Federal Communications Commission
Office of Plans and Policy
1919 M Street NW
Washington, DC 20554

OPP Working Paper Series

9 Statistical Determinants of Radio Stations' Revenues and Trading Prices

August 1982

James A. Brown, Jr.

The FCC Office of Plans and Policy's Working Paper Series presents staff analysis and research in various stages. These papers are intended to stimulate discussion and critical comment within the FCC, as well as outside the agency, on issues in telecommunications policy. Titles may include preliminary work and progress reports, as well as completed research. The analyses and conclusions in the Working Paper Series are those of the authors and do not necessarily reflect the views of other members of the Office of Plans and Policy, other Commission staff, or the Commission itself. Given the preliminary character of some titles, it is advisable to check with authors before quoting or referencing these Working Papers in other publications.

Copies of the Working Paper Series may be available for a limited time from the Office of Public Affairs, Federal Communications Commission, Room 207, 1919 M Street, N.W., Washington, DC 20554 (202/254-7674). Copies may be purchased from the Downtown Copy Center, 1114 21st Street, N.W., Washington, DC 20037 (202/452-1422). Copies are also available from The National Technical Information Service, Springfield, VA 22161 (703/487-4650). The inside back cover contains a list of previous titles.

For information on the Series, contact the Office of Plans and Policy, Federal Communications Commission, Room 838, 1919 M Street, N.W., Washington, DC 20554 (202/653-5940).

Statistical Determinants of Radio Stations' Revenues and Trading Prices*

James A. Brown, Jr.

Working Paper No. 9

Office of Plans and Policy
Federal Communications Commission
Washington, D.C. 20554

August 1982

---

*The opinions and conclusions in this paper are solely the responsibility of the author. They do not necessarily reflect the policies or views of the Federal Communications Commission or any other organization or individual.

Abstract

This study estimates the effects on radio stations' revenues and trading prices of the following variables: daytime AM power, nighttime AM power, AM frequency, FM power, consumer income, number of competing stations in a market area, and whether a station is located in the central part or on the fringes of its market area. These variables show approximately the same percentage effects on trading prices as on revenues. On the other hand, the following variables appear to have no statistically significant associations with revenues: newspaper circulation, automobile registration, and number of TV stations in a market area; whether an AM station has nighttime signal protection and/or uses a directional antenna; and whether a station has network affiliation. The data suggest somewhat more than one-half of a new station's revenues are likely on average to come from advertising dollars not previously spent on radio, while somewhat less than one-half are likely to come from advertising that previously went to old stations. The nighttime protection variable's statistical non-significance suggests that "class IV" local AM stations (which lack nighttime protection) do not on average appear to suffer a relative earnings' handicap vis-a-vis comparably powered stations that have nighttime protection. The study recommends, therefore, that the FCC consider a "class IV" approach for any allocation of new channels to the AM band.

The study uses multiple regression analysis. All specifications are double-logarithmic. Three data sets are examined: about 1100 stations in "large" markets (defined according to the Census Bureau's "Standard Metropolitan Statistical Areas" -- SMSA's), about 300 stations in "small" markets (non-SMSA counties), and about 700 stations (in both large and small markets) that changed hands in 1980 and 1981. Revenue data are examined for 1976 through 1980, with emphasis on 1978. Similar statistical results are observed across all three data sets.

Table of Contents

Tables

Acknowledgements

Work on this study began in late 1979. Helpful suggestions along the way have been made by Steve Brenner, Nina Cornell, Jerry Duvall, Lex Felker, Phil Gieseler, Ken Gordon, Dan Kelley, Jon Levy, Peter Pitsch, Jack Robinson, Fred Ruppel and Doug Webbink. They are not responsible, of course, for any errors that remain. Thanks also to Jackie Singleton, Marie Moyd, Terry Matsumoto, and Vivette Hart for typing; and to Pat Allen, Jim Gilmartin, Dave Santucci, Ken Stern, and especially Joe Bluemel and Fred Ruppel, for research assistance.

Statistical Determinants of Radio

Stations' Revenues and Trading Prices

I. Introduction and Summary

This study is a statistical analysis of certain factors that influence (a) the revenues of radio broadcasting stations and (b) the prices at which those stations change hands. There are at least three reasons for such a study. The first is to examine the economic implications of the FCC's radio broadcasting allocation/assignment policies. For example, if one takes revenues as an approximate measure of a station's economic worth to society, would a collection of small stations on a given frequency be more or less valuable in total than a few large stations on the same frequency? 1/ Answers to such questions may contribute to the economic evaluation of FCC policies. The second reason is to provide information potentially useful to the private sector in evaluating the economic potential of broadcast properties. Although abstract numbers like those presented here can never be complete substitutes for detailed (and normally confidential) information about specific properties, such data may usefully complement the private sector's other information sources. The third reason is simply to provide general information on

---

1/ Dealing here exclusively with economic criteria does not necessarily imply that society should not use additional criteria for evaluating the social worth of radio stations. Moreover, the "social economic worth" of a station will not always coincide with its private economic worth (which might be more or less than the social worth in any particular case). As a theoretical measure of social economic worth, "value added" is more appropriate than the gross revenue measure used here. Value-added data would probably not change any major conclusions of this study, however, due to their close correlation to revenues for radio stations (since radio stations purchase few "raw materials" inputs). In any event value-added data were not used here because of the belief that non-uniform accounting practices among radio stations would unnecessarily introduce errors into the statistical results.

the economic effects of regulation. To the author's knowledge, this study is the only publicly available multivariate statistical analysis of radio stations' revenue determinants, and therefore it should help fill a gap in our basic knowledge about the economics of telecommunications regulation. 2/

The determinants of a radio station's revenues are a mixture of measurable and non-measurable items. The study deals directly with just the measurable determinants. It uses a common statistical technique, called multiple regression analysis, that isolates the separate influences of two or more statistical determinants --"independent variables"-- on a "dependent variable." This study examines two different dependent variables: (a) the revenues and (b) the trading prices of radio stations. The type of regression analysis used below allows one to make such statements as, "On the average, and other things being equal, an increase of x per cent in an AM station's daytime power is associated with an increase of y per cent in that station's revenue." Finally, even though regression analysis deals explicitly with only the measurable factors, it does not overlook the nonmeasurable. Indeed, one strength of this method is that it offers a rough quantification of the uncertainty underlying its estimates. For example, it allows one to predict how often the revenues of a station with certain characteristics are likely to fall inside or outside a given "confidence interval." 3/

2/ There have been a number of similar previous studies, however, on the statistical determinants of television stations' revenues. For a survey, see Federal Communications Commission, Network Inquiry Special Staff, The Determinants of Television Station Profitability (June 1980).

3/ Alternatively, the "correlation coefficient" estimates the amount of variation accounted for, and not accounted for, by a particular regression equation. Such interpretations of the correlation coefficient often are not useful for econometric studies, however. For an explanation see, e.g., Potluri Rao and Roger L. Miller, Applied Econometrics (1971), pp. 13-20.

The study uses three data sets. The first two are random samples of (a) 100 large markets, drawn from among the 400 largest radio markets in the country, and (b) 100 small-market counties not among the top 400 markets. Data on all commercial radio stations in each of the 100 large and 100 small markets in 1978 are included (except for gaps and inconsistencies in FCC files). The third data set covers all commercial radio stations that changed hands during the 18-month period January 1980 through June 1981. The three data sets have 1125, 306, and 745 stations respectively.

The study's findings generally are consistent across the three data sets. The statistical variables significantly associated in most equations with revenues or station prices include: (a) station power levels, (b) AM frequency, (c) consumer income in the market area, and (d) number of radio stations (i.e., competition) in the market. On the other hand, the following measures, which also were hypothesized to be statistical determinants, showed no significant association with revenues: (a) use of directional AM antennas, (b) network affiliation, (c) newspaper circulation in the market, (d) automobile registrations in the market, (e) number of TV stations in the market, and (f) whether an AM station has nighttime signal protection. 4/ The consistency of these results across three separate samples gives them greater credibility than they would have if based only on one or two samples.

