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, Cyprus and Tel Aviv.

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.

The effect of competition on product quality is of increasing relevance in media markets, given the steady increase in outlets for audio and visual content over the last number of years. This project explores this issue theoretically and empirically, the latter through a study of the post World-War II expansion of the number U.S. of radio stations.

A priori, it is unclear what effect enhanced competition will have on quality. The U.K. Office of Communications report (2005) claims that “[a] competitive broadcasting marketplace” will “encourage broadcasters to provided quality, innovation”, while 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) . More precisely, the incentive to increase programming quality is the advertising revenue that accompanies the listeners thus attracted. The theoretical part of this project will show how competition determines both the number of new listeners and per-capita ad revenue, and thus quality. The theory will also suggest appropriate statistical relationships for the empirical part.

Estimating the relationship between quality, measured here by programming expenditure, and competition is difficult because of the endogeneity of competition. The natural instrument for competition is market size. However, since the quality of broadcasting is clearly an endogenous fixed cost (Shaked and Sutton, 1983, 1987), it is determined directly by market size. The empirical part of this project solves this problem by exploiting the relationship between competition and *lagged* market size inherent in the dramatic post-war expansion of AM radio station numbers after the war time construction freeze. The build up of demand during the war is used as an additional instrument, in addition to the concurrent change in demand, in estimating the relationship between the growth in programming expenditure and the growth in the number of radio stations in the post-war years.

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.

Section 1. 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 listeners, and the market is always covered. Stations' content are 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: $u - t(\text{distance})^\phi \equiv v - a^m - t(\text{dist.})^\phi, \quad t\phi > 0$. (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 the listening share D from a small increase in the common component of utility, u , when the differences in u across firms are small, is

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

where x_L (x_R) is the distance to the firm of the marginal listener on the left (right). At the symmetric equilibrium, this is equal to

(3) $\frac{dD}{du} = \frac{1}{t\phi}(2N)^{\phi-1}$, 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 increasing, 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 increases in the common component of utility less effective in gaining market share.

As in Choi and Armstrong and Weeds, I assume the station earns $r(a)$ per listener when broadcasting a ads, and that 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 of broadcasting quality v programs, and $F', F'' > 0$.

A station's choice of advertising trades-off the per-capita revenue gain against the loss of listeners to other stations. The first order condition (F.O.C.) is

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

which implies, as Choi and Armstrong and Weed note, that competitive stations broadcast fewer ads than a monopolist would, to gain market share. In their linear specification, $\phi = 1$, so N

affects the choice of ad minutes only through decreasing the firm's share of listeners in equilibrium. In this special case, the fraction of listeners lost when ads are increased is independent of the number of firms. More generally, competition also determines that fraction, 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. Thus the authors' result that advertising is decreasing in N continues to hold so long as $\phi > 0$. If $\phi < 0$, however, increases in N actually increases ad minutes and per-capita ad revenue.

Firms' choice of quality trades-off the increase in listening, multiplied by per-listener ad-revenue, against the cost increase; thus $Sr(a)(dD/du) = F'(v)$, or using (3),

$$(5) \qquad S\frac{1}{t\phi}(2N)^{\phi-1}r(a) = F'(v)$$

Thus, conditional on $r(a)$, quality is increasing (decreasing) in N if and only if $\phi > (<)1$.[1]

To determine the net effect of competition on quality expenditure and advertising, and as a means of interpreting the coefficients in the regressions that will be presented later, it is useful to specify a parametric form of the per-capita advertising revenue and quality expenditure functions. Begin with the former, and approximate $r(a)$ below a^M by a^η, with $0 < \eta < 1$. Then the F.O.C. for per-capita advertising reduces to

[1] It bears noting that existence of an equilibrium is not automatically guaranteed. 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,[1] although can be shown numerically for certain values – in particular for $\phi = -1$, for which an analytic demand exists.[1] 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.

(6) $r = \{\frac{m}{\eta t\phi} 2^{\phi-1} N^{\phi}\}^{-\eta/m}$

Substituting (6) into (5), we see that the sign of the net effect of competition is that of $(\phi-1)-\phi\eta/m$. So long as the marginal disutility of advertising is increasing (i.e., $m>1$), the net effect is guaranteed to be negative if $0<\phi\leq 1$, which of course includes the linear case of Armstrong and Weeds. It is positive if and only if $\phi>[1-(\eta/m)]^{-1}$, that is, if the disutility from non-ideal content is sufficiently convex in distance..

