

Preliminary and Incomplete

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Broadcasting Competition and Programming Costs

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This work is incomplete in many ways, not least of which is the data set, which is missing about half of the stations for any given year, as well as years 1942, 1943 and 1948. That will be remedied in future drafts. I am grateful for comments by Lisa George as a discussant at the 5th Workshop in Media Economics (Bologna) and by participants there and at Toronto, UBC, Berkeley and Cyprus.

ABSTRACT

An increase in the number of advertising-financed broadcasting stations is shown, theoretically, to effect programming expenditures through both the listener share effect (the dependence on competition of the fraction of listeners gained by increasing programming quality), and the revenue effect (per-capita ad revenue's dependence on firm concentration). These effects are estimated by an empirical examination of AM radio stations' programming expenditure and local advertising revenue during both the 'freeze' years of World War II and the period of massive expansion of radio station numbers in the latter part of the 1940s. I find that neither ad revenue nor programming expenditure of the existing firms were affected at all by the increased competition.

Section 1. Introduction

The effect of competition on firms' expenditure on product quality ought to be a central concern of Industrial Organization, but outside a few industries it is rarely studied empirically. It is, however, a matter of increasing relevance in media markets, given the steady increase in the number of outlets for audio and visual content over the last number of years. This paper explores the effect of competition on quality expenditure in advertising financed media markets, first theoretically and then empirically, the latter by studying radio broadcasting in the United States in the 1940s. The freeze on construction of new stations for nearly three years following the U.S. entry into World War II, and then the dramatic doubling of the number of stations in as many years after the war's end provides a useful environment to examine the issue at hand.

Opinions on the likely effect of competition on quality differ. The U.K. Office of Communications report (2005) claims that "[a] competitive broadcasting marketplace" will "encourage broadcasters to provided quality, innovation", a stand that seems merely to reflect an instinctive intuition that competition must be good for quality. Noll et al. (1973) take the opposing view that competition will "fragment the audience and thereby reduce the resources available to each broadcaster for programming", an opinion echoed by *The Economist* (2007) .

A priori, it is unclear what effect enhanced competition is likely to have on quality. The incentive to increase programming quality is the advertising revenue that accompanies the listeners thus attracted. In principle, competition can affect quality through both elements: the gain in listener share, and the per-capita ad revenue. A recent paper by

Armstrong and Weeds¹ (2007) captures the revenue effect. As shown previously by Choi (2006), in a Salop (1979) circle model of advertising financed broadcasting, increases in the number of stations lead stations to broadcast fewer ads, if listeners dislike advertising.

Armstrong and Weeds (2007) add quality to the model and note that with lower per-listener ad revenue, stations have a smaller incentive to increase their number of listeners, and so quality declines with competition. The listener share effect does not arise in their model.

The theoretical part of this paper shows that the Armstrong-Weeds result depends on linear transportation costs. First, under non-linearity, the listener share gained by increasing offered utility also depends on competition. Specifically, convex transportation costs will make gained listener share increasing in the number of firms, and if sufficiently convex will overturn their result and make quality an increasing function of competition. Second, under sufficient concavity, ad-revenue is increasing in the number of firms.

The empirical part of this paper estimates the effect of competition on ad revenue, the partial effect of competition on quality, holding ad revenue constant, and the net effect of competition on quality, for U.S. radio markets in the 1940s, and interprets those estimated relationship with reference to the theoretical model. Estimating the relationship between quality (i.e., programming) expenditure and competition is difficult because of the endogeneity of competition. The natural instrument for competition is market size, i.e., potential total ad revenue, since the bigger the market, the more broadcasters there will be in equilibrium. However, since the quality of broadcasting is clearly an endogenous fixed cost (Shaked and Sutton, 1983, 1987), it is determined directly by market size. This endogeneity problem is solved by exploiting the relationship between competition and

¹ The authors are primarily concerned with the comparison of advertising to subscription-based funding, and the role of a public broadcaster.

lagged market size inherent in the dramatic post-war expansion of AM radio station numbers after the war time construction freeze, which implies that the built up wartime demand can also serve as an instrument for competition.

The relationship between market size and quality is important in its own right. Shaked and Sutton (1983, 1987) and Sutton (1991) have demonstrated how crucial this relationship is to understanding industry concentration. Understanding the long run requires us to know how much of increases in market size are translated into increases in fixed costs and how much into the entry of new firms. Yet the effect of market size on quality expenditure has not been much studied empirically. Sutton (1991) and many others since (e.g., Robinson and Chiang, 1996) have explored the bivariate distribution of sales and concentration, but the direct effect of market size on fixed cost expenditures has not been tested, and certainly not measured. Sutton (1991) describes a number of industries in which increasing concentration accompanied a growth in demand, but these histories are potentially interpretable by the heterogenous capabilities theories of shakeouts that Klepper and his co-authors have offered.² So there is the need for a measurement of the effect of market size on quality expenditure. And broadcasting is a particularly convenient industry in which to examine these issues. With zero marginal costs, variable profits is equal to revenue, which is easily measured.

Most previous theoretical analysis of broadcasting has focused on content variety and not quality, starting with Steiner (1952) and Beebe (1977). The recent exceptions are described in the next section. Empirical work, such as Berry and Waldfogel (2001) and Sweeting (2006), has also concentrated on content variety, and not on quality or the investment therein.

² For example, Graddy and Klepper, 1990, Klepper, 1997.

Section 2. Theory

The model generalizes the adaptation of the Salop circle model to broadcasting markets with endogenous advertising, due first to Choi (2006) and, with endogenous quality, to Armstrong and Weeds (2006). The circle model has also been used for broadcasting media by Dukes and Gal-Or (2006), with exogenous quality, and Waterman (1992), with exogenous advertising. Motta and Polo (2003) also present a model of broadcasting with endogenous quality, but focus on long term effects and employ asymptotic analysis, which is inappropriate for our purposes here..

Listeners' ideal type of content (the 'horizontal' attribute) is distributed uniformly on the circumference of a circle. There are S consumers, and the market is always covered. Stations' content is located exogenously at equal distances along the circumference of the same circle. Stations choose advertising levels and quality.

A listener likes quality v (the 'vertical' aspect of content) and dislikes advertising a and content different from his/her ideal content type. A listener chooses the station with the greatest utility for him/her, equal to a common component $u \equiv v - a^m$ less a power function of the distance from the listener's ideal content to the station's:

$u - t(\text{distance})^\phi \equiv v - a^m - t(\text{dist.})^\phi$, $t\phi > 0$. (Thus individuals differ according to whether they prefer to listen to comedy or drama, but all prefer Jack Benny over some second rate comic, and to the same degree.) This generalizes the Choi and Armstrong-Weeds models, which assume $\phi = m = 1$.

The increase in listenership share D from a small increase in the common component of utility, u , when the differences in u across firms are small, is

$$(2) \quad \frac{dD}{du} = \frac{1}{t\phi} \sum_{i \in L, R} 1/[x_i^{\phi-1} + (N^{-1} - x_i)^{\phi-1}]$$

where x_L (x_R) is the distance to the firm of the marginal listener with respect to the neighbouring firm on the left (right), and the differences in u across firms is not too great. At a symmetric equilibrium (whose existence we will discuss at the end of this section), this is equal to

$$(3) \quad \frac{dD}{du} = \frac{1}{t\phi} (2N)^{\phi-1}$$

which also provides a first order approximation to (2).