Perhaps the most interesting policy implications of the study derive from the estimated relationships (1) between a station's revenues and the number of competing radio stations in its market and (2) between revenue and nighttime signal protection. The competition variable suggests that new stations in an average market are likely to attract something like fifty to seventy per cent

---

4/ Nighttime signal protection (and the lack of it for Class IV AM stations) is explained below on p. 13.

of their revenues from "new" advertising (as opposed to advertising drawn away from old stations). The insignificant relationship between revenue and nighttime protection indicates that the FCC's policy of not protecting signals of certain low power fulltime local service ("Class IV") stations probably has, on the average, no significant adverse economic impact on those stations. 5/ This finding suggests further that if and when the FCC should decide to authorize new fulltime local service stations (for example, on the new 1605-1705 kHz band established by the 1979 World Administrative Radio Conference), the stations will probably have a much greater collective economic value if the FCC spaces them geographically with concern only for daytime coverage areas than if it gives them nighttime signal protection against one another.

II. Statistical Methodology

The study uses a standard statistical technique called multiple regression analysis. A full explanation is beyond the scope of this paper. The basic idea, however, may perhaps be grasped from Figures One through Five. Assume a sample of daytime-only AM stations, with data on (a) the stations' revenues and power levels, (b) the number of competing stations in each of their markets, and (c) the incomes of consumers in those markets. Then draw a graph with station power on the horizontal axis and revenue on the vertical axis. For such a graph, one should expect the data points for the sample to scatter in a pattern something like Figure One. That is, stations with higher power levels usually can be heard by more people and therefore

---

5/ Another way to state this result is that "watt for watt," Class IV AM stations appears to be no less valuable economically on the average than other nighttime AM operations (i.e., those stations that have nighttime protection).

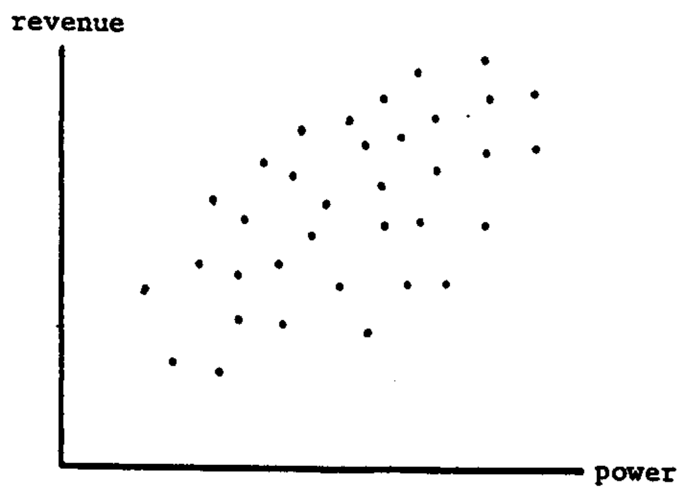

Figure One

will on average have higher advertising revenues. The relationship is a scatter of points rather than a smooth line because such statistical data can never be "controlled" (i.e., corrected) for all the factors that create variations in individual stations' revenue generating potentials. Such factors may be quantifiable influences like a station's frequency, the incomes of its listeners, or the number of competing stations in its market area; or they may be non-measurable phenomena like the quality of a station's management or the peculiar "tastes" of listeners in its geographical area.

It is important to note that the factors we do not (or perhaps cannot) measure may not always be critical for the purpose at hand. Statisticians have found that such extra influences often can be set aside (at least temporarily), so that one may draw the sort of "average" line shown in Figure Two. A precise mathematical expression for such a line can be derived by the techniques of "regression" analysis. The correspondence between a regression line and its mathematical expression are shown in Figure Three and Equation

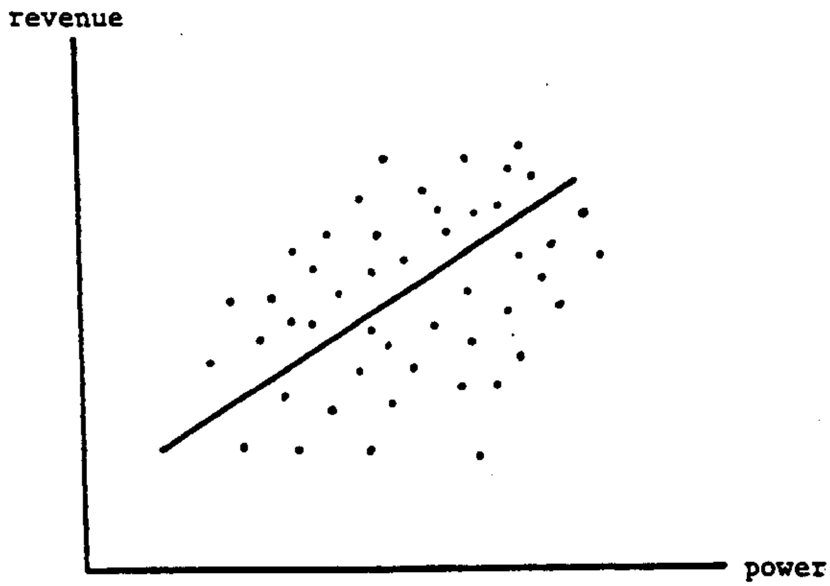

Figure Two

One, where R equals revenue; P equals power; b_1 is the "slope" coefficient, which measures the steepness of the line; and a_1 is the vertical "intercept"

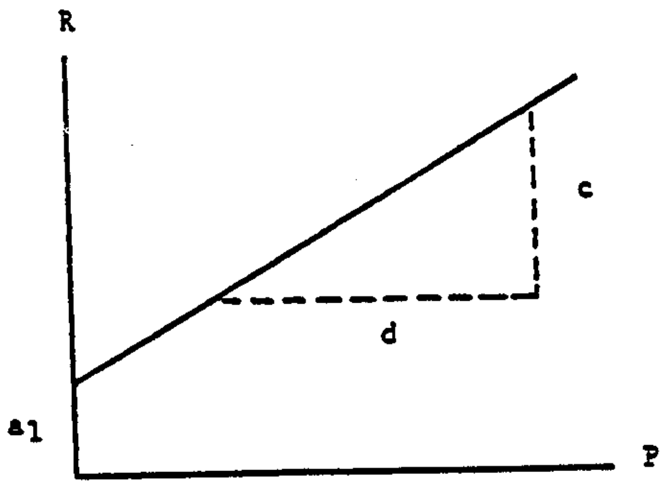

Figure Three

term. (The slope b_1 equals the distance "c" in Figure Three divided by the distance "d". It shows how much the dependent variable changes when a given independent variable increases or decreases a certain amount.)

$$R = a_1 + b_1 P \qquad (1)$$

The process of developing mathematical estimates for a and b from a real-world data set is often called "fitting" an equation.

