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FCC RADIO MARKET STRUCTURE AND MUSIC DIVERSITY PAPER

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Executive Summary: We develop a unique measure of product diversity, and apply it to R&R play lists to examine changes in diversity following the 1996 Telecommunications Act. We find that stations within the same format grew more similar in their Top Ten play lists, and that stations that switched towards similar formats also grew more similar. When owners acquired stations, they tended to make them more similar across markets and within formats, but differentiated stations in the same market. Stations in the same market and within the same format, however, grew more similar when they switched to common ownership.

Introduction

With the wave of radio mergers following the Telecommunications Act of 1996 (1996 Act), the radio market has captured more attention from observers and policymakers. Specifically, observers and policymakers wish to understand the consequences of consolidation in radio markets. In this study, we employ unique data and a novel measure of product diversity to study the relationship between ownership concentration and diversity of play lists in broadcast radio. Unlike past research, which employs formats as a proxy for diversity (Berry and Waldfogel, 2001), we employ *Radio and Record* (R&R) data on actual songs aired by radio stations to directly measure diversity. In addition, we employ a unique measure of product diversity, which allows us to directly estimate ownership concentration's effect on diversity. Our results are tentative, and we can make no definite statement regarding the relationship between concentration and diversity, but these results provide direction for further study.

The 1996 Act made two major regulatory changes in the radio market. First, the 1996 Act increased the number of radio stations that a single radio owner could possess

in any given locality. Under the 1996 Act, a single owner can own up to 8 radio stations in a market with 45 or more commercial radio stations, 7 radio stations in a market with 30-44 radio stations, 6 radio stations in a market with 15-29 radio stations, and five stations in markets with less than 15 radio stations. Second, the 1996 Act eliminated all caps on national ownership, replacing the old cap of 20 FM stations and 20 AM stations. We combine R&R play lists with data on ownership of radio stations and concentration in various radio markets to assess the impact of this important regulatory change on product diversity in the radio broadcasting market.

Literature Review

Theoretical treatments of product diversity on media markets start with Steiner (1952). Steiner averred that a single monopolist would maximize product diversity and economic welfare in a broadcast market, because the monopolist would want to capture every single viewer, and would therefore not duplicate programming. Social welfare is therefore higher under monopoly, because more viewers receive their preferred programming.

Researchers have pointed out that Steiner's finding relies on strict assumptions about preferences. For instance, if viewers may have lesser preferred substitutes in programming (Beebe, 1977), then Steiner's finding may not hold. More importantly, Steiner ignores the issue of pricing in media markets. If viewers pay for programming, either explicitly by direct payment or implicitly through exposure to advertising (Becker and Murphy, 1993; Gabszewicz, Laussel, and Sonnac, 1999; Anderson and Coate, 2000), then Steiner's conclusions may no longer hold. As Gabszewicz, Laussel, and Sonnac

(1999) and Anderson and Coate (2000) point out, if programs of the same type are perfect substitutes to viewers, then competition will now actually maximize product diversity, as competitors air different types of programming to avoid competing on price. Anderson and Coate (2000) demonstrate that Steiner's conclusions may hold only when programs of the same type are imperfect substitutes.

As theory itself does not reveal a clear relationship between concentration and diversity, researchers employ empirical methods to gauge this relationship. Notably, Berry and Waldfogel (2001) attempt to measure the effect of concentration on product diversity in radio markets between 1993 and 1997. This allows Berry and Waldfogel to use the 1996 Act as their source of exogenous variation, thereby allaying potential concerns about the endogeneity of market structure. Berry and Waldfogel use the number of unique radio formats (using Duncan's radio format classification system)[1] as their proxy for product diversity. Berry and Waldfogel find that reductions in the number of owners led to increases in the number of formats, making the case that increased concentration increases product diversity in radio markets, which is consistent with Schmalansee's theory of spatial preemption (1978).