Figures 1 and 2 show why the gain in listeners depends on N in this way. When $\phi > 1$ (Figure 1), the disutility of distance from ideal content is an increasing function of distance, so that increases in u are more effective in gaining market share when stations are more closely located to each other. In contrast, when $\phi < 1$ (Figure 2), listeners are relatively indifferent among content that is not close to their ideal point, so that crowding in more stations makes utility increases less effective.

As in Choi and Armstrong and Weeds (2007), I assume the station earns $r(a)$ per listener when broadcasting a ads, where r is concave and maximized at a^M . Thus profit is $SD(u, \bar{u}; N)r(a) - F(v)$, where $F(v)$ is the cost to the station of broadcasting quality v programs, and $F', F'' > 0$.

A station's choice of ad minutes to sell trade-offs the gain in per-capita ad revenue by against the loss of listeners to other stations. The first order condition is

$$(4) \quad \left. \frac{\partial D}{\partial a} \right|_{r(a) = Dr'(a)} \Rightarrow \frac{m}{t\phi} (2N)^{\phi-1} a^{m-1} r(a) = \frac{1}{N} r'(a)$$

which implies, as Choi (2006) and Armstrong and Weed (2007) point out, that competitive stations broadcast fewer ads than a monopolist guaranteed all listeners would. In their linear specification, ϕ equals one, so N affects the choice of ad minutes only through decreasing the firm's equilibrium listener share. More generally, competition also determines the fraction of listeners lost with increased ads, as in Figures 1 and 2. When $\phi > 1$, this second effect strengthens the first, while if $0 < \phi < 1$, the second counteracts but is dominated by the first, so that the authors' result that advertising is decreasing in N continues to hold so long as $\phi > 0$. If $\phi < 0$, increases in N actually increases ad minutes and per-capita ad revenue.

Firms' choice of quality trades-off the increase in listener share, multiplied by per-listener ad-revenue, against the increase in fixed cost of quality, thus

$$(5) \quad Sr(a)(dD / du) = F'(v)$$

or using (3),

$$(6) \quad S \frac{1}{t\phi} (2N)^{\phi-1} r(a) = F'(v)$$

Thus, conditional on per-capita ad revenue, quality is increasing (decreasing) in N if and only if $\phi > (<)1$.

To determine the net effect of competition on quality in parametric form, we need a specification for the per-capita ad revenue function. Approximate $r(a)$ below a^M by a^η with $0 < \eta < 1$ to ensure concavity³. Then the first order condition for per-capita ad minutes reduces to

$$(7) \quad r = \left\{ \frac{m}{\eta t \phi} 2^{\phi-1} N^\phi \right\}^{-\eta/m}$$

Substituting (7) into (6), we see that the sign of the net effect of competition on quality is that of $(\phi - 1) - \phi\eta/m$. Thus so long as the marginal disutility of advertising is increasing, the net effect is guaranteed to be negative if $0 < \phi \leq 1$, which of course includes the linear transportation case of Armstrong and Weeds. It is positive if and only if $\phi > [1 - (\eta/m)]^{-1}$.

To obtain a closed-form solution, suitable for estimation, assume either that

$$F(v) = \frac{1}{\beta} \delta v^\beta, \beta > 1 \text{ or } F(v) = \frac{1}{|\beta|} \delta (\alpha - v)^\beta, \beta < 0, v < \alpha. \text{ (The parameter } \delta > 0 \text{ will}$$

prove useful later for assessing biases.) Substituting this into equation (6), we obtain

$$(8) \quad F(v) = \delta^{1/(\beta-1)} \left\{ \frac{1}{t\phi} (2N)^\phi R \right\}^{\beta/\beta-1}$$

³ Equivalently, the inverse demand for advertising of $p(a) = a^{\eta-1}$.

where $R = Sr(a)/N$ is per-firm revenue.

Existence of a Symmetric Equilibrium

Armstrong and Weeds (2007) analyze the case of $\phi = 1, \beta = 2$ for which the proof of existence is quite straightforward. A proof for $\phi = 1$ and ‘sufficiently large’ β is not much more difficult; extending it to the case of $\phi \geq 2$ is more difficult, but is near completion. The proof for other values of ϕ is more difficult,⁴ although can be shown numerically for certain values – in particular for $\phi = -1$, for which an analytic demand exists.⁵ Since the second order conditions always hold at the candidate symmetric equilibrium, an equilibrium always exists for an amended model in which .[see footnote]. Those numerical analyses also show that existence of the symmetric equilibrium is not guaranteed. In general, those results are consistent with de Frutos, Hamoudi and Jarque (2002), which shows that sufficiently concave or sufficiently convex transportation costs are required for a pure strategy equilibrium in the price-setting game.

Economically Endogenous Talent Wages

Note that the above analysis assumes that a local radio market is a small part of the labour market that it draws upon, either because talent is a dime a dozen, or because talent is highly mobile (or importable as pre-recorded material on records – what was known as ‘transcription services’). To the extent that this is not the case, it is necessary to take into

⁴ In particular, increasing differences does not hold. (But perhaps it can be shown that it holds around the symmetric candidate equilibrium.)

⁵ If the model is amended so that there is a certain minimum amount of quality that every station must broadcast to attract any listeners (and some maximum amount), and that, listeners are all lost if advertising exceeds some amount.

account any increase in the wage of talent when firms increase quality. This is discussed in the appendix.

Section 3. Empirical Methodology

The first order conditions for the choice of ad minutes and quality at the symmetric equilibrium form the basis for the estimated empirical relationships. Taking logs of both sides of equation (8), we obtain our first regression equation:

$$(9) \quad \ln F = \text{const} + \frac{\beta}{\beta-1} \ln R + \frac{\beta}{\beta-1} \phi \ln N$$

which stems from the first order condition for the choice of quality. Taking logs of equation (6), we obtain

$$(10) \quad \ln R = \text{const} + \ln S - [(\eta/m)\phi + 1] \ln N$$

which is both a reduced form and structural representation of advertising revenue choice.

Combining the two, we obtain our third regression equation

$$(11) \quad \ln F = \text{const} + \frac{\beta}{\beta-1} \ln S + \frac{\beta}{\beta-1} [(\phi-1) - \phi\eta/m] \ln N$$

which expresses programming cost as a reduced form function of the number of firms. Estimating (9) and (10) will yield β , ϕ and η/m . No additional parameters are estimated by (11), but it may be preferred as it involves one less potentially endogenous variable.

Biases in the OLS estimation of equations (9)-(11) can arise for any number of reasons. The most obvious bias results from using imperfect proxies for $\ln S$ in (10)-(11) so that the coefficient on $\ln N$ will absorb part of the market size effect. Equation (9) is immune to that bias, as revenue is an included variable and by definition is proportional to S .