The preceding exposition has dealt only with the relationship between our hypothetical stations' power levels and revenues. But the example also assumed data were available on both the number of competing stations and total consumer income in each station's market area. The latter two types of data may also be graphed separately in relation to revenues, as shown in Figures Four and Five. But note that Figure Four shows an important difference: Here, one should expect the relationship to be "negative." That is, the

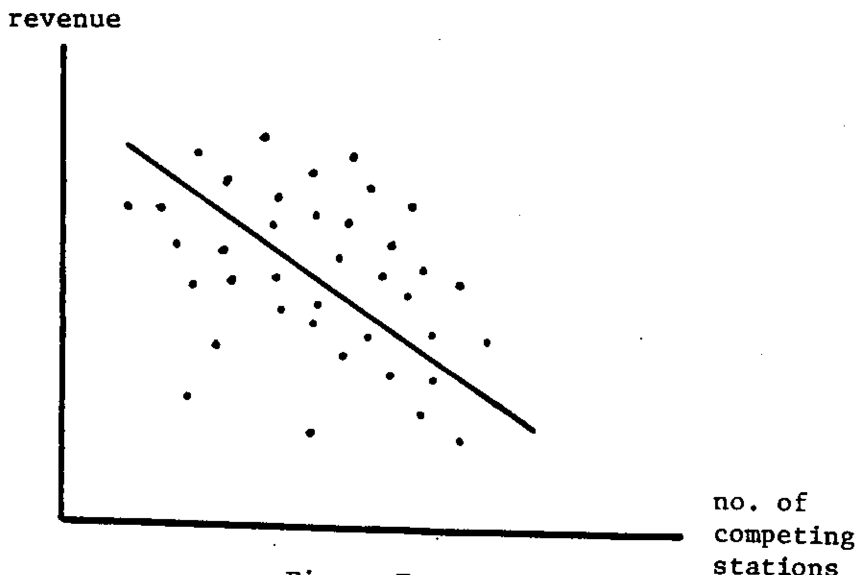

Figure Four

greater the number of competing stations, the lower a station's expected revenues. A mathematical expression that reflects this relationship is Equation Two. Here, a_2 is the vertical intercept, N the number of stations, and b_2 the slope term. Note that b_2 has a negative sign, indicating that the regression line slopes downwards:

$$R = a_2 - b_2 N. \qquad (2)$$

Figure Five shows the expected positive relationship between station revenues and consumer incomes.

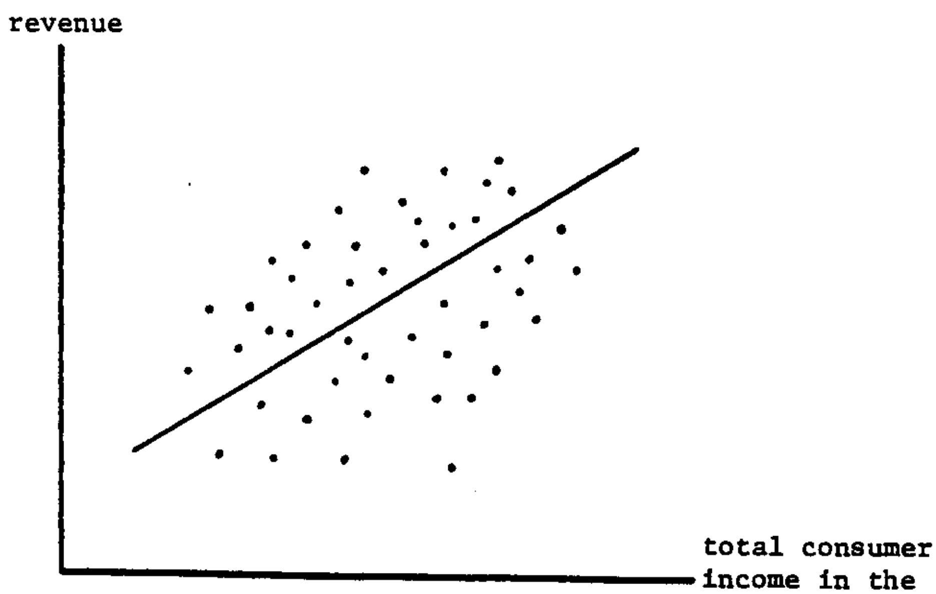

Figure Five

Equation Three gives a mathematical expression for this same positive relationship:

$$R = a_3 + b_3 I. \qquad (3)$$

The discussion so far has dealt only with relationships between two variables at one time. Each example has had the same "dependent" variable — revenue — and only one "independent" variable — power, competition, <u>or</u> income. Such two-variable relationships can be presented either as mathematical equations or as simple two-dimensional graphs. But what if one wants to represent <u>simultaneously</u> the relationships of revenues to power, competition, and income? In such a case, it is no longer possible to portray the mathematical relationship as a graph or scatter diagram. On the other hand, it is still possible to portray the relationship as an equation. Equation Four, for example, expresses such relationships as one might expect between a station's revenues (R—the dependent variable) and its power (P), number of competing stations (N), and consumer income (I):

$$R = A + b_1 P - b_2 N + b_3 I. \qquad (4)$$

In this equation, A is still called an "intercept" term even though it is impossible to portray it pictorially as intercepting anything; and likewise b_1, b_2, and b_3 may still be called "slope coefficients" or simply "coefficients" (the more common terminology). The effect of power on revenue is shown by b_1, the effect of competition by b_2, and the effect of income by b_3 (in each case holding the other two independent variables constant).

Regression analysis may again be called upon to estimate the intercept and the coefficients in such a multi-variable equation, just as in our earlier case of the two-variable equation. Such estimates can be bounded by standard errors, which indicate ranges within which the true values of the coefficients are likely to lie. These range estimates serve to "quantify the uncertainty" that virtually always underlies a particular regression equation.

Mathematically, all variables in this study (except dummy variables) have been transformed into their natural logarithms, and then the relationships among them have been estimated in linear form. This technique is not without technical drawbacks, but it has several distinct advantages: (1) it is widely used and understood, particularly among econometricians; (2) it is computationally straightforward and economical; (3) it allows relationships to take curvilinear form and thereby exhibit diminishing marginal returns; and (4) it allows relationships to be stated as percentage changes of both dependent and independent variables, independently of the original measurement units. 6/ Ordinary least squares estimation is used exclusively. 7/

6/ To economists, these double-log revenue functions are analogous to "Cobb-Douglas" production functions. There is a large technical literature in the general area.

7/ Ordinary least squares (OLS) is a technical term for the commonest computational method of fitting a regression equation. The analysis of its strengths and weaknesses is, in fact, at the core of modern econometric theory. The non-technical reader of this paper should, however, be able to

III. The Conceptual Model: What Probably Determines Radio Revenues and Station Prices?

A statistical correlation between two variables can never prove that changes in one of them have "caused" the variations in the other. Proper inferences about causation require some kind of logical relationship -- formally called a "model" or a "theory." This section provides such a conceptual framework. 8/

The factors that influence a radio station's revenues differ greatly in importance from place to place and station to station. Some are clearly measurable, while others are not only unmeasurable but sometimes even unknowable. Nonetheless, certain average tendencies are likely to hold across the nation and across sufficiently large samples of stations. This study poses a number of measurable factors that arguably might influence revenues, explains the reasons for selecting them, and then examines the available data to see which effects are statistically discernible.

The point of the study is to discover generally applicable relationships rather than to deal with the isolated case. For example, one may know from personal experience that the closing of a daily newspaper in some metropolitan

---

(continued)
follow the results below without any particular knowledge of these issues. A standard technical reference is J. Johnston, Econometric Methods, 2nd ed. (McGraw-Hill, 1972). The units of observation used in the regressions below are, strictly speaking, firms rather than radio stations. Some firms in the data sets operate only AM stations, some operate only FM stations, and some are joint AM-FM operations. The difference is technical rather than substantive, and it does not bear upon the common-sense interpretation of the results. The statistical package SHAZAM (by Kenneth J. White, Rice University) was used for all calculations.

8/ Econometricians should take the framework presented here as a "reduced form" rather than a "structural" model.

area was followed by a significant increase in local radio stations' advertising revenues. One might thereupon reasonably hypothesize that radio revenues in most other markets are systematically related to local newspaper circulation and moreover that such a relationship will show up meaningfully in the available statistics. But until the data actually are consulted, one should maintain the notion as an untested hypothesis. It will always be possible that such a relationship does not actually hold on the average across the nation. Or even if it does hold, the available statistics may be so error-ridden as to conceal the true relationship.

Certain potentially important factors have been ruled out as objects of this study altogether (a) because they are not covered by available data, (b) because they cannot currently be measured, (c) because there is no clear consensus or well-understood "theory" about how they are likely to affect revenues, or (d) for some combination of these three reasons. Some potentially important revenue determinants that might be so categorized, and that have not been included in this study, include management quality, audience demographics, and "formats" (i.e., type of programming, particularly type of music played).