For the quality expenditure function, assume either $F(v)=\frac{1}{\beta}\delta v^{\beta}, \beta>1$ or $F(v)=\frac{1}{|\beta|}\delta(\alpha-v)^{\beta}, \beta<0, v<\alpha$. Substituting this specification into (6) yields

(7) $F(v)=\delta^{1/(\beta-1)}\{\frac{1}{t\phi}(2N)^{\phi} R\}^{\beta/\beta-1}$, where $R = Sr(a)/N$ is per-firm revenue.

Take logs of both sides to obtain our first regression equation:

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

This structural equation, which stems from the station's optimal choice of quality, interprets the elasticity of quality expenditure with respect to per-firm ad revenue in terms of the marginal cost of quality. It also shows that the convexity of the disutility from ideal content function can be inferred from the ratio of the elasticity of quality expenditure with respect to the number of stations to the former elasticity.

Now take logs of (6) to obtain

$$(9) \qquad \ln R = const + \ln S - [(\eta / m)\phi + 1]\ln N$$

which is both a reduced form and structural representation of advertising revenue choice. This equation shows us that whether total market ad revenue increases or decreases in firm numbers depends on whether the ideal content disutility function is convex or concave.

Combining the two equations, we obtain our third regression equation

$$(10) \qquad \ln F = const + \frac{\beta}{\beta - 1}\ln S + \frac{\beta}{\beta - 1}[(\phi - 1) - \phi\eta / m]\ln N$$

which expresses programming cost as a reduced form function of the number of firms. Estimating (8) and (9) will yield β, ϕ and η/m. No additional parameters are estimated by (10), but it may be preferred as it involves one less potentially endogenous variable.

Section 2. Empirical Methodology

Biases in the OLS estimation of equations (8)-(10) can arise for any number of reasons. The most obvious bias results from using imperfect proxies for $\ln S$ in (9)-(10) so that the coefficient on $\ln N$ will absorb part of the market size effect. Equation (8) is immune to that bias, as revenue is an included variable and by definition (of S) 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 disamenities 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 (10) and (8), 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 (8)) and so reduce expenditure on it, and increase per station profits and $\ln N$, leading to biases in the estimation of (9) (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.

The proposed methodology deals with these biases in two steps. The first time differences the data. For the wartime regression, this should approximately[2] 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 measures of economic activity as instruments. This exploits the history of FCC licensing of AM radio stations. From February 1942 to the fall of 1945, construction of new radio stations was

[2] Approximately, to the extent that firms are equal sized

halted. Thereafter, there was a doubling of the number of stations from about 900 stations to about 1,800 by the end of 1948 (see Figure 3). 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 and the log-number of firms in the differenced form of the structural equation (8), and the wartime growth rate to instrument the log-number of firms in the differenced form of the reduced form equations (9)-(10), with post-war growth proxying for $\ln S$.

Instrumenting log revenue with the concurrent change in economic activity in equation (8) 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. Of course, having wage or employment figures will circumvent this problem. Such data are only partially available (see Section 4).

Section 3: Issues in Applying the Model to Radio in 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.[3] There is an additional problem that newer firms would presumably be less capable initially than existing firms. Restricting the sample to firms 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; that being unavailable, one based on advertising shares will be used instead.

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

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.

Television was not yet a serious competitor. In 1947 there were but 12 TV stations (and only 8 outside of New York City, Los Angeles 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 4. Data

Revenue and programming costs are available 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 services. (There are some additional data with more limited coverage, that will be used in future drafts, but not this one: 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.)

Lists of radio stations, published in the trade weekly *Broadcasting,* are used to construct the number of stations in each market. (Finer definitions of coverage are available in a single cross section from the Broadcasting Measurement Bureau's spring 1946 report; this will be used in future drafts.) For annual economic activity (proxies for $\ln S$), 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 (unknown date), 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.

(For future drafts: city specific ratings data, necessary to check for market expansion effects (see Section 7) are available in *A. C. Nielsen Company Reports, 1943-1957* and *Pulse Incorporated, Reports 1941-1958* at the Wisconsin Historical Society, and possibly in *Cooperative Analysis of Broadcasting* reports, at the Harvard Business School Baker Library.)

