classic Linear Regression Assumptions

Autocorrelation. Tests were conducted to assess the model's adherence to the classical linear regression assumptions. Investigating first for autocorrelation, the graph of the disturbance term versus a time variable demonstrated an increasing trend, suggesting autocorrelation. (See Chart 2.) The Durbin-Watson test (dw = 2.500) was inconclusive (n = 8*, k' = 3, a = .01; d_L = .229, d_U = 2.102; 4-d_U = 1.898, 4-d_L = 3.771). [*Eight was chosen as the number of observations for the Durbin-Watson test because critical values based on five observations were not available. Since the critical region expands (inconclusive region shrinks) with more observations, the Durbin-Watson test conducted with eight observations instead of five would overestimate the critical region and underestimate the inconclusive region.] Due to the small sample size the coefficients could be dependent on the technique used to correct the autocorrelation.[21] For this reason, two methods of autocorrelation were used (Prais-Winsten and maximum likelihood). The results, regardless of technique, were identical (See Table 12.); therefore, dismissing the method dependent coefficients concerns.

Heteroscedasticity. Heteroscedasticity may also be present in the model as demonstrated by the graph of the squared residual versus the predicted RATCERT estimates and the independent variables. (See Charts 3 - 6.) Although present, heteroscedasticity in the RATCERT model is insignificant due to small residuals. Therefore, no attempts were made, such as using weighted least squares, to compensate for it.

Multicollinearity. On the basis of RATCERT's high R^2 and significant coefficients (especially after autocorrelation was taken into account), multicollinearity was not felt to be present.

Chart 2

Autocorrelation: RATCERT Disturbance Term (e) Versus Time

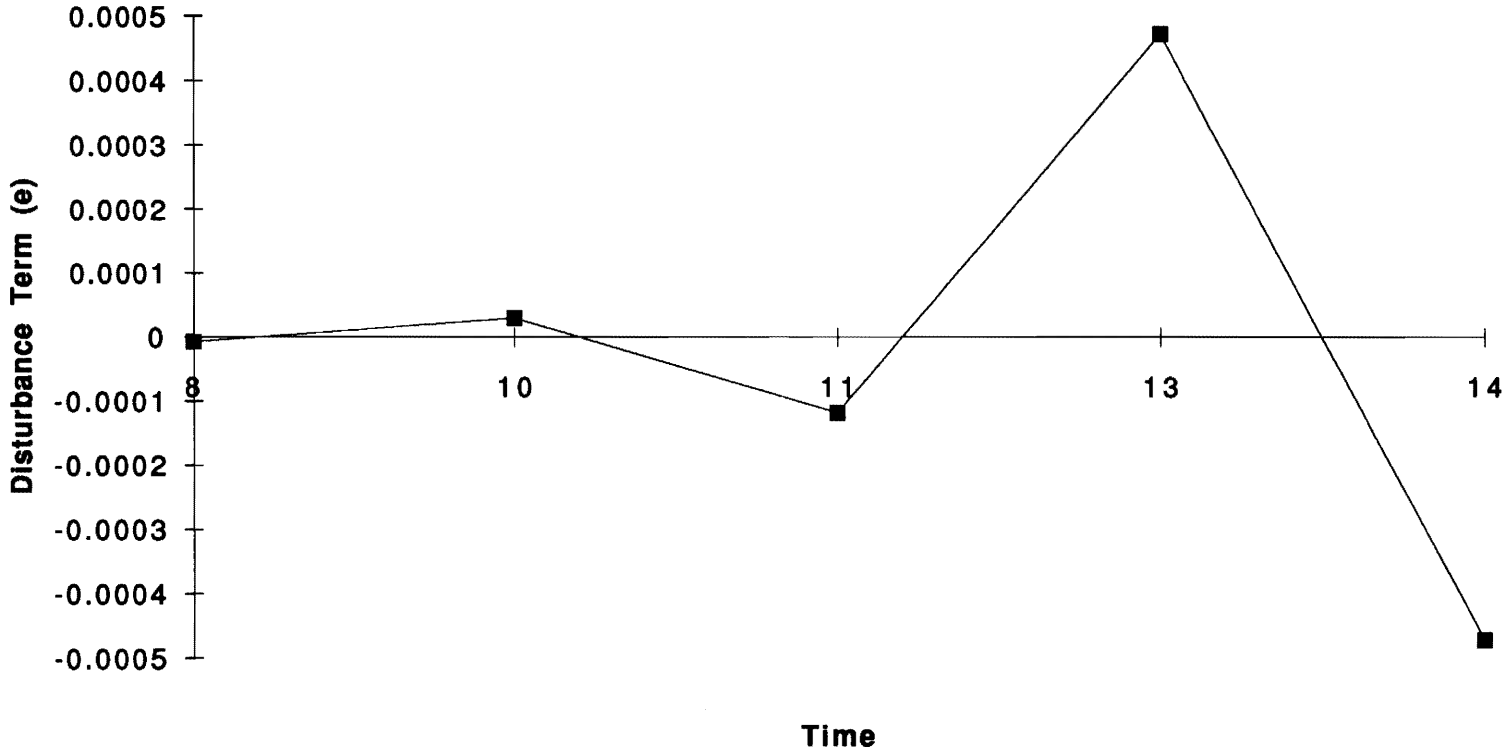


Table 12: RATCERT Autocorrelation by Prais-Winsten and Maximum Likelihood Techniques

RATCERT	Prais-Winsten			Maximum Likelihood		
	b	t-Ratio	P-value	b	t-Ratio	P-value
CONSTANT	.864	228.568	.00000	.864	228.568	.00000
NOMDUES	-.368E-03	-29.274	.00000	-.368E-03	-29.274	.00000
FWDDUES	-.929E-04	-14.965	.00000	-.929E-04	-14.965	.00000
STATE	.420E-03	3.356	.00079	.420E-03	3.356	.00079

Specification Error. The variables in the RATCERT model seem to adequately explain the RATCERT variable. The adjusted R^2 and the R^2 are extremely high (.99972 and .99993, respectively) and differ by only a small amount. Furthermore, once autocorrelation is considered, all of the variables are significant and most (the exception being STATE) have the anticipated sign. The sign on STATE being positive, when a negative sign was expected, may be the result of incomplete data.