Factors likely to influence revenues divide into two basic categories, the individual station characteristics and market characteristics. Among measurable revenue-determining station characteristics, perhaps the most obvious is transmitting power. Power influences revenue due to its impact both on the station's geographic coverage area and on the quality (i.e., the signal-to-noise ratio) of its signal. Therefore the relationship between power and revenue should be positive. Three types of power are treated -- daytime power for AM stations, nighttime power for AM stations, and FM power. AM day and night power are two separate components of a station's revenue-producing assets not only because the FCC licenses many AM stations with different night and day power levels, but also because night signals and day signals have radically different geographic coverage characteristics on the frequencies used for AM broadcasting. (By contrast, signals on the frequencies used for FM broadcasting propagate essentially the same during the day as at night, and consequently the FCC licenses FM stations for the same night- and daytime power levels.) Another important technical characteristic that may affect an AM station's revenues is its frequency. During the daytime, AM stations on the lower frequencies have much larger coverage areas than stations on the higher AM frequencies (given equal power levels). In fact, a favorable frequency can overcome substantial daytime power differences. For example, a 5000 watt AM station in the vicinity of 600 kHz will typically have a larger daytime coverage area than a 50,000 watt station on 1500 kHz. The relationship of AM frequency to station revenue is therefore hypothesized to be negative, indicating lower revenues to stations at higher frequencies, all other things being equal.

Additional station characteristics included in this study are (a) use of directional AM antennas, (b) whether a station in a multi-county market is in a "core" or "ring" county, (c) whether a station has network affiliation, and (d) whether a station is AM Class IV. Core-county location and network affiliation are hypothesized to have positive influences on a station's revenue, while directional antenna use and Class IV status are hypothesized as having negative influences. Rationales for these hypotheses follow. It is worth mentioning again, however, that no matter how reasonable they seem, these hypotheses may not survive examination of the data (as seen below in Section III).

Use of directional AM antennas is hypothesized to reduce potential revenues because the stations concerned must to some extent confine their coverage areas by lowering signal strengths in certain geographic directions. (Offsetting this confinement, however, may be the more effective use of the directional station's power in other directions.) Class IV AM status is hypothesized also to reduce revenues because Class IV stations do not have "nighttime protection." Class IV stations operate with 1000 watts during the day and 250 watts at night, with non-directional antennas. They are each assigned one among six AM frequencies reserved for Class IV stations only. Unlike other AM stations operating after sunset, they lack nighttime "protection." They are spaced across the country so that they do not interfere with one another during the day. They therefore enjoy effective daytime coverage areas reaching perhaps 15 to 20 miles from their transmitters. At night, however, "skywave" conditions cause their signals to travel much farther and thereby to interfere with one another. This interference is so great that their effective nighttime coverage areas extend out no more than about five miles from their transmitters. On other AM channels, stations are placed farther apart and/or use nighttime directional antennas, so that their "protected" signals have greater effective nighttime coverage areas (per watt) than do Class IV stations. Therefore, Class IV stations are hypothesized to have lower revenues, all other things being equal, than do other AM stations. Network affiliation and "core" county locations (in multicounty markets) are hypothesized to raise stations' revenues, network affiliation because it presumably offers a station's listeners a commercially superior service to independent stations and core location because it centers a station's signal in the most heavily populated parts of multi-county markets.

The market-specific factors considered in this study (all for 1978) are (a) per capita automobile registrations, (b) per capita daily newspaper circulation, (c) number of daily newspapers, (d) total consumer spendable income (CSI), (e) number of commercial radio stations, (f) total number of radio stations and (g) the number of TV stations in the market area. 9/ Automobile registrations were hypothesized to show a positive relationship with radio revenues due to the large amount of radio listening that alledgedly occurs during "drivetime." Newspaper circulation is hypothesized to have a negative relationship with radio revenues because newspapers are competitively important as local advertising alternatives to radio. Consumer income (taken in this study as total rather than per capita) is hypothesized to show a positive relationship with radio revenues, since a larger "pool" of consumer income should on the average translate into more lucrative business conditions, while the numbers of commercial radio stations, total radio stations, and TV stations are -- for competitive reasons -- hypothesized to affect revenues negatively. 10/

IV. Revenue Determinants

A. Large Markets

The large market data set covers 1125 radio stations (in 812 separate observations). Of these, 350 are AM-only, 149 are FM-only, and 313 are joint

---

9/ Consumer Spendable Income is similar to Consumer Disposable Income as reported by the Department of Commerce. CSI, which is estimated by the Standard Rate and Data Service, has the advantage of being available quickly on a yearly basis for the nation's 400 largest radio markets, together with comparable data on retail sales, automobile registrations, updated population, and the like.

10/ Total population for each market area has not been used in this study as an independent variable because of the presumption that "people without income" would not be a revenue source for stations. Total consumer income presumably captures both a "pure" population effect for a given market area and the average citizen's purchasing power, since total income is simply per capita income multiplied by population. Per capita auto registrations and per capita daily newspaper circulation were used, on the contrary, to avoid double counting of the pure population impact and at the same time to provide measures of the intensity of both automobile driving and newspaper readership.

AM-FM (i.e., two-station) operations. These stations are spread among 100 metropolitan areas selected at random from the largest 400 radio markets in the country. All of these markets are defined by county boundaries. 11/

The data are from three main sources. Revenues are from stations' FCC Form 324 filings. Data on stations' power levels, frequencies, and other characteristics are from Broadcasting Yearbook, 1979. Data on each market's consumer spendable income, automobile registrations, and daily newspaper circulation are from the Standard Rate and Data Service, as of December 31, 1978.

Multiple regression analysis was used to estimate the separate effects upon radio stations' 1978 revenues of the fifteen variables defined in Table One. 12/ All regressions were fitted as linear in logarithms, except for the dummy variables. 13/ Basic results are shown in Table Two. The table shows estimated coefficients and intercept terms for four slightly different forms

---

11/ The study's original intent was to include all commercial stations on the air in the 100 markets as of December 31, 1978. This total would have given about 895 observations. Inconsistencies and gaps in data sources limited the useful sample, however, to 812. The 400 metropolitan areas are the country's major radio markets as defined by the Standard Rate and Data Service (SRDS), as of December 31, 1978. The SRDS list consists principally of the Census Bureau's 318 SMSA's for 1978 plus 82 additional markets selected by SRDS. The SRDS supplemental markets are all single counties with large urban populations. All SMSA's, except those in New England, are defined by county boundaries. Most of the larger SMSA's consist of more than one county. The present study substitutes the Census Bureau's New England County Metropolitan areas for New England SMSA's, in order to keep all markets defined consistently in terms of county boundaries.

12/ The results reported in the text use not only 1978 revenues as the dependent variable, but also 1978 values for all the independent variables. The selection was made because 1978 revenues were the most recent available data in FCC files when the study began. In order to compare the 1978 results with both previous and subsequent years, however, limited regressions for 1976 through 1980 are reported in Appendix A. Nothing in those results presents any significant contradiction to the results presented here in the main text.

13/ A dummy variable takes a value of zero when a given condition is absent, and a value of one when the condition is present. For example, stations with AM directional antennas receive a value of one for the variable DADUM. For other stations, DADUM is zero.

of the basic model. That is, there are four slightly different equations. Changing the "specification" in this way causes the estimated coefficients and intercepts to vary somewhat from equation to equation. The first equation tests the maximum number of variables. The second, third, and fourth equations test fewer variables, and they also try alternative measures of market competitiveness: The second equation takes the total number of stations in the market area (NSTA) as the measure of competitiveness, whereas the third equation takes only the number of commercial stations (CSTA). The fourth equation takes a weighted index of commercial stations (WSTA) as the measure of competition, where stations in "ring" counties of SMSA markets count only as one-half a station each and all others count as full stations. Mean values of the dependent variables are shown in the two right-hand columns.