Section 5. Some Preliminary Results: War-time Analysis

Preliminary results shown here use 1944-1947 annual data from a sample of stations (and corresponding markets) for which I have succeeded gathering NARA 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. Unlike the model, stations were of unequal sizes, so that an ad-share based concentration measure that incorporates differential size (such as the HHI) might be preferable to the number of firms, but as I do not yet have the data on all stations, I am restricted here to the latter. Since new firms are likely to be smaller than existing ones, at least in their first years, one should expect the coefficient on the increase in the number of firms to 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.)

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. Growth in economic activity averages at 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. The implication is that the higher variable profits (revenues, here) in larger markets are dissipated[4] 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

[4] Or would be, absent any constraint on the number of available frequencies.

around the estimate in the IV estimate of column (6) (although not in columns (5) and (7)) 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. (Note that the analysis in Tables 3, 4 and 5 only uses all 149 markets, and not simply the 79 markets for which I currently have station data.)

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

Table 5, which shows wartime growth have a t-statistic of nearly three, justifies the methodology outlined above. Yet wartime growth is responsible for only a quarter of the explained variation in the change in $\ln N$. 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, *pace* integer effects.

Regulatory constraints, both before and after the wars, might be responsible for this level effect. 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.[5] 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, as observed.

Table 5's 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.)

[5] 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).

Table 6 shows the total effect of $\ln N$ on programming costs in the postwar period. Columns (1)-(6) present estimates of the net effect ($(\phi-1)-(\phi\eta/m)$), corresponding to the differenced form of equation (10). 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$\approx$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)). These results show that competition certainly does not decrease quality, and might even increase it.

The remaining columns show the empirical counterpart to the differenced form of equation (8): the regression of programming costs growth on revenue growth ($\beta/1-\beta$) and the growth in the number of firms ($\phi\beta/1-\beta$). 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 concave distance function. 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. Although the coefficients vary widely, the implied estimate of ϕ is quite stable, and ranges from -.06 to .03. 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 shows the OLS regression of ad revenue growth on firm growth, the empirical counterpart of the differenced form of equation (9). 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. 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 the implied value of 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.[6] 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, page 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, page 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.

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

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Table 1: Summary Statistics, Wartime

Variable	Mean	S.D.	Min	Max
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)			
p-value: coefs=0	.11		.20				
p-value: equal coefs	.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:					
WartiemL 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: First Stage Regression of Number of Firms on Determinants

	(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)	
R-2	.22	.22	.21	.20	.05

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

Table 6

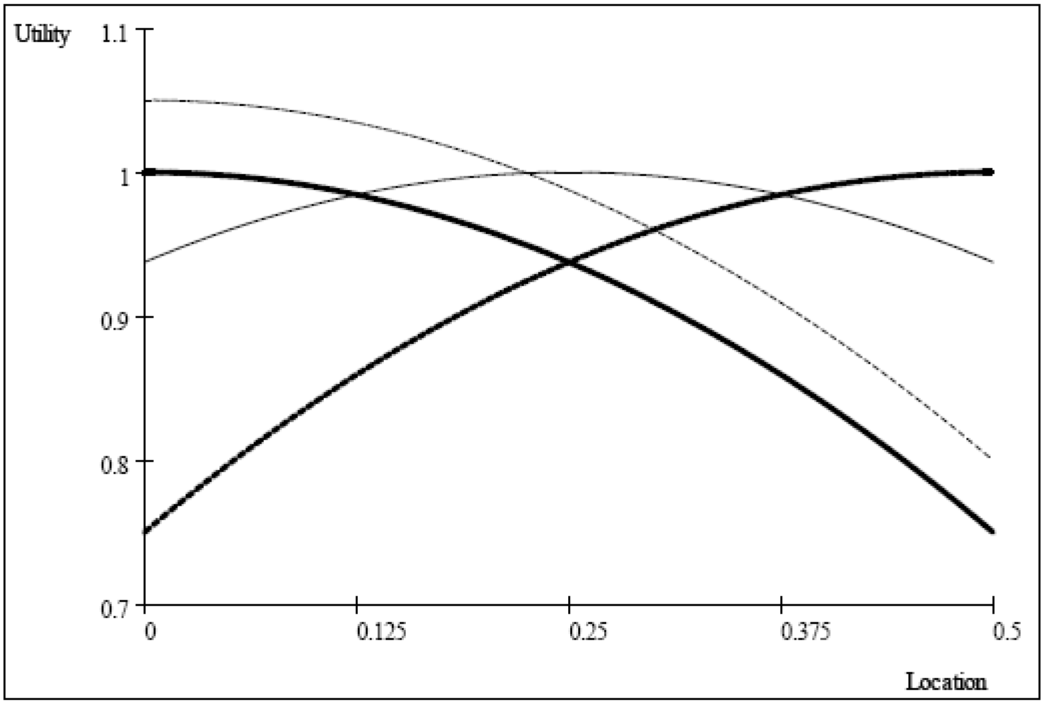
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
N Growth (46/48)	.07	.06	.53	.39	.26	.02	-.07	-.14
	(.09)	(.09)	(.20)	(.19)	(.20)	.09)	(.58)	(.42)
Concurrent Growth		.36		.39	.26			
		(.21)		(.19)	(.23)			
Pop Growth (`40s)					.36			
					(.27)			
Revenue Growth						.75	1.18	4.95
						(.26)	(1.19)	(7.94)
Inferred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