B. Log-Log Model

Ordinary Least Squares: The log-log model for elasticity obtained an extremely tight fit to the data (R^2 of .99992), with all coefficients being statistically significant at a .10 level. (See Table 13.) The coefficients, all of which have absolute values less than one, suggest that board certified ACR members are price inelastic. In addition, board certified members seem relatively more sensitive to changes in ACR dues than state or anticipated dues.

Classical Linear Regression Assumptions. For the reasons previously discussed for the RATCERT model, tests like those performed on the RATCERT model were conducted on the log-log model in order to ensure that the log-log model complied with the classical linear regression assumptions.

Autocorrelation. The graph of the disturbance term versus time showed an increasing trend relationship indicative of autocorrelation. The Durbin-Watson statistic (dw=2.500) was inconclusive. The model was transformed by both the Prais-Winsten and maximum-likelihood techniques to correct the autocorrelation and to ensure that the coefficients were not technique dependent. (See Table 14.)

Chart 3

RATCERT Heteroscedasticity: Predicted Y (RATCERT) Versus Residual Squared

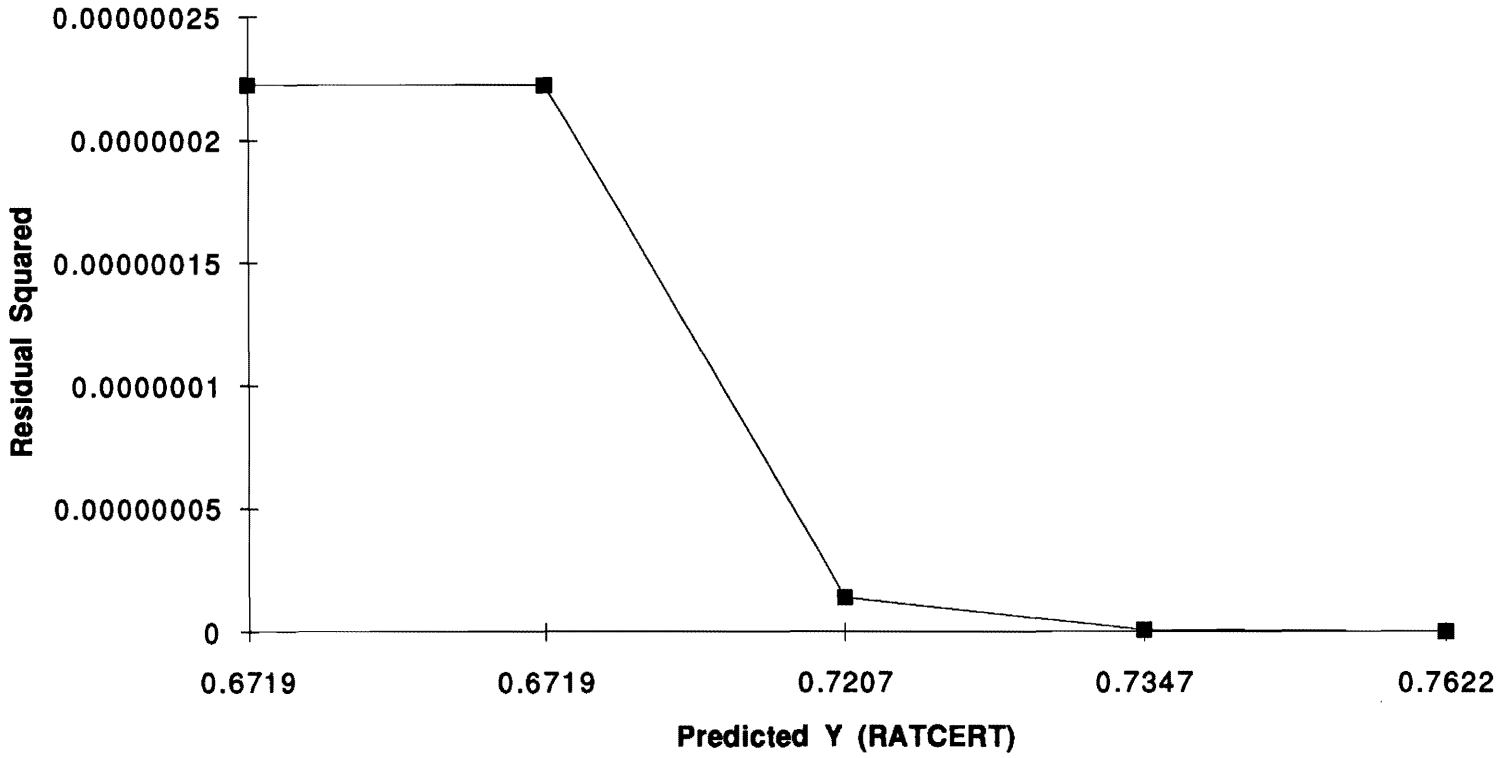


Chart 4

RATCERT Heteroscedasticity: Nominal Dues Versus Residual Squared

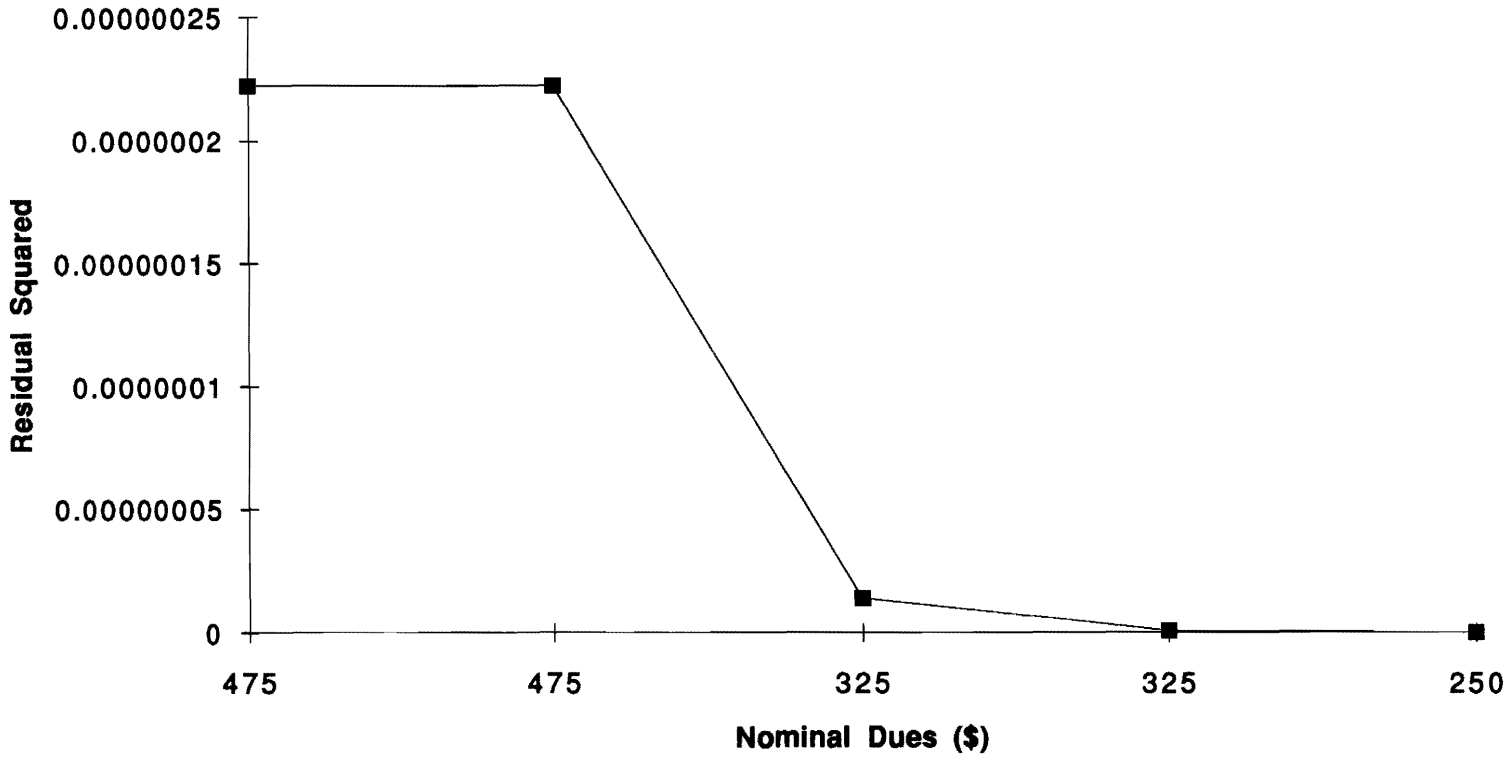


Chart 5

RATCERT Heteroscedasticity: Forward Dues Versus Residual Squared

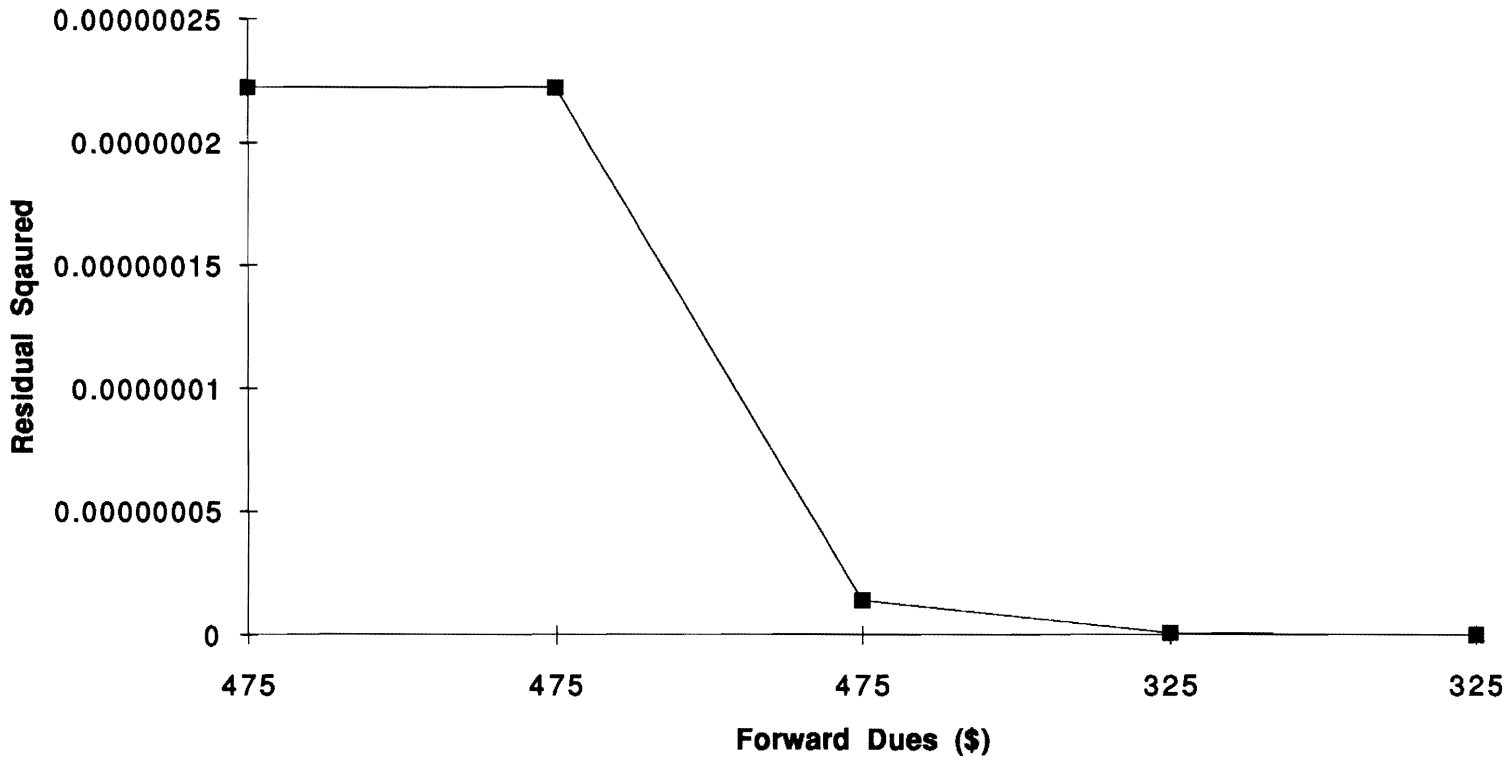


Chart 6

RATCERT Heteroscedasticity: State Dues Versus Residual Squared

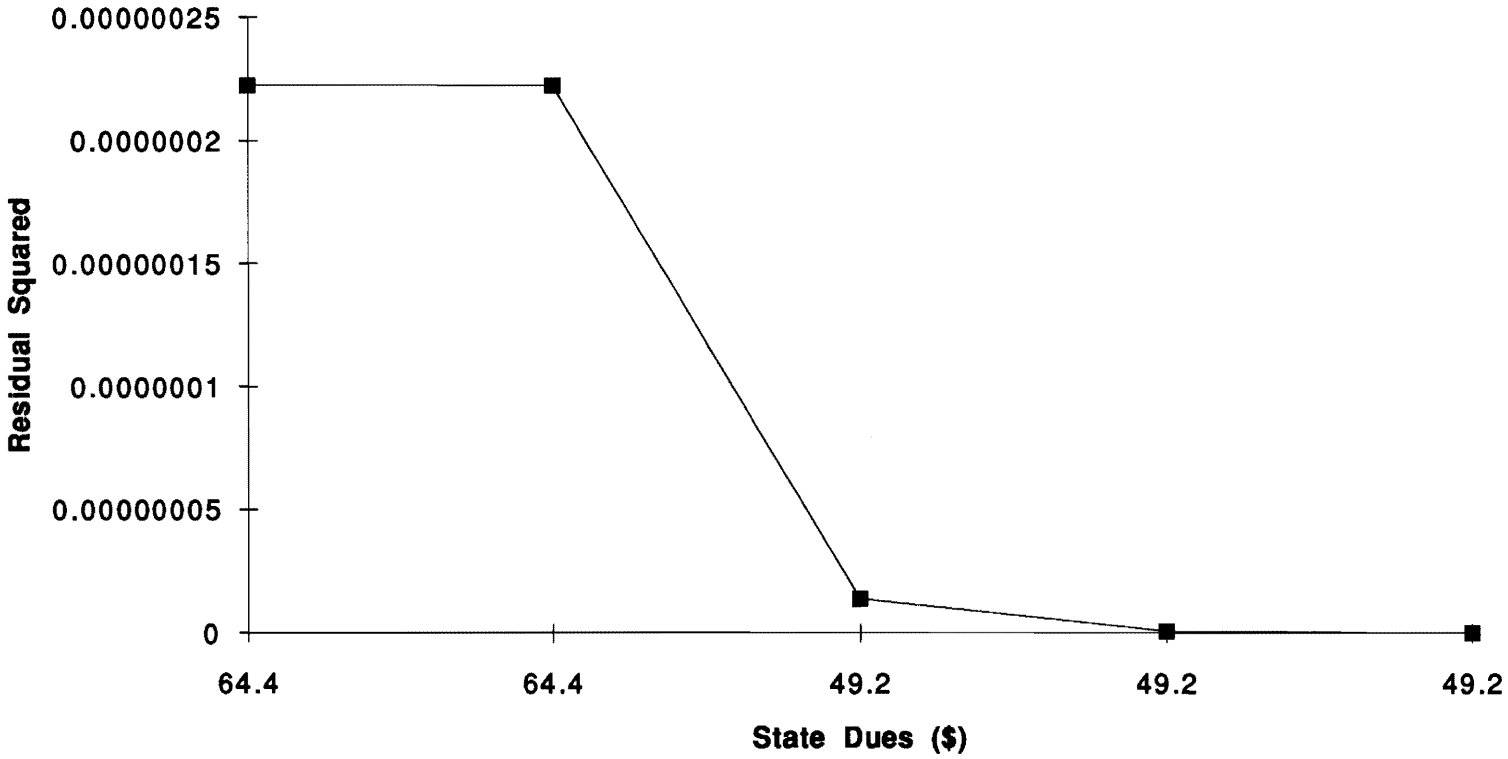


Table 13: Log (RATCERT) Ordinary Least Squares

Dependent variable: log (RATCERT)			
	R^2 = .99992	ADJ R^2= .99968	DW= 2.500
	SSE = .0010	F(3,1)= 4224.0727	
	b	t-Ratio	P-value
log (CONSTANT)	1.0398	57.203	.0113
log (NOMDUES)	-.140328	-26.228	.02426
log (FWDDUES)	-.510E-01	-13.794	.04607
log (STATE)	-.620E-01	-7.049	.08972

Heteroscedasticity. The predicted log(RATCERT) and the logs of the other independent variables were graphed against the squared residuals from the log-log model. (See Charts 8-11.) The graphs show that, like in the case of RATCERT, heteroscedasticity was present. However, the residuals from the log-log model were small enough to conclude that heteroscedasticity was not a problem.

Multicollinearity. The log(RATCERT) model's high R^2 and significant coefficients provided proof against multicollinearity.

Specification Error. The log(RATCERT) model seemed to adequately describe the data-points, achieving a high adjusted R^2 and significant coefficients with the expected sign.

Table 14: Log (RATCERT) Autocorrelation by Prais-Winsten and Maximum Likelihood Techniques

log (RATCERT)	Prais-Winsten			Maximum Likelihood		
	b	t-Ratio	P-value	b	t-Ratio	P-value
log (CONSTANT)	1.039	68.308	.00000	1.039	68.308	.00000
log (NOMDUES)	-.140537	-26.287	.00000	-.140537	-26.287	.00000
log (FWDDUES)	-.504E-01	-13.807	.00000	-.504E-01	-13.807	.00000
log (STATE)	-.623E-01	-7.852	.00000	-.623E-01	-7.852	.00000