Sweeting (2005) uses data from Mediabase to measure the differences between radio station play lists. Sweeting has complete play lists for 766 stations over 30 weeks across 148 markets. Sweeting uses a measure of diversity based on the differences in proportion of songs by different artists. Sweeting also employs another measure of diversity based on the number of times one station plays an artist that its paired station does not play at all during the same week, and vice versa. Sweeting finds that commonly

[1] This refers to the method employed by Duncan Radio Reports when they classify radio formats. Duncan classifies formats far more finely than BIA.

owned stations within the same format in the same market differentiate themselves from one another but steal listeners from other stations in the same market and format by airing similar music to them. Because commonly owned stations within the same format and market differentiate from one another but become more similar to other stations, the effect of concentration on total variety is small. In addition, Sweeting finds that commonly owned stations in different markets are more similar. Commonly owned stations tend to have both shorter and more homogenized play lists, carry more commercials, and apparently do not lose listeners. Sweeting avers that this indicates that commonly owned stations take advantage of better market research by their corporate parents.

Rossman (2005) uses cross-sectional data from Nielsen Media Research's Broadcast Data Systems (BDS), which yield comprehensive playlists for 253 "Rock" stations[2], to create playlist diversity metrics. One metric measures the diversity of songs and artists within each station, and another measures the diversity of songs and artists across stations. Rossman does not directly examine common ownership across station pairs. Rossman finds that stations with larger owners have lower playlist diversity and play more similar songs to other stations.

Our Contribution

As Berry and Waldfogel point out, formats are merely taxonomic methods of roughly classifying various radio stations, and certain formats are more similar than

[2] "My dataset consists of the 253 commercial stations in the BDS "rock" file for which there were September 2003 observations." (p. 51)

others. Therefore, the change in the number of formats may not be an accurate measure of the change in product diversity. If the number of formats does not change, but the diversity of songs across formats increases by 5%, using formats as the measure of diversity would inaccurately lead a researcher to conclude that radio product diversity did not change when in fact it increased by 5%. The ideal method of measuring product diversity would use radio stations' comprehensive play lists and would measure concentration based on the relationship between the number of unique songs played and the number of total songs played.

We do not have comprehensive play lists, but we obtain from the R&R database the top songs played by a large sample of radio stations in March, 1996 and March, 2004. We therefore create a measure of playlist diversity based on the songs themselves, rather than format classification. In doing so, we forgo one advantage of Berry and Waldfogel's study. Berry and Waldfogel observed data across both large and small markets, and the radio ownership rules in the 1996 Act varied according to market size. The variation in ownership in Berry and Waldfogel's sample was therefore (arguably) driven by the exogenous regulatory changes in the 1996 Act.

Our data, however, are drawn from radio stations in the most populated markets. Therefore, our sample's variation in ownership changes is not as driven by differences in the 1996 Act's ownership rules, which raises the possibility of market structure endogeneity. In addition, our sample draws from a possibly unrepresentative sample within these large markets. R&R only lists stations that meet a minimum rating requirement, meaning that stations with very few listeners are not listed by R&R. In addition, R&R only lists stations that play new songs, so stations that specialize in older

songs, like Oldies stations or Classical stations, are not included in our sample of R&R play lists.

Our approach allows us to create and exploit a new measure of product diversity - the distance measure. As one may imagine, measuring diversity in a market is a daunting task. However, as Alexander (1997) points out, if we can break down products into a bundle of characteristics and simply treat the existence or non-existence of each characteristic as a binary variable, then we can create a measure of product diversity. In this case, songs are individual product characteristics, and we can create a measure of diversity between any two stations by comparing the songs played on each station. Below, we detail the creation and application of the distance measure.

The Distance Measure of Diversity

We compare the similarity of m different product characteristics (in this case songs) across n different producers (in this case radio stations). In this case, we compare the 10 most-played songs across 2 stations. So, $m = 10$ and $n = 2$. Under this condition, we can define a distance function that embodies a measure of diversity. This distance function will conveniently equal the number of unique songs played by each station. Therefore, when comparing two stations and the diversity of their top ten songs, if there is no duplication of songs, the distance function = 10, if the two stations duplicate one song, the distance function = 9, etc. Below, we demonstrate the creation of the distance function:

In the present case, we are interested in a subset of a set of many characteristics. Let this finite vector of dimensionality (the number of characteristics) be equal to m, and let n be the number of objects in the system. We now define the following.