The cost of talent (δ) may be especially high in some cities, due to other industries that draw on the same labour pool, coupled with limited labour mobility, or because of relative area dis-amenities for artistic individuals. For $\beta > 1$ ($\beta < 0$), a high δ lowers (increases) programming expenditures, and thus lowers (increases) per-station profits, given N , and so the number of firms as well. This leads to a downward (upward) bias on the $\ln N$ coefficient in (11) and (9), post-war.

Cross market differences in sensitivity to horizontal content differences (i.e., t , which can represent the degree of listener heterogeneity) can also generate an OLS bias. By decreasing the number of listeners lost by an additional ad, a greater t increases equilibrium ad revenue; in the war-time regression, this upwardly biases the coefficient on ad-revenue in (9). In the post-war regression, matters are complicated by induced firm entry. A greater t will also reduce the returns from increased quality (see (9)) and so reduce expenditure on it, and increase per station profits and $\ln N$, leading to biases in the estimation of (10) (post-war, only) and (11).

A fourth bias type arises when a report covers only part of the year (when a station operates for only part of a year or there is an ownership change), but that partial coverage is not recorded. With expenses and revenues distributed more or less uniformly over the year, the regression of expenses on revenues will be biased towards one. A fifth bias type, also towards one, results from variation across stations in the share of broadcasting devoted to network programs: those with more network shows will have less local revenue and programming.

These biases are dealt with in two steps. The first step time differences the data. For the wartime regression, this should approximately⁶ eliminate biases due to $\ln N$'s correlation with the error, and mitigate the biases for the post-war period, to the extent that entry is driven by wartime growth and the auto-correlation in, say, changes in $\ln \delta$ is low. Of course, any biases from permanent differences across markets, or partial coverage, will be eliminated as well.

The second element in the identification strategy is the use of concurrent and lagged changes in measures of economic activity as instruments. This exploits the history of FCC licensing of AM radio stations, as shown in Figure 3. From February 1942 to the fall of 1945, construction of new radio stations was halted. Thereafter, there was a doubling of the number of stations from about 900 stations to about 1,800 by the end of 1948. The post war increase in stations consequently reflected not only concurrent demand changes but the pent up demand of the war-years. So long as the wartime and post-war growth rates of economic activity are sufficiently uncorrelated, we can use both to instrument log-revenue

⁶ Approximately, to the extent that firms are equal sized. . Based on the data gathered to this point, the mean variance of market share of local programming revenue in 1944 is .03. The mean standard deviation of the absolute deviation of market share from the inverse number of firms is .002, which may be a more appropriate measure, given (2).

and the log-number of firms in the differenced form of the structural equation (9), and the wartime growth rate to instrument the log-number of firms in the differenced form of the reduced form equations (10)-(11), with post-war growth proxying for $\ln S$.

Instrumenting the change in log revenue with the concurrent change in economic activity in equation (9) may, unfortunately, exacerbate an additional bias, if growth in economic activity is associated with growth in local wages. If $\beta < (>)1$, the coefficient on log revenue will be upwards (downwards) biased. This problem shows up as an OLS bias in the equations (10)-(11), for which economic activity enters as a regressor. Of course, having wage or employment figures will circumvent this problem. Such data are being collected, but they are available only for selected cities and years.

The *level* of economic activity should also have affected post-war growth in the number of radio stations, although the direction of that effect is not a priori clear. On the one hand, legislative and judicial developments combined to acted policy change in the FCC. Licensing policy in the previous decade had been a mix of economic and social forces. The allocation of stations across states in the 1930s and 1940 was distorted, relative to the potential ad revenue, due to the 1928 Davis Amendment, which mandated that the number of stations be equalized across five zones of the continental U.S., and that the number in each state be proportional to the state's share of the zone population,. Although its repeal dated in 1936, sunk costs and the Depression, as well as the war time freeze, would have delayed the effect of that repeal to the boom years of the post war period. Also, the limited degree of pressure from existing stations to thwart new entrants in the 1930s dissipated with the U.S. Supreme Court's *Sanders Brothers* decision of 1940 that made clear that FCC licensing decisions need not take the financial effect on incumbents into

consideration.⁷ Both developments have the likely implication that growth in firm numbers would have been greater in areas with greater economic activity. On the other hand, larger cities would have been closer to the constraint on the number of frequencies, which would imply a negative correlation between prewar economic activity and the growth in the number of firms..

Section 4: Issues in Applying the Model to Radio in 1940s

A number of issues arise in applying the model to the radio markets of the 1940s. The model assumes identical firms, but stations differed in their transmitters' potential reach, and surely also in their capability to provide quality programming. First order differencing will approximately eliminate the resultant difference in firms' incentive to provide quality (only approximately, as market size changes will lead different sized firms to expand at different rates⁸). There is an additional problem that newer firms would presumably be less capable initially than existing firms. Restricting the sample to firms

⁷ . Edelman (1950, p. 103) writes that “[s]ince the end of the war, the Commission has been particularly liberal in authorizing new stations without regard to economic injury.” He quotes the FCC Chairman as saying, in 1947: “We shall not attempt to fashion an umbrella with which artificially to shelter this industry from the consequences of free competitive enterprise.” Or as an anonymous letter to the editor in *Broadcasting* put it, the new policy was that of “survival of the fittest” or “dog eat dog”, in which “the FCC has little interest in whether or not a station operates profitably.” (*Broadcasting*, July 29, 1946, page 52).

⁸ Note, however, that (2) shows dD/du to be non-monotonic in market share and symmetric around $1/N$.

that existed in 1944 only does not solve the problem entirely, since with existing firms larger than the entrants, changes in $\ln N$ will overstate the change in concentration. Ideally, one would use a measure of concentration based on listening shares; as those data are unavailable, the long term plan is to firm a concentration measure based on advertising shares instead. The latter requires collection of data from all the stations – that not having been collected, the number of firms is used in this draft.

Network broadcasting also complicates the analysis. Instead of incurring the programming costs of network shows, stations ‘pay’ the network through receiving only part of the ad revenue. Thus all programming costs are for non-network shows. Furthermore, per-capita ad rates on network shows should be insensitive to local competition, since the uniformity of the network show means that the amount of time given to ads is constant among all stations broadcasting the show. For this reason, I restrict the analysis to non-network ad revenue.

The model also assumes that each station in a market was owned by a single firm. That was very nearly the case in the post-war period, after the FCC’s break-up of the so-called ‘duopoly’ stations in 1944. We drop those stations for the war-time analysis.

Television was not yet a serious competitor. In 1947 there were but 12 TV stations (and only 8 outside of NYC, L.A. and Chicago. 1948 ended with 58 stations on the air, but, still, over the year television ad revenue was barely two percent that of radio (Sterling, 1984).

Section 5. Data

Revenue and programming costs are taken from the individual schedules of stations' annual financial reports to the FCC, from 1942-48, on file at the National Archives and Research Administration. Revenue is stations' reported "Total sale of station nonnetwork time". Programming costs is the reported "Total programming expenses", which includes program department wages and salaries, talent expenditures, royalties and license fees, transcription services, wire and teletype services and news services⁹. Wage and employment data for specific jobs are available for selected years only, the former only at the market, and not individual station level. Employment data at the station level are available for selected years. Neither wage nor employment data are used in this draft.