Chart 7

Autocorrelation: Log(RATCERT) Disturbance Term (e) Versus Time

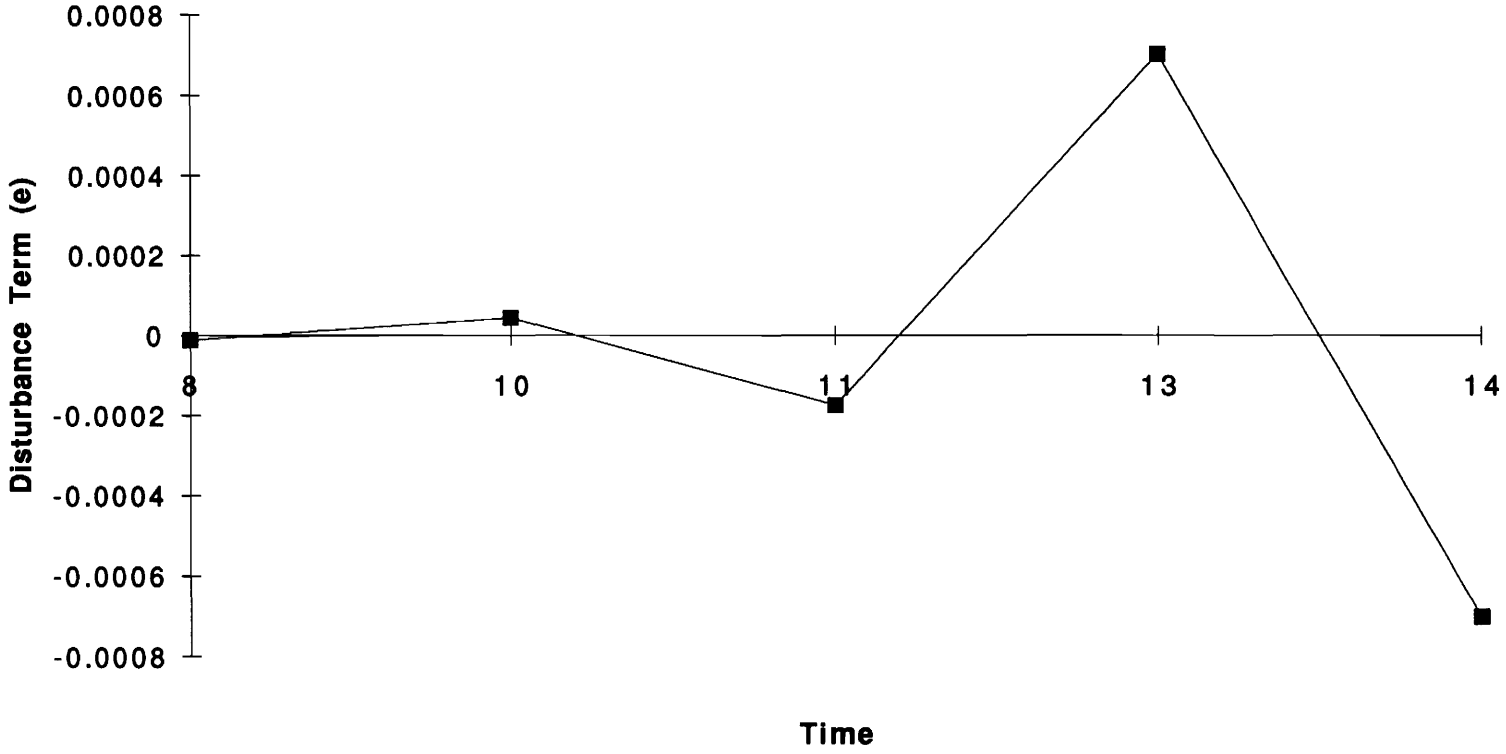


Chart 8

Log(RATCERT) Heteroscedasticity: Predicted Y Values Versus Residual Squared

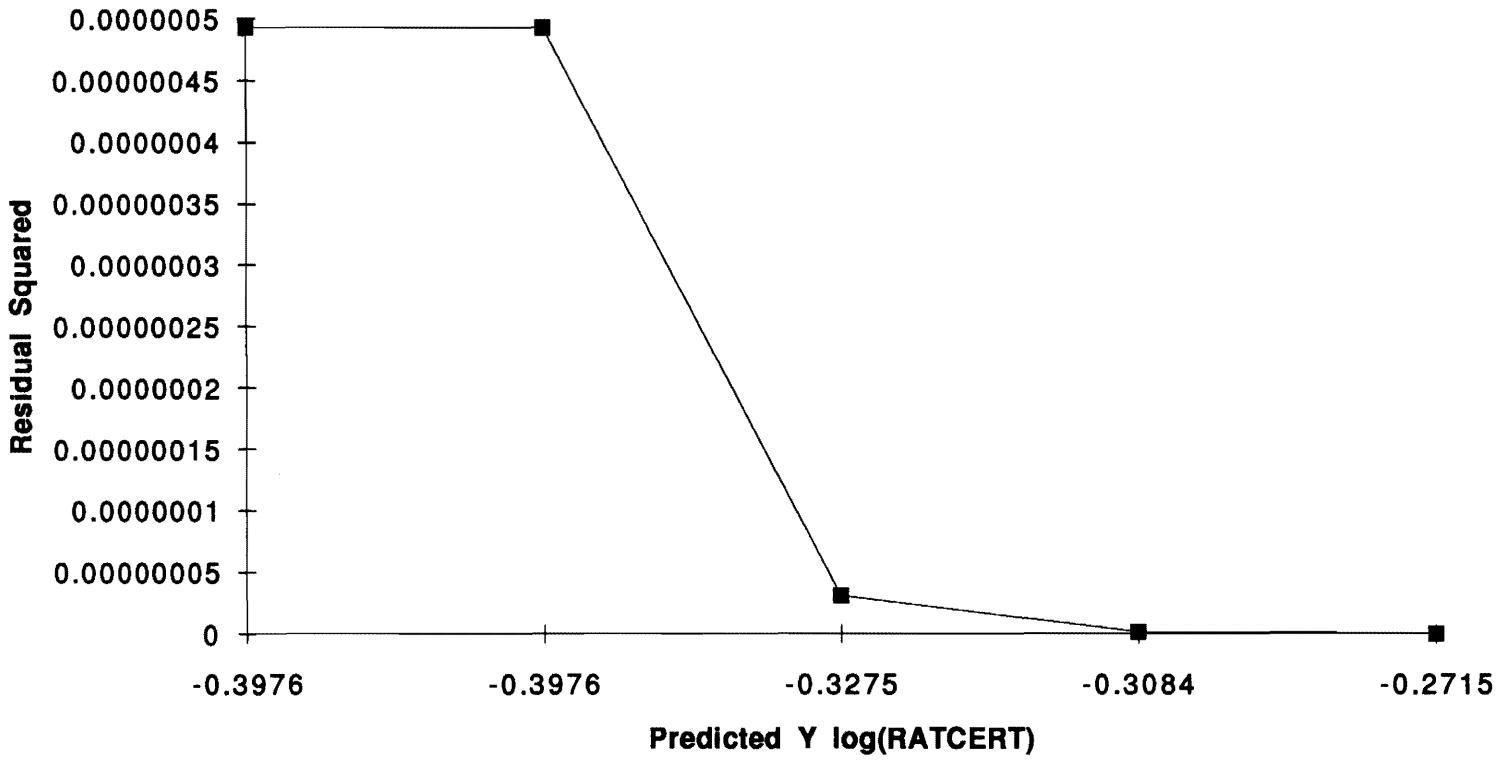


Chart 9

Log (RATCERT) Heteroscedasticity: Log Nominal Dues Versus Residual Squared