Table Two may be read as follows. The values in parentheses are "t-scores" for the coefficients immediately above them. A t-score of 1.96 or more is taken to mean that the corresponding coefficient is statistically significant at the 95 per cent level. 14/ Except for the dummies, the coefficients themselves may be read as saying that a one per cent increase in the particular variable is associated with an indicated percentage change in stations' 1978 revenues. For example, the coefficient on CSI78 in the first equation indicates that, on the average, an increase of one per cent in 1978 consumer spendable income was associated in this sample with an estimated increase of about 0.45 per cent in stations' revenues, all other things being

---

14/ In other words, the odds are 95-to-5 or better that the true coefficient is not zero and has the same sign as the estimated coefficient.

equal. 15/ Unfortunately, the coefficients of the dummy variables do not have such a straightforward "percentage" interpretation. 16/

As shown in Table Two, the following variables appear to be statistically significant determinants of radio broadcasting revenues: (1) AM daytime power, (2) AM nighttime power, (3) AM frequency, (4) FM power, (5) consumer spendable income in the market area, (6) the number of competing stations in the market area, and (7) whether the station is in a "core" county (as opposed to a "ring" county) of a multi-county market. The significance levels are quite high compared to much cross-section economic research and generally are confirmed across all three sets. 17/

The following variables do not appear as statistically significant determinants of revenues: (1) number of TV stations in the market area, (2) per capita automobile registrations in the market area, (3) per capita daily newspaper circulation in the market area, (4) the number of daily newspapers in the market area (coefficient not reported in Table Two), (5) whether or not the station uses a directional AM antenna, (6) whether or not the station is AM class IV, and (7) whether or not the station has network affiliation.

15/ The t-score of 9.07 indicates that the true value of the coefficient, assuming only sampling errors, stands a 95 per cent chance of lying between 0.344 and 0.564.

16/ They do show, however, a mathematical formula for predicting the effect of a given condition. For example, CORDUM will predict the advantage of a station's being located in a central county for any given set of AM and FM powers. But this advantage will decrease steadily for higher power levels (and/or higher levels of other variables like CSI). And when a dummy variable is not significantly different from zero, it shows that the presence of a given condition has no statistically significant impact on revenues.

17/ But see Appendix B for a discussion of possible bias in the calculation of significance levels.

Table One

Definitions of Variables

AMDPWR - Daytime AM power in watts, transformed to natural logarithms.

AMFREQ - AM frequency in kilohertz, transformed to natural logarithms.

AMNPWR - Nighttime AM power in watts, transformed to natural logarithms.

CARSPC - Per capita automobile registrations in the market area,transformed to natural logarithms.

CIRCPC - Per capita daily newspaper circulation in the market area,transformed to natural logarithms.

CORDUM - Equals one if station is located in the "core" county of a multi-county SMSA or in a one-county market, and equals zero if astation is in a "ring" county of a multi-county SMSA.

CSI78 - Consumer spendable income in the market area for 1978 as reported by the Standard Rate and Data Service in thousands of dollars, transformed to natural logarithms.

CSTA - Number of commercial radio stations in the market area, transformed to natural logarithms.

DADUM - Equals one if the station uses a directional AM antenna (day or night) and equals zero if the station does not use an AM directional antenna.

FMPWR - FM power in watts, transformed to natural logarithms.

FOURDM - Equals one if the station is a Class IV AM; otherwise equals zero.

NETDUM - Equals one if the station is a network affiliate; otherwise equals zero.

NSTA - Number of radio stations in the market area, transformed to natural logarithms.

NTV - Number of television stations in the market area, transformed to natural logarithms.

WSTA - Weighted index number of commercial radio stations in the marketarea, tranformed to natural logarithms. For the index, stations in "ring" counties of multi-county markets are given a weight of 0.5, while all other stations receive weights of 1.0.

Table Two

Determinants of Revenues, Large Markets

Dependent Variable: 1978 Revenue
(all variables, except dummies, in natural logs; parentheses show t-scores)

Equation No.	1	2	3	4	Means	
Independent Variable					logs	originals
AMDPWR	0.178	0.175	0.181	0.179	6.246	4419.3
	(6.09)	(6.01)	(6.28)	(6.28)		
AMNPWR	0.091	0.094	0.093	0.093	3.256	2337.3
	(8.19)	(9.61)	(9.59)	(9.72)		
AMFREQ	-0.149	-0.145	-0.149	-0.147	5.760	980.24
	(4.65)	(4.57)	(4.75)	(4.74)		
FMPWR	0.076	0.075	0.075	0.074	5.576	23485
	(13.20)	(13.37)	(13.40)	(13.41)		
CSI78	0.454	0.462	0.511	0.520	15.014	8,514,200
	(9.07)	(9.66)	(11.59)	(12.82)		
NSTA	-0.310	-0.371			2.926	26.034
	(3.33)	(4.58)				
CSTA			-0.539		2.838	20.720
			(6.26)			
WSTA				-0.558	2.649	17.904
				(7.20)		
NTV	-0.073				1.036	3.362
	(0.93)					
CIRCPC	-0.035				-1.262	0.329
	(0.68)					
CARSPC	0.123				-0.643	0.542
	(1.34)					
CORDUM (dummy)	0.446	0.439	0.435	0.506		0.796
	(6.64)	(6.56)	(6.59)	(7.75)		
FOURDUM (dummy)	0.065	0.048	0.047	0.038		0.151
	(0.69)	(0.56)	(0.56)	(0.46)		
DADUM (dummy)	0.035					0.367
	(0.50)					
NETDUM (dummy)	0.042					0.390
	(0.78)					
Intercept	5.831	5.798	5.515	5.26		
	(10.06)	(10.99)	(11.64)	(11.33)		
1978 Revenue					12.993	829,450
F	74.49	120.54	125.44	128.83		
R^2 ADJ	0.54	0.54	0.55	0.56		
N	812	812	812	812		

Three alternative measures of competition (NSTA, CSTA, and WSTA) were tested, and all were found statistically significant. These last results from the large market data set suggest that the number of commercial stations in the market is a better measure of competitive impact than is simply the total number of stations in the market, and that the weighted index number is perhaps slightly better still. These results are not surprising. On the other hand, they are not repeated in the small markets and trading price data sets (see below).

B. Small Markets

A second sample consists of 100 counties not located in the top 400 markets. Leaving aside non-commercial stations and stations whose financial data in FCC files could not be used due to gaps or inconsistencies, the remaining stations in these counties furnished a total of 306 stations for the sample (in 208 observations), of which 93 are AM-only, 17 are FM-only, and 98 are joint AM-FM (two-station) operations. The regression procedures were generally the same as for the large-market sample, except that fewer variables were tested for significance. 18/

As shown in Table Three, the following variables were statistically significant as determinants of small-market stations' revenues: (a) AM daytime power, (b) AM nighttime power, (c) AM frequency, (d) FM power, (e) consumer spendable income, and (f) number of stations in the market. The dummy variables for class IV status and directional antennas were not significant.

18/ Due to their insignificance in the large-market sample, the following variables were thought likely to be insignificant here also and therefore were not tested for the small-market sample: automobile registrations, newspaper circulation, number of TV stations, and network affiliation. Core-county location and "weighted" number of competing stations are not relevant, since all the small markets are single counties.