Lists of radio stations, published in the trade weekly *Broadcasting*, are used to construct the number of stations in each market. For annual economic activity, I use bank debits to demand deposits (the dollar value of cheques on demand deposits at banks reporting to federal reserve banks), from Federal Reserve Board (19??), as well as census population figures, aggregated up from the county level to the market level.

The final sample will consist of stations in 149 markets - the 137 metropolitan districts, as well as 41 other markets listed in FCC (1948), less New York-N.E. New Jersey, Chicago and Los Angeles (to avoid entangling national with local programming, as these were the source of most national programs), and markets for which bank debit data for any year from 1942-8 are missing.

Preliminary results shown here, however, use only 1944-1947 annual data from a sample of stations (and corresponding markets) for which I have so far gathered NARA

⁹ Ryan (1946) writes, "Under production expenses we carry salaries of program director and announcers, salaries of production manager and the production staff, any charge for freight cartage and express that is incurred for the program department, music copyright including license fees paid to ASCAP, BMI, SESAC and other holders of music copyright, amounts spent for news wire services and expenses of news gathering and the charge for al talent that appears on the station."

data: stations with call letters KABC to KRUX, WAAB to WDHL, and an additional set of stations in relatively large markets, data on which were gathered for a different project.

Overall, there are 153 stations in 79 cities. The final sample should have about three times as many stations in about twice as many markets, and three more years. Since constructing an ad-share based concentration measures requires information on all the stations in a market, I use the number of firms, the coefficient on which should be downwards biased in magnitude.

The preliminary station level data shows that the ratio of local ad revenue in 1947 of new to existing firms, averaged across the 58 markets in which I have managed to collect data with at least one of each type is .39, (s.e.= .04), which suggests that our estimates for the coefficient on $\ln N$ be multiplied by 2.5.

Section 5. Some Preliminary Results: War-time Analysis

Table 1 reports the summary statistics for the wartime period. From 1944-45, non-network revenue increases by 13 percent on average, while programming costs increase by 24 percent. Both have a standard deviation of about .24. Economic growth averages 7 percent; over the three years from 1942 to 1945 it is .34, with a standard deviation somewhat less than half of that. Importantly, as Table 2a shows, annual economic growth is uncorrelated from year to year.

Table 2 presents the regression analysis. (Standard errors are clustered by market.) Columns (1) and (3) regress revenue growth and programming expenditure growth on concurrent annual economic growth, and its two lags. Although the individual coefficients are noisy and jointly only weakly significant, one cannot reject equality of the set within each regression. Imposing that restriction, as in (2) and (4), yields revenue and

programming cost growth of 0.7 and 0.6 percent for every one percent increase in economic growth over the three year period, each significantly different from zero, but not from one. The last three columns present the regression of programming costs on revenue growth, corresponding to (9), with $\ln N$ differenced out to zero, because of the freeze. Whether instrumented by the three separate annual growth terms or the total wartime growth, or estimated by OLS, the estimated coefficient (equal to $\beta / 1 - \beta$), is always close to .85 and highly significant. Although significantly less than one under the first and last estimation method. The implication is that the higher variable profits (revenues, here) in larger markets are dissipated¹⁰ for the most part not by entry in the long run, but by competitive investments in programming in the short run. Indeed, a 95% confidence interval around the estimate in column (6) would include the possibility that the programming expenditure response is sufficiently great so as to induce firm exit, a possibility that Sutton (1991) briefly discusses.

Section 6: Expansion Years Analysis

As a preliminary step to estimating the dependence of programming costs on revenue and station concentration, we first consider the first stage regression of the number of stations on various instruments. Summary statistics for this analysis are shown in Tables 3 and 4.

Table 5 presents regressions of the change in $\ln N$ on these measures of economic activity, from 1946-48. As expected, war-time growth increases the post-war growth in N . Concurrent growth, in contrast, has a negative and insignificant coefficient, a result which

¹⁰ Or would be, absent any constraint on the number of available frequencies.

will prove useful later on. Similarly, 1940s population growth is highly insignificant, while 1930s population growth has a large, although at most weakly significant, effect.

The variable responsible for most of the explained variation is 1942 economic activity. Note that were N determined by a free entry condition both before and after the war, (and were it sufficiently large that integer constraints could be ignored) we would expect only growth and not the level of economic activity, to determine the growth in N , but as we have noted, regulatory aspects in the industry were such for the free entry condition not to hold. Notwithstanding the large predictive power of 1942 activity, wartime growth, which explains only a quarter of the explained variation in N , has a t-stat of nearly three.

These results point to an additional empirical strategy. That post-war entry reflects war-time but not post-war economic growth strongly suggests that it does not reflect changes over that period in any of the factors identified, viz., t , β etc., and so justifies treating entry as exogenous. It is hard to imagine the entry decision being affected by, say, changes in heterogeneity over the period but not economic growth. (Entry required FCC approval; but all the indications are that the FCC's sole concern was entrants' ability to finance construction.)

Table 6 shows the effect of $\ln N$ on programming costs in the postwar period. Columns (1)-(6) present estimates of the net effect $((\phi - 1) - (\phi\eta/m))$. The bivariate OLS regression (Col. (1)) shows an insignificant coefficient of .07. That barely changes when the concurrent economic growth is added (Col. (2)), the coefficient on which is estimated at .36, insignificant and less than half the estimated coefficient in the analogous OLS regression for the wartime period (Col. (3) in Table 3). Columns (3)-(5) present the IV

estimates. The coefficient on $\ln N$ in the bivariate regression (Col. (3)) increases dramatically to .53 (t-stat ≈ 2.5). Adding concurrent growth to the regression decreases that coefficient to only .39 (Col. (4)), while adding 1940s population growth yields three individually insignificant coefficients (Col. (5)). So the preliminary results show that competition certainly does not decrease quality, and might even increase it.

The remaining columns show the empirical counterpart to equation (9): the regression of programming costs growth on revenue growth ($\beta/1 - \beta$) and numbers growth ($\phi\beta/1 - \beta$). Column (6) shows the OLS estimates. The coefficient on revenue growth is .75, not far from that in Table 2. The coefficient on $\ln N$ is essentially zero, with a standard error that, although quite large, allows us to reject a convex distance function. Recalling that the revenue term is the per-firm ad revenue and not per-capita ad revenue, we see that the implied listener share effect is actually negative and about -1: more firms decreases the marginal fraction of listeners gained by increased quality, consistent with concave transportation costs. The standard errors balloon when the two regressors are instrumented by the three determinants of firm growth and concurrent growth (for revenue growth), and both coefficients are insignificant. In column (8), firm growth is treated as exogenous, with revenue growth instrumented by concurrent growth.

Table 7 shows the OLS regression of ad revenue growth on firm growth, the empirical counterpart of equation (10). The OLS estimate of $-[(\eta/m)\phi + 1]$ is a mere, insignificant, .02, indicating that per-firm ad revenue was unaffected by the increased competition.