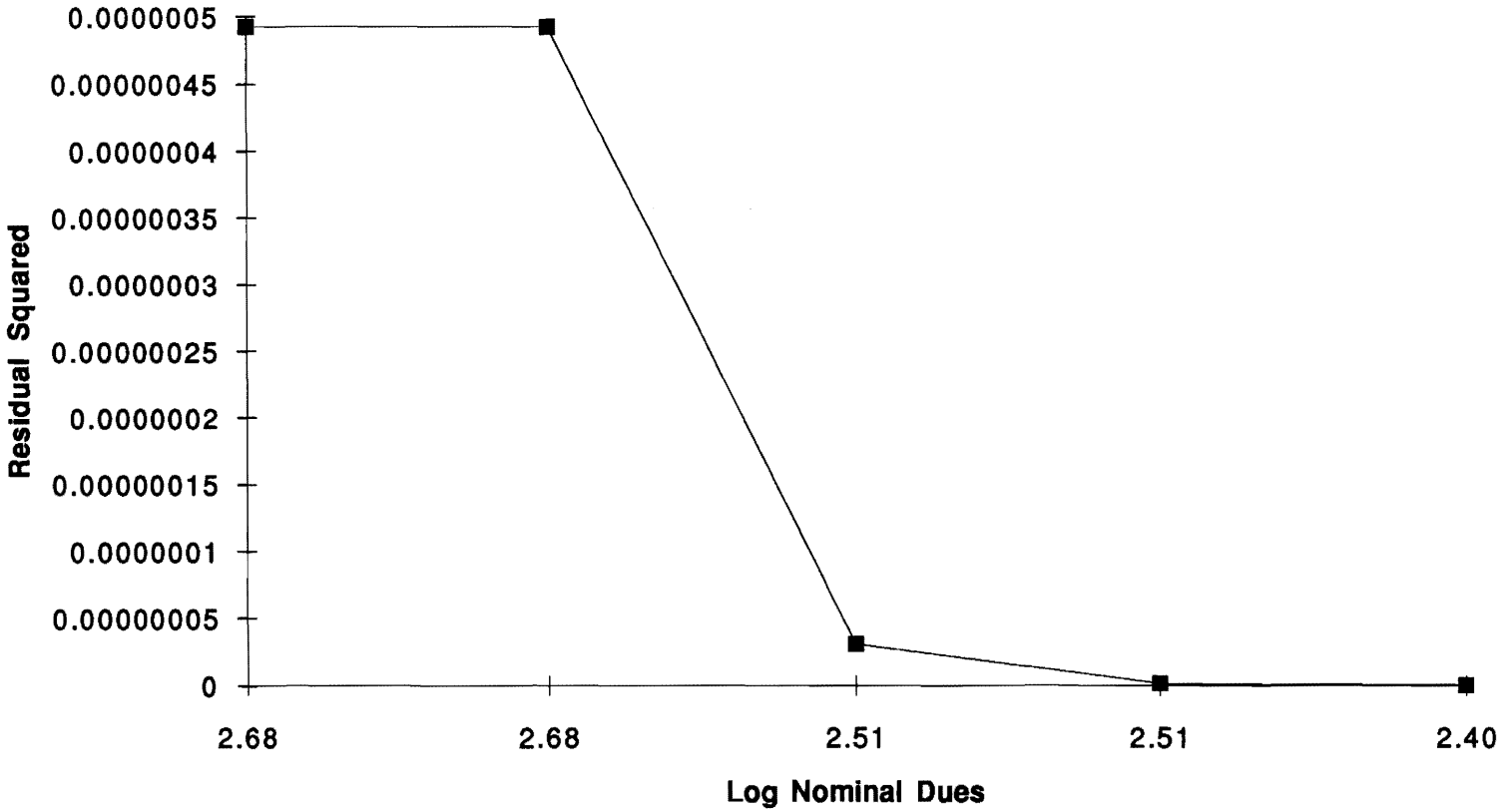


Chart 10

Log(RATCERT) Heteroscedasticity: Log Forward Dues Versus Residual Squared

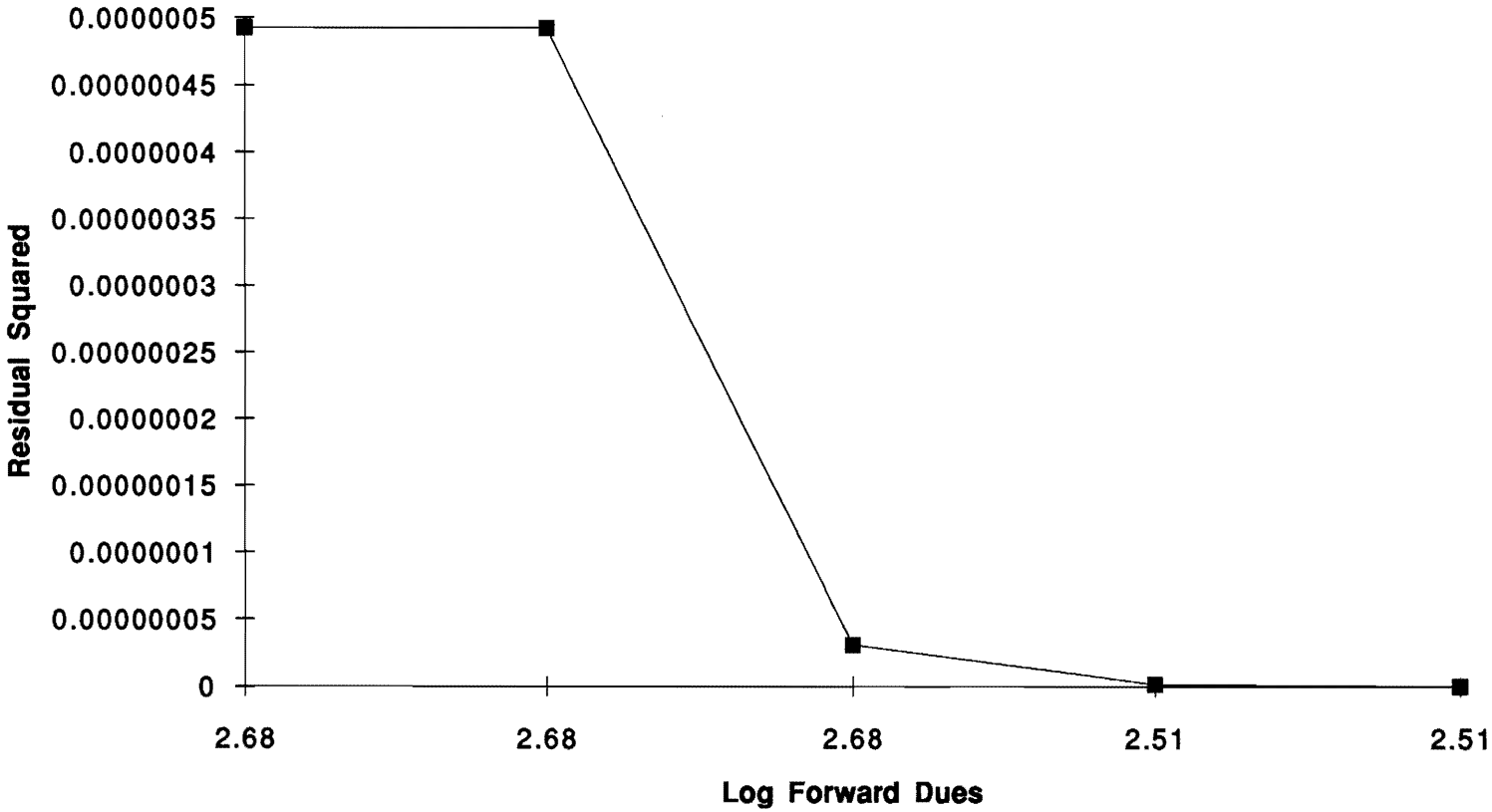
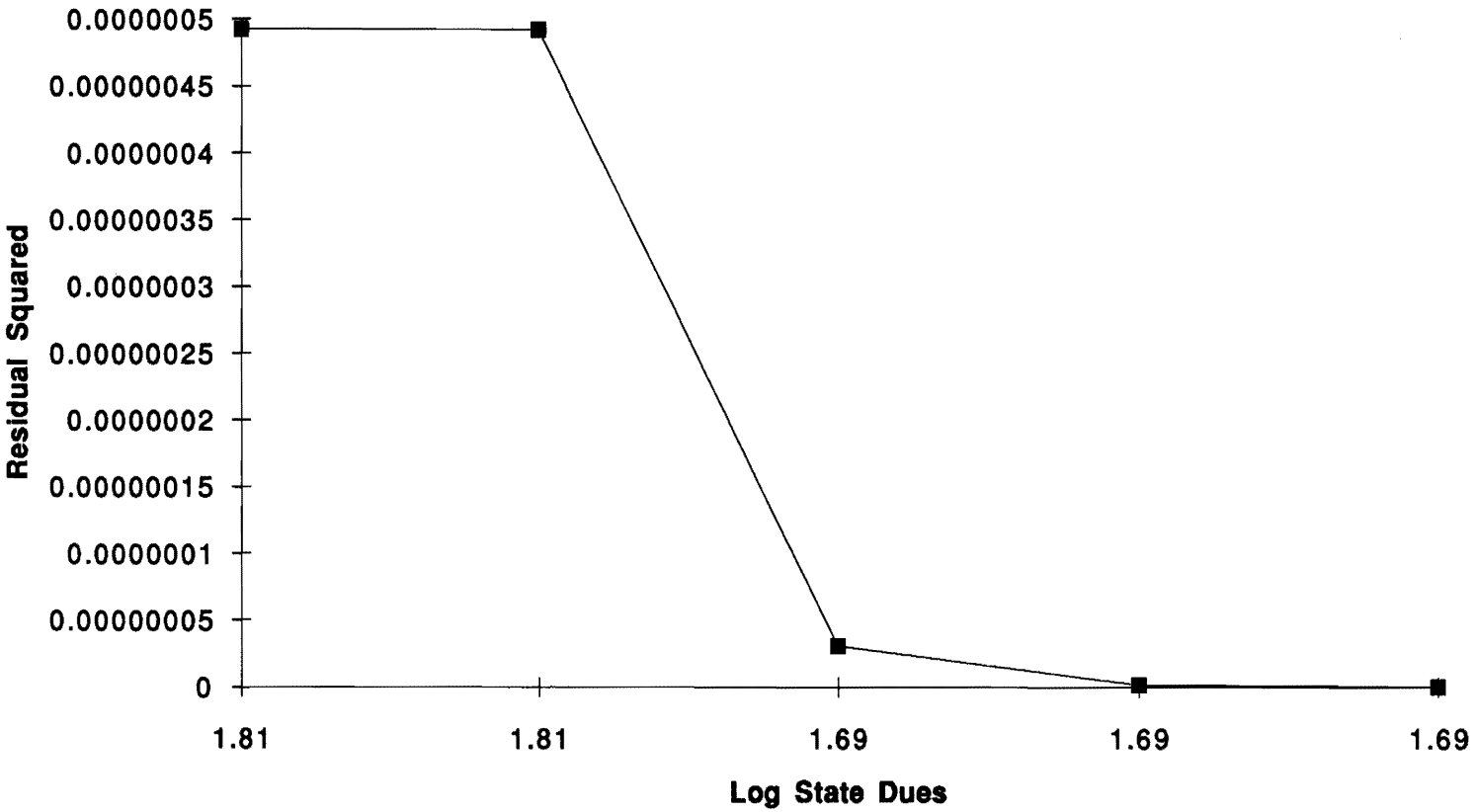


Chart 11

Log(RATCERT) Heteroscedasticity: Log State Dues Versus Residual Squared



IV. DISCUSSION

A. Membership Rate of the ACR

The ACR's market share of those radiologists eligible for membership, regardless of how defined (RATIOALL or RATCERT), has steadily fallen over the time period from 1981 to 1990. However, the trend seems to have reversed itself starting in 1990, coinciding with the establishment of the Introductory member category.