Table Three

Determinants of Revenues, Small Markets

Dependent Variable: 1978 Revenue
(all variables, except dummies, in natural logs; parentheses show t-scores)

Equation No.	1	2	Means	
Independent Variables			logs	originals
AMDPWR	0.256 (5.47)	0.260 (5.55)	6.455	1736.8
AMNPWR	0.040 (2.15)	0.034 (1.83)	2.368	591.4
AMFREQ	-0.180 (3.73)	-0.178 (3.70)	6.498	1120.4
FMPWR	0.055 (6.54)	0.055 (6.59)	4.887	11424.0
CSI	0.359 (5.01)	0.367 (5.13)	12.062	250,970
NSTA	-0.369 (3.92)		1.027	3.45
CSTA		-0.400 (4.07)	0.968	3.18
FOURDM (dummy)	-0.058 (0.47)	-0.052 (0.42)		0.2356
DADUM (dummy)	0.152 (1.23)	0.172 (1.39)		0.1731
Intercept	7.332 (8.93)	7.213 (8.74)		
1978 Revenues			12.159	237,580
F	19.41	19.66		
R^2 ADJ	0.42	0.42		
N	208	208		

V. Determinants of Trading Prices

Trading price data and basic station data were taken from Broadcasting magazine, January 1980 through June 1981, on all radio station sales. The file has data on 745 stations, 167 of which were joint AM-FM (two-station) operations, 282 were AM-only, and 129 were FM-only. The stations sold were categorized as being in either SMSA markets or non-SMSA single-county markets. The total numbers of radio stations in the respective SMSA's and counties were taken from the 1979 Broadcasting Yearbook. Data on 1978 consumer spendable income in the same SMSA's and counties were taken from the Standard Rate and Data Service. 19/

As with the data set on revenue determinants, the dependent variable (trading price) and all independent variables for the trading price set (again except dummies) were transformed into their natural logarithms. Data on newspaper circulation, automobile registrations, television stations, and radio network affiliations were not included in these regressions, due to their non-significance in the revenue-determinants' regressions. 20/ The following independent variables were tested, then, as possible determinants of trading prices: (1) AM daytime power, (2) AM nighttime power, (3) AM

19/ Therefore all the basic data for this section of the study are from relatively accessible public sources, as opposed to confidential FCC files. Although the files on station sales are not closed to the public (as are FCC files on stations' financial data), they are difficult to use. There are variable lags in the time between FCC approval of an actual station sale and Broadcasting magazine's report of the sale, but no particular gain in precision was seen in using dates reported in FCC records, especially since the 18-month period for study was itself chosen arbitrarily. Sales reported at less than $10,000 were omitted from the sample, due to the belief that they did not reflect arms-length market values.

20/ An exception was made in the case of the dummy variable for AM Class IV stations, which was included in the trading price regressions because of its policy relevance -- even though it also was insignificant in the revenue regressions.

frequency, (4) FM power, (5) consumer spendable income in the market area, (6) total radio stations and commercial radio stations in the market area, (7) location in the "core" county of a multi-county market, and (8) Class IV AM status. (The last two variables are zero-one dummies.) The results of the trading price regressions are shown in Table Four. An additional linear variable, TIME, was used to test the hypothesis that station prices increased according to a linear trend over the 18-month period. 21/

The trading price regressions show results similar to the revenue regressions, in terms of both the absolute values and the significance levels of the coefficients. Notable again is the insignificance of the Class IV dummy. TIME is also insignificant, although it has the expected positive sign. Perhaps the most notable difference between the trading price results and the previous regressions is that in the former, the alternative measures of competition (CSTA and WSTA) do not offer better fits than does the simple measure of total stations (NSTA). 22/ The overall similarity of results, however, is consistent with a hypothesis that the market for radio broadcast properties functions well insofar as it puts the "correct" economic values on the determinants of trading prices. And the fact that similar results came from separate data sets speaks well for the robustness of the methodology used here. 23/

21/ TIME was the month in which Broadcasting reported the transaction, with January 1980 taken as month number one and June 1981 as number 18.

22/ Based on their t-scores. There is no readily apparent explanation for this result.

23/ Actually, the two data sets have a small overlap. About 17 per cent of the observations in the trading price file were also in the large markets file, and about three per cent were in the small markets file. The small markets and large markets files are mutually exclusive to one another.

Table Four

Determinants of Radio Stations' Trading Prices
(all variables, except dummies and TIME,
in natural logs;parentheses show t-scores)

Equation No.	1	2	3	Means	
Independent Variable				logs	originals
AMDPWR	0.152 (3.54)	0.150 (3.49)	0.148 (3.46)	5.570	1915.2
AMNPWR	0.063 (4.59)	0.065 (4.72)	0.064 (4.62)	2.439	710.64
AMFREQ	-0.125 (2.84)	-0.126 (2.85)	-0.124 (2.80)	5.534	988.18
FMPWR	0.080 (10.53)	0.079 (10.45)	0.079 (10.43)	4.722	16081
CSI78	0.525 (10.27)	0.483 (10.71)	0.471 (10.53)	13.615	
NSTA	-0.361 (4.63)			2.049	14.384
CSTA		-0.323 (4.37)		1.928	11.306
WSTA			-0.304 (4.04)	1.901	10.901
CORDUM	0.640 (6.00)	0.714 (6.61)	0.710 (6.56)		0.872
FOURDUM	-0.003 (0.027)	-0.010 (0.091)	-0.008 (0.08)		0.178
TIME	0.007 (1.21)	0.007 (1.19)			9.599
Intercept	5.379 (8.93)	5.838 (10.56)	5.898 (10.68)		
PRICE				13.089	851,410
F	58.54	65.03	57.60		
R^2 ADJ	0.48	0.47	0.47		
N	578	578	578		

To investigate further the relationships between revenues and trading prices, 1978 revenue data from FCC files for stations traded from January 1980 through June 1981 were regressed against the same set of determinants (except TIME). Table Five presents these results, and Table Six compares the revenue determinants and trading price determinants to one another directly. The reults again are basically similar, with two exceptions: (1) the coefficient in the revenue regressions on AMFREQ falls below the 95 percent significance level, and (2) the coefficient on FMPWR is much higher in the trading price regressions. There is no obvious explanation for the insignificance of the AMFREQ coefficient. The higher FMPWR coefficient is due, no doubt, to buyers' expectations that FM revenues will grow more rapidly in future years than will AM revenues. This phenomenon has been noted in the trade press. 24/ In addition to the regression analysis, a direct comparison of trading prices to revenues was also performed. The results are presented in Table Seven. Here also one can see a marked premium for FM stations, again based no doubt upon investors' expectations that FM will continue to outpace AM.

VI. Implications of the Results

These findings should be interpreted with caution for several reasons. First, apparently no comparable study is publicly available. A single unreplicated statistical study is not necessarily a suitable basis for strong policy conclusions. Moreover, the present study is not based on strictly random samples. And its data are necessarily limited to past years -- years

---

24/ See, e.g., Broadcasting, January 12, 1981, p. 48, and January 21, 1980, p. 54, which report on the relative popularity among broadcast investors of FM properties. FM's share of the radio audience has risen above 50 per cent nationally in recent years and is now 65 per cent or more in many larger urban markets.

Table Five

1978 Revenue Determinants for Stations that
Changed Hands from January 1980 through June 1981
(all variables, except dummies, in natural logs; parentheses show t-scores)

Equation No.	1	2	3
Independent Variable			
AMDPWR	0.125 (3.34)	0.123 (3.25)	0.122 (3.23)
AMNPWR	0.065 (5.48)	0.066 (5.54)	0.066 (5.52)
AMFREQ	-0.055 (1.40)	-0.054 (1.38)	-0.053 (1.35)
FMPWR	0.064 (9.56)	0.064 (9.46)	0.063 (9.45)
CSI78	0.511 (11.01)	0.457 (11.26)	0.451 (11.27)
NSTA	-0.386 (5.45)		
CSTA		-0.330 (4.93)	
WSTA			-0.323 (4.87)
CORDUM (dummy)	0.752 (7.90)	0.820 (8.47)	0.821 (8.47)
FOURDUM (dummy)	-0.075 (0.85)	-0.077 (0.88)	-0.079 (0.90)
Intercept	4.634 (8.48)	5.164 (10.33)	5.221 (10.54)
F	64.61	63.32	63.15
R^2 ADJ	0.50	0.49	0.49
N	514	514	514

Table Six

Comparison of Revenue Determinants and Trading Price Determinants for Stations that Changed Hands During January 1980 through June 1981
(all variables, except dummies, in natural logs; parentheses show t-scores)

Dependent Variable / Independent Variable	Trading Price[a]	Trading Price[b]	1978 Revenue[c]	1978 Revenue[b]
AMDPWR	0.152 (3.54)	0.148 (3.31)	0.125 (3.34)	0.131 (3.21)
AMNPWR	0.064 (4.66)	0.061 (4.3)	0.065 (5.48)	0.070 (5.40)
AMFREQ	-0.126 (2.85)	-0.119 (2.58)	-0.055 (1.40)	-0.060 (1.42)
FMPWR	0.080 (10.41)	0.081 (10.20)	0.064 (9.56)	0.067 (9.15)
CSI78	0.526 (10.28)	0.560 (10.16)	0.511 (11.01)	0.502 (9.91)
NSTA	-0.363 (4.65)	-0.408 (4.85)	-0.386 (5.45)	-0.382 (4.95)
CORDUM (dummy)	0.643 (6.03)	0.629 (5.56)	0.752 (7.90)	0.703 (6.78)
FOURDM (dummy)	-0.007 (-0.07)	-0.003 (0.03)	-0.075 (0.85)	-0.064 (0.67)
Intercept	5.432 (9.04)	5.075 (7.81)	4.634 (8.48)	4.739 (7.94)
F	65.62	58.31	64.61	55.27
R^2 ADJ	0.47	0.47	0.50	0.46
N	578	517	514	517

NOTES:
a. For all stations in the data set.
b. For stations with 1978 revenues greater than zero.
c. For stations with 1978 revenues greater than $10,000.