The pattern of the signs of coefficients on $\ln N$ in the two tables are consistent with the model. Under OLS, per-firm ad revenue is unaffected by increased competition,

indicating that per capita ad revenue increases with competition, implying, in turn, concave transportation costs. Concave transportation costs are, in turn, necessary for competition to have no effect on quality expenditures.

The quantitative results, however, are inconsistent with the model. The results in these two tables can be used to infer the value of ϕ . The ratio of the coefficient on $\ln N$ to that on $\ln R$ in the last three columns of Table 6 provides one estimate. Although the pair of coefficients vary widely, the implied estimate of ϕ is quite stable, and ranges from -.06 to .03, with standard errors (calculated by the delta method) about ***. Applying the factor of 2.5 to account for the lower revenues of the expansion firms will change this range to -.15 to .075. It is, in any case, very clearly less than one.

Table 7 also provides evidence on ϕ . Although ϕ is not identifiable from this regression alone, under the assumption that $0 \leq \eta/m \leq 1$ (increasing disutility from ads and a downward sloping demand for ads), the 95% symmetric confidence interval of ϕ lies beneath -0.9. The IV estimate, consistent under weaker assumption, is .48, but insignificant. As for ϕ , it is at least five standard deviations beneath zero. Applying the 2.5 factor, will, of course, make these results even more extreme.

How to reconcile Table 6, which implies a ϕ around zero, with Table 7, which implies a much lower value? Perhaps with more stations, advertisers are better matched to the listener (Chandra, 2005), which one could model by having per-capita ad revenue depend directly and positively on N . By itself, this can just explain a zero effect on per firm ad revenue, in the most extreme case of matching, with discrete types of consumers and mutually exclusive sets of advertisers interested in them, and so can explain the OLS but not the IV result.

Or perhaps the increased expected utility from the presence of more stations induces more radio listening, which increases stations' ad-revenue.¹¹ Some market expansion took place over this period: the fraction of US households with radios increased from 88 percent in 1945 to 93 percent in 1947 (Sterling, p. 222) and hours spent listening to radio among radio families increased from 4.79 to 5.20 hours a day over the same period (Butsch, 2000 p. 244). Those rates of increase seem inadequate to fully explain the empirical findings. In any case, a definitive proof must await collection of city specific ratings and radio ownership data over this period.

Section 8. Conclusion

[INCOMPLETE]

This paper has shown, theoretically, that competition affects quality/programming costs not only indirectly through the change in advertising revenue, but also directly through the change in the sensitivity of the marginal listener to the common component of utility. When the marginal disutility from listening to other than one's favoured type of show falls with the distance in content types, increases in competition will lead broadcasters to decrease their expenditures on programming.

The empirical analysis exploits the timing of station entry in the 1940s. Preliminary results are mixed. OLS estimates of both the net effect of concentration, and its effect conditional on ad-revenue, on programming expenditure are near zero. IV estimates of the latter are also small. IV estimates of the net effect are large, but at insignificant. The effect of competition on per-firm advertising revenue is zero under OLS estimation, and positive,

¹¹ Given the FCC ban on owning more than one local station, neither externality could be internalized by a single firm.

although at best weakly significant, under IV. These estimated effects of competition on programming costs, given ad-revenue, and on ad-revenue all imply a concave distance function, i.e., a decreasing marginal disutility from non-ideal content type, but they are quantitatively inconsistent with each other, given the framework of the model. Possible explanations for this inconsistency are variety effects and advertiser-listener externalities. Hopefully, more exact statements will be possible when all the data are collected.

The paper also shows that programming expenditures are very sensitive to market size. Although it can not be established that the effect is so large so that increases in demand will actually lead to firm exits, the relationship is such that it is reasonable to infer that most of the long run response to increases in advertising demand in such a market will be met by existing firms' increasing their endogenous fixed costs and not by the entry of new firms.

I eschew any involved discussion of welfare effects, since variety introduces non-marginal changes. Adding stations, will lead to an increase in listeners enjoying very high utility – infinitely high for $\phi < -1$. Even were I confident of the estimate of phi, I would not dare assert that the functional form could be extended over the new inframarginal listeners.

To what extent can we take empirical regularities during the expansion of AM radio station and infer policy recommendations from them to the current situation? Radio in the 1940s was very much like television is today. There were news shows in the morning, soap operas in the early afternoon, news at 8 o'clock, dramas and comedy shows in the evenings. Radio differed only in the greater fraction of musical programs. A somewhat bolder statement would be that radio in the pre-war and war periods was like television up until

fifteen twenty years ago, while radio in the immediate post-war period was like television is today.

One might also ask how relevant advertising funded broadcasting is in a world in which more and more content is being offered for payment. I would answer that, first, many new goods, typically information goods, are being offered with advertising, where exclusivity is difficult or impossible to impose; and second, even with the possibility of exclusivity and so a payment based revenue model, it may yet be an equilibrium to rely on the advertising financing mechanism only, as Armstrong (2006) and Armstrong and Wright (2005) have noted.

Appendix

Endogenous Talent Wages

Assume, then, that there is an increasing supply curve for talent. Let z be the number of efficiency units of talent that the station employs, assume $v = z^\omega$, and let δ be the wage-rate of talent, with $\delta(Z) = (Nz)^\alpha = (Nv^{1/\omega})^\alpha$. I will assume that radio stations have no market power in the market for talent, so that in making its quality decision, firms see $F(v) = \delta v^{1/\omega}$; however a Cournot assumption would yield the same result, up to a constant in the log-linear forms. Firms choose v so that

$$(12) \quad \delta v^{1/\omega-1} / \omega = Sr(\alpha) \partial D / \partial u \Rightarrow v = [(\omega / \delta) RN^{\phi-1}]^{\omega/(1-\omega)}$$

This implies that

$$(13) \quad \ln F = \text{const} + \frac{(1+\alpha)\beta}{(1+\alpha)\beta-1} \ln R + \frac{\phi(1+\alpha)\beta-\alpha}{(1+\alpha)\beta-1} \ln N$$

Clearly, the parameters are now identifiable only conditional on one of the three. Data on wages or employment are necessary to identify all three. Such data are available for a subset of the years, and I intend to gather it and incorporate it into future drafts. In the meantime, I will proceed as if $\alpha = 0$. The biases in the inferred values of $\frac{\beta}{\beta-1}$ and ϕ from doing so are likely to be small when the estimate coefficient on log revenue in (13) is near one, as will be seen to be the case. In particular, letting the coefficient on log revenue

(log number of firms) be denoted as ψ_R (ψ_N), we have: $\frac{\beta}{\beta-1} = \frac{\psi_R}{1+(1-\psi_R)\alpha}$, while

$\phi = \frac{\psi_N}{\psi_R} + \frac{1-\psi_R}{\psi_R}\alpha$. Finally, for many purposes, including the long run analysis discussed

in the next section, what part is α and what part β , i.e., what part of the increase in fixed costs derives from increased quality, and what from the bidding up of the price of quality, is immaterial.