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. Columns (1)-(5) correspond to the differenced form of equation (10), columns (6)-(8), that of equation (8). Standard errors in parentheses.

Table 7

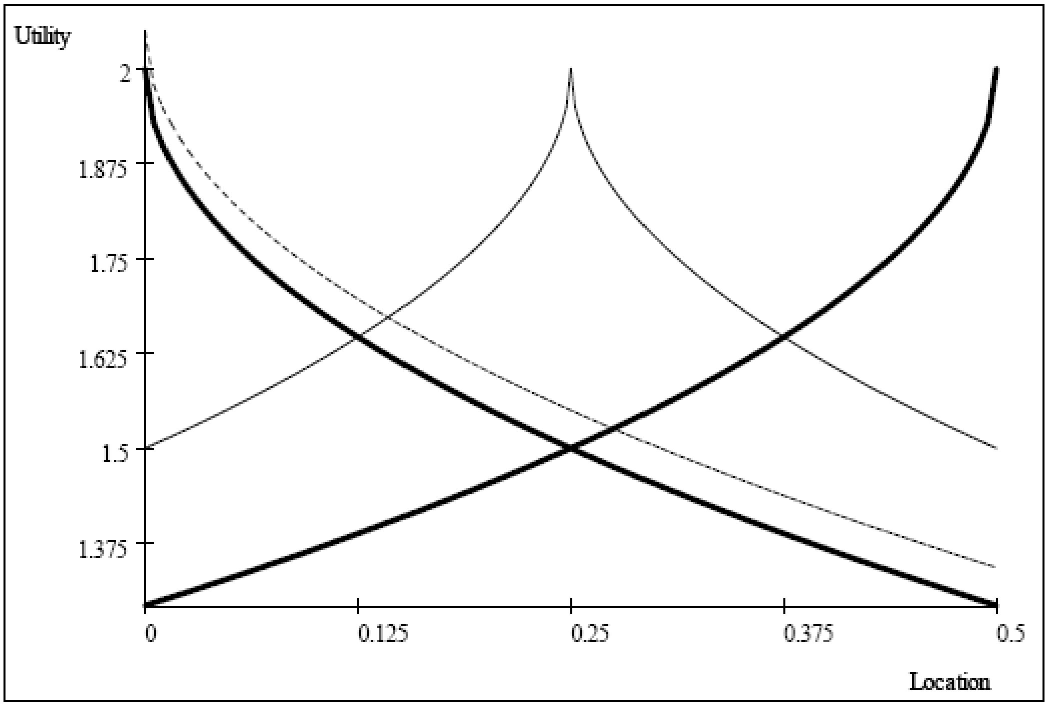
	(1)	(2)	(3)	(4)
	Growth in Revenue (1945-1947)			
N Growth (46/8)	.02	.48	.01	.41
	(.06)	(.29)	(.05)	(.26)
1946-47 Growth	-.45	-.10	.24	-.15
	(.35)	(.47)	(.15)	(.46)
1945-46 Growth	.23	.13	-.42	.13
	(.17)	(.24)	(.33)	(.23)
1944-45 Growth	-.05	-.19	.16	-.27
	(.32)	(.47)	(.16)	(.44)
1940s pop. Growth		.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. These regressions correspond to equation (9). Standard errors in parentheses.



The two thick, solid lines show the utility from listening to a station located at positions 0 and 0.5 as a function of the listener's location, when the stations offer a common component of utility equal to one, $t = 1$ and $\phi = 2$. When $N = 2$, these are the only stations and the marginal listener is located at 0.25. When the 0-station increases its offered common utility by .05, utility from it shifts up to the thin, dashed line. The marginal consumer is now at 0.3, so that the station increases its market share by 10 percentage points. When $N = 4$, the neighbouring station is located at 0.25, offering the utility of the thin, solid line, so that the marginal listener is at 0.125. The upwards shift in the utility shifts the marginal listener twice as much, to 0.225, so that station-0's market share increases by 20 percentage points.