Table Seven
Trading Prices vs. 1978 Revenues for Radio Stations
Traded, January 1980 through June 1981[a]

	Ratios of Trading Price to Revenues				
	Weighted Average[b]	Unweighted Average	Average Price	Average Revenue	Number of Sales
All Properties	2.57	2.73	901,850	350,960	514
AM only	1.92	2.22	596,990	310,860	251
FM only	3.74	3.94	1,250,100	334,640	104
AM-FM	2.72	2.72	1,155,300	424,930	159

Notes: a. Stations with either trading prices or 1978 revenues less than $10,000 are omitted from these calculations.
b. Weighted by revenue; equivalent to average price divided by average revenue.

that will be much more distant before any major policy based on its results could be implemented. So the discussion below should be taken only as a series of hypotheses not contradicted by the available data. On the other hand, the results have plausibility for at least three reasons. First, they are generally consistent across all three data sets, the third of which has absolutely no claims of statistical randomness. Second, all the statistically significant coefficients have the predicted signs and thereby are consistent with theory and our expectations. Third, the coefficients have significance levels quite high by ordinary standards of economic research.

The coefficients on competition cluster in the neighborhood of -0.55 for the large markets (based on WSTA in Table Two), -0.40 for the small markets (using CSTA in Table Three), and -0.35 for the trading price data set (Tables Four and Five). These numbers indicate for example, that a one per cent increase in the number of stations in the large market data set is associated with a decrease in old stations' revenues, on the average, of about 0.55 per cent, and that an increase in the number of stations by ten per cent (a much more likely situation) is associated with an average decline in per-station revenues of about 5.1 per cent. 25/ In other words, these figures indicate that, on the average, most of a new station's revenues can be expected to come from "new" advertising; less than half of its revenue is likely to be drawn away from other stations. (Of course, any such statement must be qualified by the probability that individual stations in individual markets will diverge from the average. But about as many will probably be above the average as below it.)

The insignificance of the Class IV dummy variable in all of the regressions, across all three data sets, suggests that Class IV AM stations are just as viable and just as valuable economically as other nighttime AM broadcasters, on a watt-for-watt basis. As noted above (p. 13), Class IV AM stations interfere severely with one another at night. This interference severely limits each station's nighttime geographic coverage. One might expect, therefore, that Class IV stations should suffer economically as compared to stations with nighttime signal protection. Yet, the data fail to reveal any such handicap. 26/

25/ With the coefficient of 0.55, an increase in stations by 20 per cent is associated with a decrease in per-station revenues of about 9.4 per cent; and an increase in station revenues of 30 percent is associated with a decrease in per-station revenues of about 13 per cent. The average number of commercial stations per market in the large market data set is 20.7, so that one new station in the representative market would represent an increase of about five per cent in the number of stations, associated on the average with a decline of about 2.6 per cent in per-station revenues.

26/ A possible explanation of this finding is that most of a Class IV station's potential audience typically lives within about five miles of the transmitter so that listeners living beyond five miles are usually not numerous enough to attract large advertising revenues for Class IV stations.

This lack of a handicap suggests that if the FCC has the opportunity to establish new AM channels, it should consider assigning stations there without nighttime protection. An opportunity to apply such an approach may arise in the late 1980's, when ten new AM channels may be assigned in the band 1605 to 1705 kilohertz. (This band was established by the 1979 World Administrative Radio Conference. Implementation of assignments in the Western hemisphere might not be undertaken until almost 1990, however.) The current distribution of Class IV stations indicates that these new channels could probably accommodate something like 1500 fulltime local service stations without nighttime protection. If nighttime protection should be given, on the other hand, the new channels could probably accommodate only 300 to 400 stations. 27/ Thus it appears that the total economic value of the new channels might be four or five times greater for an allocation of unprotected nighttime operations than for an allocation of protected assignments.

The results above also have an implication for future statistical analysis of radio revenue determinants. The FCC decided in March 1982 to abolish mandatory annual financial reporting for broadcasters. 28/ These reports furnished the revenue data used in this study. The trading price regressions presented above suggest, however, that essentially the same results may be expected when analyzing certain policy questions whether one uses trading prices or revenues as the dependent variable. Thus, both non-government analysts and the FCC should be able in the future to use publicly available trading price data for making many policy-oriented statistical inferences about the determinants of radio broadcasting revenues.

27/ Current Class IV channels accommodate about 150 stations each; thus the estimate of 1500 stations for ten new channels. Calculations during the Commission's 9 kHz studies showed that ten new channels on the existing AM band would probably accommodate only 300 to 400 local service stations with nighttime protection.

28/ Docket No. 80-190, 47 F.R. 13345 (1982). The data formerly were filed on FCC form number 324.

APPENDIX A

A Comparison of Revenue Determinants for 1976 through 1980

The main data files for this study were originally set up with station revenues, income (CSI), and numbers of stations (NSTA) for 1978. After much of the data gathering and regression analysis were completed, however, data on station revenues became available for 1979 and 1980. Although time constraints prevented re-analysis of all variables, a limited set of regressions were run on 1979 and 1980 revenues, together with 1976, 1977, and 1978 revenues, for the large market sample. The results of these regressions are shown in Table A-1. The most notable features of these coefficients are their relative stability from year-to-year and their general conformity with the 1978 results presented in the main text. Another notable feature is the consistent, although slight, year-to-year increase in the coefficient on FM power (FMPWR). This increase probably reflects FM's growing share of the total radio audience (see text, footnote 24).

The regressions in Table A-1 have a slightly larger sample of stations for 1978 (N = 825) than the large market regressions in the text (N = 812). The reason is that new data became available between the work on the original regressions and the work for Table A-1. Since the results were so close, however, it was thought not worthwhile to recalculate the original regressions. The regressions in Table A-1 also have slightly different sample sizes from year to year, due to annual variations and other problems in the FCC files. Although it would have been possible to calculate the coefficients with an identical (and smaller) sample for all five years, this exercise was judged not worth the effort that would have been involved. Finally, the NSTA numbers used in each year are all for 1978, due to the lack of time available during the project to build up a complete new set of station numbers for 1976-78 and 1979-80. This circumstance appears to be reflected in the relatively lower t-scores on NSTA for 1976-77 and 1979-80, as opposed to the t-score for 1978.

Table A-1

Revenue Determinants for Large Market Stations, 1976-80
(All variables, except dummy, in natural logs; parentheses show t-scores.)