Free Entry Equilibrium

Although the empirical analysis estimates relationships that are conditional on the number of firms, it is nonetheless useful to analyze the free entry equilibrium. The extent to which the radio broadcasting industry in the late 1940s is well described by the free entry model is an open question given the licensing process and the capacity constraints inherent in the limited radio frequencies. That, however, should not in itself be an impediment to inferring the long run nature of other media industries at other times, on the basis of the empirical findings in this paper.

The analysis in Chapter 3 of Sutton (1991) is useful here. Figure A shows a set of iso-profit curves, showing variable profits, here, advertising revenue, as a function of the number of firms. Each curve corresponds to a different market levels (S). As S increases, the curve shifts out. The red curve is the locus of long run equilibrium pairs of the number of firms N and total fixed costs (F and an exogenous fixed cost, σ) that are traced out by the intersection of an iso-profit curve as market size increases. In the case of no endogenous fixed costs, the long run locus would be horizontal, and the number of stations would increase without end as market size increased. More generally, we expect the curve

to be at least initially upward sloping: increases in market size induce firms to expend more on programming, thus limiting the attractiveness of the industry so that N increases less than it would otherwise. Sutton notes that there is the possibility that the red curve could bend back upon itself – if the induced increase in quality expenditure is so large that at some point increases in market size actually reduce firm profits and so induce exit.

In the current model, clearly the response of fixed costs and concentration to market size is governed by the parameters ϕ and $\beta/\beta-1$. The locus of long run equilibrium

$(N, F + \sigma)$ here is $(w[\sigma + F]N^\phi)^{\beta/\beta-1} = F$, and its slope is

$$(14) \quad \frac{dF}{dN} = \frac{F}{N} \phi \frac{\beta/\beta-1}{1 - (\beta/\beta-1)(F/[\sigma + F])}$$

so that the backward bending case can only occur if $\beta/\beta-1$ is greater than one. A sufficient condition for the case to occur is this condition along with $(\phi-1) - \phi\eta/m > 0$, i.e., that the net effect of the number of firms on programming cost is positive.

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Table 1: Summary Statistics, Wartime

<u>Variable</u>	<u>Mean</u>	<u>S.D.</u>	<u>Min</u>	<u>Max</u>
Revenue Growth	.13	.23	-0.55	1.62
Programming Cost Growth	.24	.24	-0.44	1.51
Growth in Economic Activity				
1942-1943	.18	.10	-0.08	0.56
1943-1944	.09	.07	-0.10	0.46
1944-1945	.07	.07	-0.14	0.29
War Years (1942-1945)	.34	.15	0.08	1.00

Table 2: Revenue and Programming Costs Growth: Wartime

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable:	Revenue Growth			Programming Costs Growth			
Revenue Growth					.83	.86	.84
					(.08)	(.10)	(.05)
1944-45 Growth	.43		.66		Inst.		
	(.28)		(.45)				
1943-44 Growth	.99		.80		Inst.		
	(.78)		(.68)				
1942-43 Growth	.64		.42		Inst.		
	(.28)		(.32)				
War Growth		.70		.60		Inst.	
		(.37)		(.32)			
<i>p-value: coefs=0</i>	.11		.20				
<i>(p-value: equal coefs</i>	.78		.76				
Est. Method	OLS	OLS	OLS	OLS	IV	IV	OLS

Standard errors in parentheses. Instruments are indicated by "Inst."

Table 3: Summary Statistics, Post-War Period

	Mean	S.D.	Min	Numb=0	Max
Ln of Bank Debit to Demand Deposits in 1942	6.78	1.16	4.37		10.00
GROWTH IN ECONOMIC ACTIVITY:					
Wartime: 1942-1945	0.33	0.16	-.17		1.00
1942-1943	0.17	0.12	-.08		0.72
1943-1944	0.09	0.08	-.21		0.46
1944-1945	0.07	0.08	-.17		0.41
1945-1946	0.17	0.11	-.17		0.45
1946-1947	0.14	0.06	.005		0.41
POPULATION GROWTH:					
1930s	0.11	0.11	-.07		0.63
1940s	0.23	0.16	-0.13		0.75
CHANGE IN LOG NUMBER OF STATIONS					
1946 to 1948	0.51	.40	0		1.79
1946 to 1947	0.19	.35	-.69		1.37
1947 to 1948	0.32	.32	0		1.79
NUMBER OF STATIONS					
1946	2.99	2.06	1	(35)	13
1947	3.52	2.22	1	(20)	13
1948	4.71	2.75	1	(5)	17

Table 4: Correlations, Post-War Period

	War	Concurrent	lnbd42	Pop Growth 30s	
Wartime growth	1.00				
Concurrent growth	-0.02	1.00			
Ln 1942 Eco. activity	-0.16	-0.43	1.00		
Pop growth 1930s	0.29	0.14	-0.07	1.00	
Pop growth 1940s	0.29	0.09	0.04	0.76	1.00

Table 5: Explaining the Number of Firms

	(1)	(2)	(3)	(4)	(5)
Concurrent Growth	-.29	-.29			
	(.29)	(.29)			
Wartime Growth	.42	.41	.44	.53	.58
	(.20)	(.20)	(.19)	(.19)	(.20)
Pop Growth (^40s)	-.05				
	(.29)				
Pop Growth (^30s)	.56	.52	.47		
	(.42)	(.28)	(.28)		
Ln 1942 Eco Activity	-.13	-.13	-.12	-.12	
	(.03)	(.03)	(.02)	(.02)	
<i>R</i> ²	.22	.22	.21	.20	.05

Dependant. variable is the growth in number of firms from 1946-1948. Standard errors in parentheses.

Table 6: Explaining the Growth in Programming Expenditures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
N Growth (46/48)	.07 (.09)	.06 (.09)	.53 (.20)	.39 (.19)	.26 (.20)	.02 (.09)	-.07 (.58)	-.14 (.42)
Concurrent Growth		.36 (.21)		.39 (.19)	.26 (.23)			
Pop Growth (^ 40s)					.36 (.27)			
Revenue Growth						.75 (.26)	1.18 (1.19)	4.95 (7.94)
Inferred value of phi						.03	-.06	-.03
Endogenous Variables	None	None	N	N	N	None	N,R	N

Dependent Variable is Growth in Programming Expenditure from 1946-1948. When there are endogenous variables, instruments always include wartime growth. When Revenue Growth (R) is endogenous, concurrent growth is also an instrument. Standard errors in parentheses. Columns (1)-(6) present estimates of the net effect of competition on programming expenditures, and so are analogous to equation (11), while columns (7)-(9) present the partial effect, conditioning on ad revenue, and so are analogous to equation (9).

Table 7

	(1)	(2)	(3)	(4)
Growth in Revenue (1945-1947)				
N Growth (46/8)	.02 (.06)	.48 (.29)	.01 (.05)	.41 (.26)
1946-47 Growth	-.45 (.35)	-.10 (.47)	.24 (.15)	-.15 (.46)
1945-46 Growth	.23 (.17)	.13 (.24)	-.42 (.33)	.13 (.23)
1944-45 Growth	-.05 (.32)	-.19 (.47)	.16 (.16)	-.27 (.44)
1940s pop. Growth		.17		.19
Estimation Method	OLS	IV	OLS	IV

Dependent Variable is Growth in Advertising Revenue from 1946-1948. Instruments are wartime growth, 1942 economic activity and 1930s population growth. Standard errors in parentheses. These estimates are analogous to equation (10).