First, two objects, $X(x_1, x_2, \ldots x_m)$ and $X'(x_1', x_2', \ldots x_m')$ are *identical* to each other provided all $x_n = x_n'$, where $0 < n \leq m$. Second, an object $X(x_1, x_2, \ldots x_m)$ is *unique* if there is no other object $X'(x_1', x_2', \ldots x_m')$ such that all $x_n = x_n'$, where $0 < n \leq m$. Third, two objects are *divergent* from each other provided $x_n \neq x_n'$ for all $0 < n \leq m$. Fourth, two objects $X(x_1, x_2, \ldots x_m)$ and $X'(x_1', x_2', \ldots x_m')$ are *analogues* provided some $x_n \neq x_n'$ and some $x_j = x_j'$, where $0 < n, j \leq m$. Finally, two objects, $X(x_1, x_2, \ldots x_m)$ and $X'(x_1', x_2', \ldots x_m')$ have the n^{th} *degree of analogy* to each other, provided there are exactly n characteristics such that $x_n = x_n'$. The greater (*lesser*) the degree of analogy, the more similar (*dissimilar*) the objects.

Proposition 1: Suppose that object A has the i^{th} degree of analogy with object B and the j^{th} degree of analogy with object C, where $0 < i, j \leq m$. Then, the degree of analogy k between B and C is such that $0 \leq k \leq m - |i - j|$. **Proof in technical appendix.**

We extend our measure to include binary systems. In this system, each characteristic takes the value of 0 or 1, indicating the absence or presence of a characteristic. We define the degree of divergence between objects X_i and X_j as:

$$d_{ij} = \sum_{k=1}^{m} | x_{ik} - x_{jk} |$$

The degree of analogy can be computed as:

$$a_{ij} = m - d_{ij}$$

allowing us to calculate the nominal analogous diversity of the system as:

$$nd = \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{m} | x_{ik} - x_{jk} | / 2 = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij} / 2.$$

The higher the nominal analogous diversity (nd) of the system, the more diverse is the system.

Proposition 2: Minimum (nominal analogous) diversity, $nd_{\min}$, equals zero. Maximum (nominal analogous) diversity, $nd_{\max}$, equals $\frac{1}{4}m(n^2)$ when n is even, and $\frac{1}{4}m(n^2-1)$ when n is odd. **Proof in technical appendix.**

Therefore, when we compare play lists of m songs between n = 2 stations, maximal diversity equals $\frac{1}{4}m(n^2)$ = ¼ (m)(4) = m, so that maximum diversity obtains when we have two completely unique play lists, and our distance measure is equal to the number of songs played. Note that these play lists must be of equal size.

Data and Methodology

We combine data on station play lists and station ownership from R&R magazine with BIA data on station-level market share and market-level concentration. Using the partial play lists from the R&R database for March 15, 1996 and March 16, 2004, we count the total number of different songs within each format. Table 1 presents data on the number of unique songs in our sample by R&R format. In eight out of twelve formats (Active Rock, Adult Alternative, CHR Pop, CHR Rhythm, Country, Jazz, Rock, and

Urban) the number of unique songs has remained the same or declined between these two time periods. The number of different songs played in the other four formats (AC, Alternative, Hot AC, Urban AC) has increased. There is, of course, some overlap between these formats; some songs are common to a number of formats, especially similar formats, such as Rock and Active Rock. On the bottom row of Table 1, we present the total number of unique songs across all formats published in our selected R&R database: 1109 in 1996 and 989 in 2004.