Year Independent Variable	1976	1977	1978	1979	1980
AMDPWR	0.165 (6.92)	0.172 (7.06)	0.162 (6.64)	0.162 (6.44)	0.157 (6.15)
AMNPWR	0.101 (11.93)	0.095 (11.15)	0.098 (11.37)	0.091 (10.30)	0.090 (10.05)
AMFRQ	-0.106 (4.11)	-0.122 (4.66)	-0.119 (4.54)	-0.120 (4.47)	-0.126 (4.61)
FMPWR	0.070 (13.47)	0.075 (14.09)	0.084 (15.64)	0.089 (16.25)	0.095 (17.16)
CSI[a]	0.335 (7.93)	0.365 (8.58)	0.452 (9.77)	0.397 (8.98)	0.404 (8.94)
NSTA[b]	-0.160 (2.23)	-0.214 (2.97)	-0.366 (4.67)	-0.247 (3.31)	-0.249 (3.28)
CORDUM (dummy)	0.496 (7.71)	0.476 (7.39)	0.456 (7.04)	0.553 (8.32)	0.524 (7.70)
Intercept	6.689 (14.37)	6.548 (13.83)	5.787 (11.33)	6.216 (12.42)	6.259 (12.14)
R^2 ADJ	0.56	0.55	0.56	0.56	0.57
F	146.17	143.78	153.88	148.97	148.78
N	811	817	825	825	795

Notes: a. Consumer Spendable Income for each market in the year shown in the column heading.
b. Number of Stations in the market in 1978.

Appendix B

Heteroskedasticity and Biased Significance Tests

Significance tests for parameters estimated by ordinary least squares (OLS) regression generally assume that the disturbance term has a constant variance across the entire range of observations. When this assumption of "homoskedasticity" is violated, a regression is said to display "heteroskedasticity." A consequence of heteroskedasticity may be bias in the significance tests for the estimated parameters, such that an insignificant relationship appears to be significant. 1/ Therefore, if heteroskedasticity is present in the regressions above, then the estimated coefficients actually may be less significant than the OLS t-scores indicate.

A popular and relatively simple test for heteroskedasticity is the method of Goldfield and Quandt (G-Q). 2/ That method is used here. Briefly, it involves separating the observations into three groups, rank-ordered by an independent variable thought to be a likely source of heteroskedasticity, and then running separate regressions on the top and bottom groups. If the postulated regression model displays heteroskedasticity then the ratio of residual variances for the two separate regressions should diverge significantly from unity (judged by an "F" test with appropriate degrees of freedom).

1/ Many econometrics textbooks discuss the problem of heteroskedasticity. The most accessible and compact discussion is probably in J. Johnston, Econometric Methods, 2nd ed.(1972), pp. 214-221.

2/ S.M. Goldfeld and R.E. Quandt, "Some Tests for Homoscedasticity," Journal of the American Statistical Association, 60 (1965), pp. 539-547, summarized in Johnston, op. cit., p. 219.

There were no strong a priori reasons in this study to suspect that rank ordering by some particular independent variable was most likely to reveal heteroskedasticity. 3/ Therefore, seven different G-Q tests were performed with the large market data file, with the observations rank-ordered successively by 1978 revenue (the dependent variable) and the following six independent variables: (a) consumer spendable income, (b) AM day power, (c) AM night power, (d) AM frequency, (e) FM power, and (f) number of stations. The results of these tests are shown in Table B-1. A ratio of unity for the residual variances from each "upper" regression to its corresponding "lower" regression would indicate the total absence of heteroskedasticity. In these

Table B-1

Tests for Heteroskedasticity

Observations Ranked by [a]	Ratio of High to Low Residual Variance		Critical Value for F-test
	Before Adj.	After Adj.[b]	(95%)
REV78	1.04	1.22	1.20
CSI78	1.59	1.14	1.20
AMDPWR	1.11	1.09	1.22
AMNPWR	1.08	1.10	1.21
AMFREQ	1.34	1.29	1.20
FMPWR	1.10	1.10	1.20
NSTA	2.02	1.50	1.20

Notes: (a) Variables defined in text, Table 1.
(b) All variables divided by CSI.

tests, therefore, a ratio greater than the critical F-value for any single pair means one can reject with 95 per cent confidence the hypothesis that the

3/ It is commonly suggested in the econometric literature, however, that heteroskedasticity is most likely where there is great variation in the size distribution of a variable. E.g., S.M. Goldfeld and R.E. Quandt, Nonlinear Methods in Econometrics (1972), p. 78.

disparity in residual variance between the upper and lower regressions in a pair is due simply to sampling variation. Therefore, based upon the "before adjustment" ratios where the observations are ranked by CSI, AMFREQ, or NSTA, one can be 95 per cent confident that the estimated regression suffers from heteroskedasticity.

In an attempt to eliminate heteroskedasticity, the data were adjusted by dividing all variables (which are already in natural lograrithms) by the logarithm of consumer spendable income (CSI78). 4/ The results of the G-Q tests after this adjustment are also shown in Table B-1. There are substantial reductions in two of three ratios that showed heteroskedasticity before adjustment, but one can nevertheless reject with 95 per cent confidence the hypothesis that the adjusted regression is homoskedastic. 5/ Thus one must be alert to the possibility that the true significance levels (t-scores) for regressions estimated in the text above are lower than the levels shown.

Time limitations prevented use of more ambitious methods of correcting the data for heteroskedasticity. It seems unlikely, however, that even "perfect" adjustment would render insignificant more than a few of the coefficients that are shown as significant in the text tables. The reasons are several. First, a Q-G test performed on the small-market data ranked by CSI produced a ratio of residual variances (1.24) that was well below the critical F-test value (1.47 for 69 degrees of freedom in both numerator and denominator). Second, the results in the text display marked consistency across three

---

4/ G-Q call this "the cheapest method of adjusting for heteroskedasticity" and note that it "appears to work moderately well in a variety of cases." *Op. cit.*, p. 119.

5/ Similar adjustments were performed with NSTA, the square root of CSI, and the square root of (CSI x NSTA). Reductions of the ratios were less after these adjustments than after the adjustment by CSI.

separate data sets. And third, sampling experiments by G-Q over a variety of cases indicate that OLS for heteroskedastic regressions typically biases a coefficient's variance estimator by factors of 2.0 or less. 6/ Since division by 2.0 would still leave most of the significant t-scores in the text at 1.96 or more, the basic thrust of the findings above is probably not affected by the model's obvious departure from homoskedasticity.

6/ *Op. cit.*, pp. 102-118.

Working Paper Series
Office of Plans and Policy
Federal Communications Commission

1. Social Objectives and Competition in Common Carrier Communications: Incompatible or Inseparable? by Nina W. Cornell, Daniel Kelley, and Peter R. Greenhalgh, April 1980. (NTIS No. PB81 169178; $8.00; 67 pp.)

2. Frequency Spectrum Deregulation Alternatives, by Douglas W. Webbink, October 1980. (NTIS No. PB81 169203; $8.00; 32 pp.)

3. Speech Bandwidth Reduction, by Philip B. Gieseler and John B. O'Neal, Jr., November 1980. (NTIS No. PB81 128068; $6.50; 35 pp.)

4. Reforming Regulatory Policy for Private Line Telecommunications Services: Implications for Market Performance, by Jerry B. Duvall and Michael D. Pelcovits, December 1980. (NTIS No. PB81 172520; $8.00; 58 pp.)

5. Economics and Telecommunications Privacy: A Framework for Analysis, by James A. Brown, Jr., and Kenneth Gordon, December 1980. (NTIS No. PB81 169229; $8.00; 50 pp.)

6. Deregulating Personal and Amateur Radio, by Alex D. Felker and James A. Brown, Jr., August 1981. (NTIS No. PB81 247751; $10.50; 70 pp.)

7. Negotiating for Improved Interconnection: The Incentives to Bargain, by Roy L. Morris and Robert B. Preece, January 1982 (Revised April 1982). (NTIS PB82 237066; $9.00; 58 pp.)

8. Deregulation After Divestiture: The Effect of the AT&T Settlement on Competition, by Daniel Kelley, April 1982. (NTIS No. PB 206232, $10.50; 80 pp.)

9. Statistical Determinants of Radio Stations' Revenues and Trading Prices, by James A. Brown, Jr., August 1982.

ABOVE PUBLICATIONS MAY BE ORDERED FROM NTIS BY MAIL OR TELEPHONE. PLEASE INCLUDE NTIS NUMBER (SEE ABOVE).

NTIS
Springfield, VA 22161
703/487-4650