Table A.1: Within Market Regressions

	1944	1945	1946	1947
	Dep Var: Log Programming Costs (OLS)			
lnRevenue	.89	.84	.71	.79
	(.05)	(.04)	(.05)	(.03)
	Dep Var: Log Programming Costs (IV)			
lnRevenue	1.14	1.16	1.07	1.12
	(.07)	(.07)	(.10)	(.07)
	Dep. Var.: Log Revenue (OLS)			
lnPower	.36	.32	.32	.32
	(.03)	(.02)	(.03)	(.03)
No. of Obs.	195	192	181	175

First Panel: OLS Estimation of the regression of log Programming Costs on log Revenue.

Second Panel: Instrumental Variables Estimation of the regression of log Programming Costs on log Revenue, with the log of the station's power as instrument.

Third panel: First stage regressions: OLS regression of log revenue on lnpower.

Not referenced in paper.

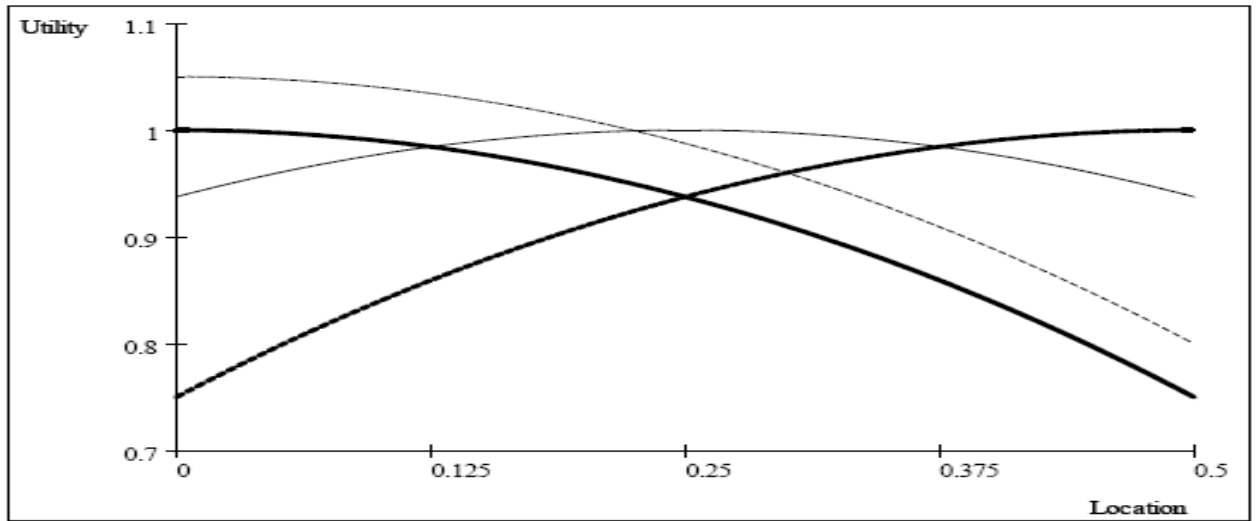
Metropolitan district dummies included in all regressions.

Table A.2

STRUCTURAL, Cross Section, OLS: Ln Programming Costs

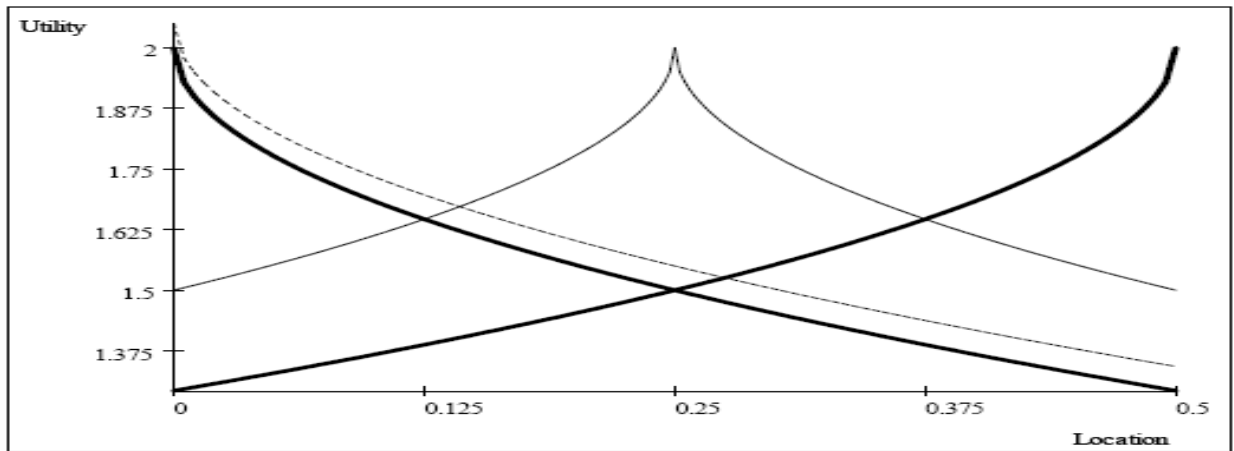
<u>N=153, 79 Cities</u>	(1)	(2)	(3)	(4)
	1944	1945	1946	1947
Ln Revenue	.95 (.07)	.98 (.07)	.91 (.11)	.96 (.05)
Ln Number of Stations	-.01 (.08)	.04 (.07)	.03 (.06)	.08 (.06)
R-squared	.67	.71	.55	.76
Number of Observations`	153	153	153	153

Note: not referenced in paper.



The two thick, solid lines show utility from stations located at 0 and 0.5 as functions of the listener's location, when the stations offer $u = 1$ ($t = 1$, $\phi = 2$). When $N = 2$, these are the only stations and the marginal listener is at 0.25. When station-0 increases u by .05, its curve shifts up to the dashed, thin line. The marginal listener is now at 0.3, and station-0's market share increases by 10%. $N = 4$: the neighbouring station is at 0.25, offering the thin, solid line; the marginal listener is at 0.125. The u increase now shifts the marginal listener to 0.225, so that station-0's market share increases by 20%.

Figure 1



The two thick, solid curves and the solid, thin curve show utility from stations located at 0, 0.5 and 0.25, respectively, that offer common component of utility equal to two, $t = 1$ and $\phi = 0.5$. The thin, dashed curve shows the utility from listening to a station located at 0 that offers utility equal to 2.05. The gain from increasing the common component of utility decreases with the number of firms.