Figure 1



The two thick, solid curves and the solid, thin curve show the utility from listening to a station located at positions 0, 0.5 and 0.25, respectively, that offers a 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

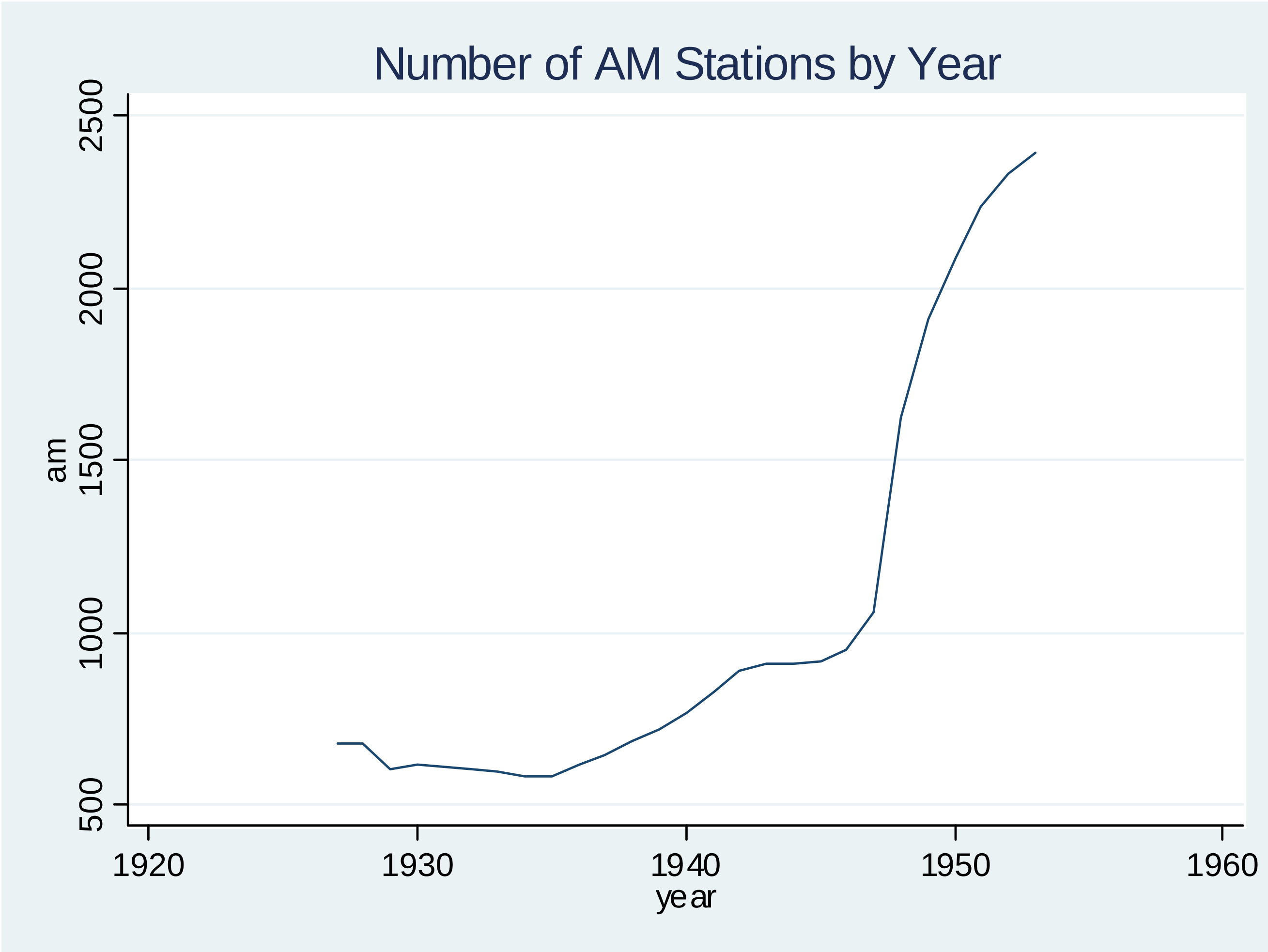


Figure 3

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