The declining membership percentage may be primarily attributed to a disparity in growth rates between ACR membership and those eligible for membership. The compounded annual growth (CAG) for those eligible for ACR membership has exceeded the CAG in ACR membership by two-to-one. [For the period 1981 to 1992, those eligible for ACR membership grew at a rate of 3.2% (board certified) and 3.5% (with or without board certification), while ACR members grew by 1.6% and 1.7%, respectively.] With the number of those eligible for ACR membership growing faster than those who join the ACR, the ACR membership percentage will, therefore, decline. However, since 1990, the growth in ACR members (3.6% for both categories) has exceeded the growth of those eligible (2.2% for board certified, 2.5% for all radiologists).

An explanation of the disparity in growth rates between the ACR and radiologists eligible for membership rests with a comparison of board certification and specialty identification. Diplomates of the American Board of Radiology (ABR) are more likely to join the ACR. In a comparison of year of board certification and when the radiologist joined the ACR, over ninety-percent of the diplomates of the ABR join the ACR (exclusive of those who later drop their membership). Physicians who take the ABR examinations typically have completed a residency in radiology and, as a consequence, they would have a strong

identification with radiology.[21] On the other hand, many diplomates of the American Board of Nuclear Medicine (ABNM) entered nuclear medicine through a residency other than radiology (e.g. internal medicine). As a result, these physicians have less identification with radiology (and the ACR) and more allegiance with nuclear medicine (and the American College of Nuclear Physicians -- the primary medical society for nuclear medicine specialists).[22]

B. Other Exogenous Variables

The percentage of radiologists who join the ACR, as demonstrated by the RATCERT model, is driven solely by anticipated or actual changes in ACR dues and dues charged by state chapters. Conversely, members do not seem to react to changes in more personal/individual variables (e.g. income, member benefits).

The lack of responsiveness of income in the RATCERT model may be due to the relatively small share of net income that ACR dues represent. The share of net income representing ACR dues is approximately 0.2%; a relatively small amount. Furthermore, if averaged across all members, the ACR dues-net income share is probably less because many members have their practice, hospital, or employer pay their ACR dues.

The benefits accrued by members also failed to explain the ACR's market share. The lack of the benefits variable in the RATCERT model may be a result of measurement error. As discussed in earlier (see Data section), ACR operating expenses were used as a proxy for member benefits. This variable overlooks the value members place on the services offered by the ACR. As a result, the variable may not represent the actual perceived benefits from ACR membership.

In general, nominal valued variables had better explanatory power against RATCERT than did real variables. Only for mean net income did the real variable outperform the nominal variable; although the difference was small. But in the final RATCERT model, income did not contribute significantly for the reasons discussed earlier. The superior performance of nominal variables relative to real variables suggests that ACR members are not cognizant of changes in the price level and focus only on the current period when making membership decisions.

The frequency of dues changes was inconsequential in the membership decision. Members are, therefore, indifferent between frequent and infrequent dues changes.

C. Elasticities

Although the log-log model of RATCERT reaffirms that dues are an important factor in the membership decision, the impact dues have on the membership decision is small (i.e. members are price inelastic). Perhaps the most significant factor contributing to the insensitivity of members to dues changes is the fact that a number of ACR members have someone else (e.g. group practice, hospital, etc.) pay their dues for them. Thus, having been "taken out of the loop", radiologists may not care how much ACR dues are if someone else is paying. Although radiologists may not directly paying their dues, ACR dues may be paid indirectly through lower practice earnings.

If ACR dues accounted for a sizable share of members' income, then the effect of a dues change on the membership would be more pronounced than what the RATCERT model suggests. Since dues are relatively small relative to net income (approximately 0.2%), the

additional financial burden brought about by a dues increase is probably inconsequential (even for those who pay their dues directly).

Lastly, perhaps the benefits of ACR membership more than offset the impact of a dues increase. Since the ACR is the principle advocate of radiologists in the U.S., members may be less willing to drop their membership based solely on dues (especially in an era of health care reform and medical cost containment). Furthermore, the services offered by the ACR may be more highly prized than the RATCERT model suggests.

The members' price inelasticity is valuable information for the ACR leadership. Financially speaking, the ACR's total revenue can be enhanced by a dues increase without seriously reducing the number of members. Since members are price inelastic, the amount of additional revenue earned from a dues increase will more than offset the revenue lost from members leaving the ACR.

Although the membership percentage had been in decline through 1990, the price inelasticity reaffirms that the ACR remains the principle socioeconomic association for radiologists. Price elasticity speaks to the availability and the closeness substitutes.[23] If a good is price elastic, then close substitutes are readily available. Conversely, price inelastic goods have fewer close substitutes. Since the ACR membership is price inelastic, then belonging to other organizations (e.g. the AMA, other radiology associations, etc.) is not a close substitute for ACR membership. Phrased differently, other organizations do not stand ready to gain ACR members leaving as a result of a dues increase.

V. CONCLUSIONS

Of the exogenous variables tested in the model, membership dues (both actual and anticipated) have the greatest impact on the ACR's membership percentage. This observation coupled with the fact that the ACR membership rates have fallen steadily over the past decade, reaffirms the basic economic tenet that price and quantity demanded are inversely related. The American Medical Association has also experienced a decline in the rate of membership, from 67 percent in 1940 to 45 percent in 1982. Higher dues are partly the blame.[24]

While dues are the over-riding element in the membership rate, radiologists are generally not willing to resign from the ACR over dues. A potentially more important consideration may be which organization best represents the interests of radiology in the upcoming health care reform debate. The ACR, while still the primary socioeconomic association for radiologists, has witnessed a tremendous proliferation of new radiologic subspecialty associations (e.g. Society of Breast Imaging, Society of Magnetic Resonance in Medicine, etc.) during the mid-1980s. Moreover, with the advent of specialty-specific organizations such as the ACR, subspecialty-specific associations such as the Society of Breast Imaging, in addition to the "umbrella" organization for all of medicine, the AMA, competition for members is likely to increase.

VI. SUMMARY

Using time-series data from 1977-1992, regression analyses were performed to identify those variables critical in determining the ACR's membership rate. The regressions showed that actual and anticipated ACR dues and state chapter dues had the most explanatory power. Although dues were the key factors in the ACR membership rate, ACR members were price inelastic, implying that they did not alter their membership greatly based on dues.

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