Figure 2

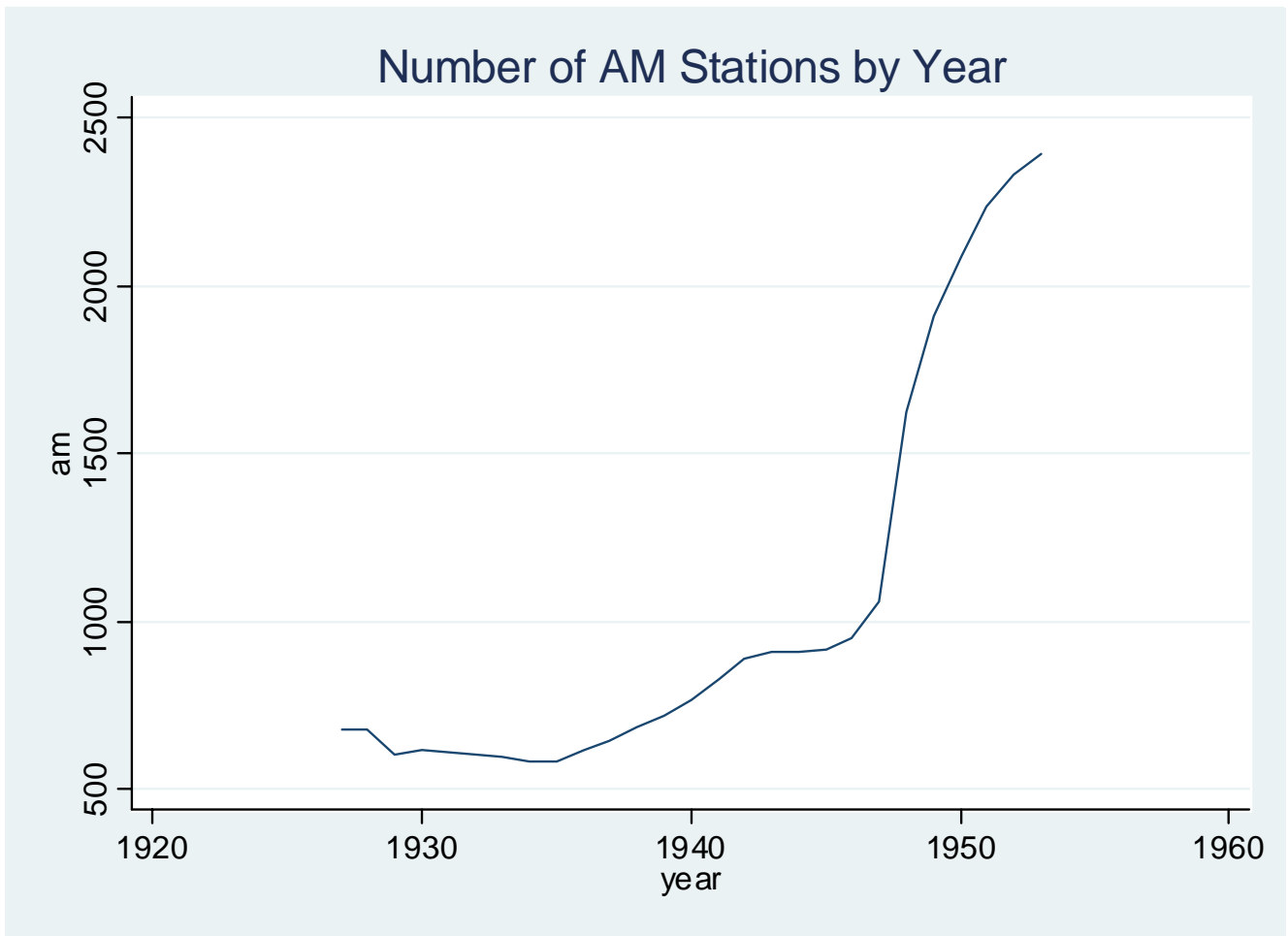


Figure 3

Source: Sterling, 1984, Table 170-A, taken from Department of Commerce, Federal Radio Commission and Federal Communications Commission.

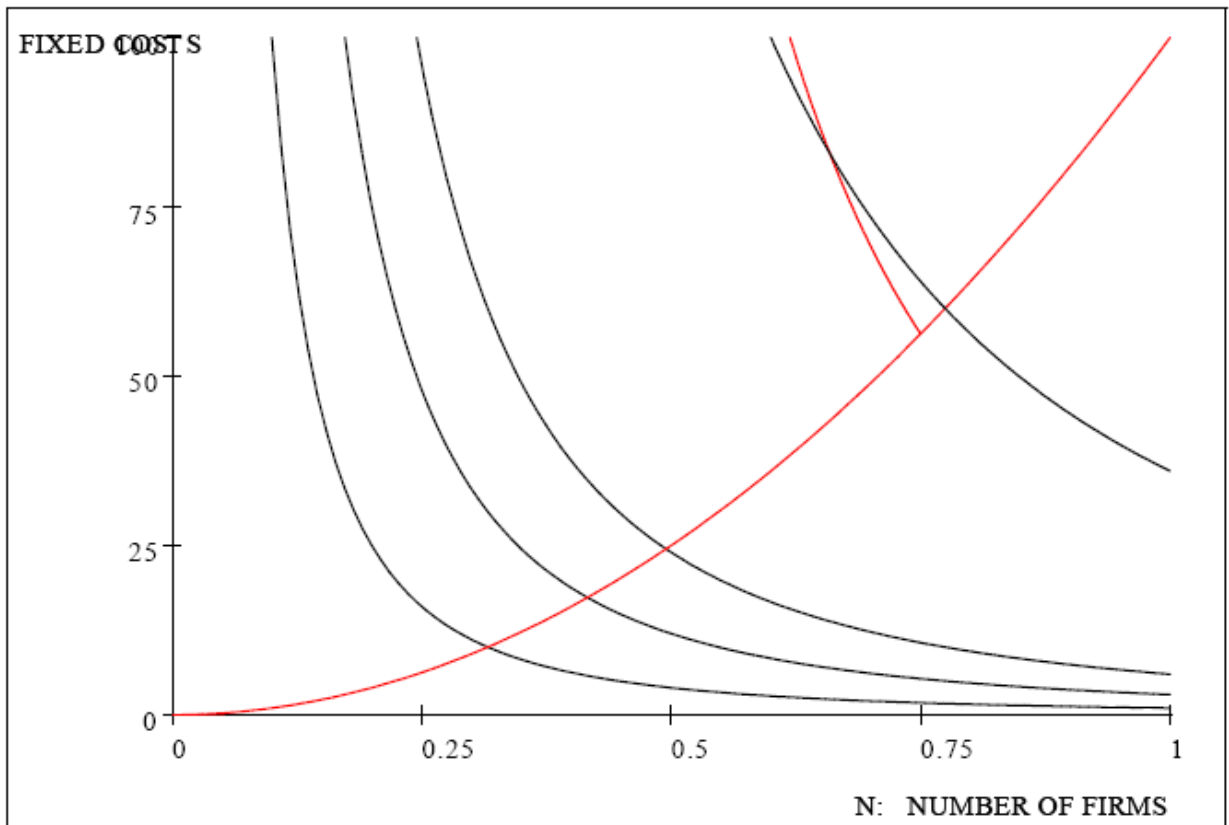


Figure A