Table 1
Number of Unique Artists and Songs on Play lists

Format	Number of Stations		Number of Unique Artists		Number of Unique Songs	
	1996	2004	1996	2004	1996	2004
Adult Alternative	14	10	118	102	189	128
AC	17	17	68	65	97	100
Active Rock	13	17	78	71	123	113
Alternative	32	30	133	142	182	210
CHR_POP	41	41	177	107	243	134
CHR_RHY	14	19	133	114	174	152
Country	38	34	80	67	124	104
Hot AC	19	22	78	90	102	137
Jazz	14	14	102	77	156	98
Rock	10	5	76	51	105	88
Urban	25	23	102	90	149	128
Urban AC	8	13	54	78	64	119
All Formats	245	245	660	634	1109	989

Our methodology raises some issues concerning our sample. First, R&R play lists draw mainly from the largest markets. Therefore, our sample draws mainly from the top markets and does not include data from smaller markets. In addition, we compare only the top ten songs across stations and do not observe other songs. We therefore only observe a truncated sample of each station's songs. For example, if two stations grew more similar in their top ten songs but grew more different in all of their other songs, we

would observe these stations as growing more similar. Conversely, if two stations grew more different in their top ten songs but grew more similar in all of their other songs, we would observe those stations as growing more different. In addition, we also do not observe how frequently stations played their top ten songs. We therefore cannot assess the relative importance of this truncation issue.

In addition, we only observe those stations tracked by R&R in both periods. This means that we observe only 245 stations out of a universe of thousands. These stations are in no way randomly sampled, and are mainly the largest stations in the largest markets. Thus, to the extent changes in diversity differ across different market sizes, we fail to observe changes in diversity within smaller markets.

Our sample does, however, contain two different points in time, which allows us to perform differences-in-differences analysis. This means that we can adjust for unobserved station-specific heterogeneity, which cannot be done in simple cross-sectional analysis. In addition, the first time period is March 1996, before stations could have merged in response to the radio ownership rule changes in the 1996 Telecommunications Act, and the other time period is March 2004, well after the 1996 Act. We therefore observe ownership changes generated at least partially by an exogenous regulatory shift.

First, we assess song diversity across every R&R station-pair in March 1996 and in March 2004.[3] For each station pair in 1996 and 2004, we calculate the distance function, which measures the number of unique plays between any two stations.

We use the distance function to create some simple descriptive statistics. Table 2

shows the average distance between top ten lists among stations within the same R&R format.

Table 2
Average Distance Within Formats

Format	1996	2004
Adult Contemporary	6.99	5.86
Active Rock	6.58	6.78
Adult Alternative	7.99	7.93
Alternative	7.27	7.17
CHR Pop	7.16	5.11
CHR Rhythm	7.60	5.69
Country	4.74	5.00
Hot Adult Contemporary	6.89	5.61
Jazz	8.00	7.07
Rock	7.04	7.30
Urban Adult Contemporary	6.93	6.23
Urban	5.24	3.79

The first row in Table 2 shows that, on average, Adult Contemporary top 10 radio lists differ by 6.99 songs during the week of March 15, 1996 and by 5.86 songs during the week of March 16, 2004. Overall, Table 2 shows that the average difference between radio station top ten lists declined in our time period for nine out of twelve formats; these include Adult Contemporary, Adult Alternative, Alternative, CHR Pop, CHR Rhythm, Hot Adult Contemporary, Jazz, Urban Adult Contemporary, and Urban. Average diversity for top 10 songs increased in the remaining formats: Active Rock, Country, and Rock. The difference between songs therefore decreased within 9 formats and increased within 3 formats.

[3] As the word "every" would imply, this means that each station was paired with every other station. Therefore, station 1 was paired with 244 other stations, station 2 was paired with 243 other stations (because station 2 had already been paired with station 1, and so forth.

As we noted above, we also compare songlists between radio stations in similar formats, such as Adult Contemporary and Hot Adult Contemporary. In many cases, however, radio stations in different formats have no top 10 songs in common. For instance, there will be no top ten Jazz song played on any Country station. Thus, for many format pairs, our distance measure yields 10 (meaning no top 10 songs in common). For our purposes, we focus only on relatively similar formats and discard format pairs that are highly dissimilar.[4] Table 3 presents the results of comparing radio stations across similar formats.

Table 3
Average Distance Across Selected Formats

Formats		March 1996	March 2004
Adult Contemporary	Hot Adult Contemporary	8.08	7.71
Active Rock	Alternative	7.76	7.40
Active Rock	Rock	8.05	7.30
Adult Alternative	Alternative	8.80	9.37
Adult Alternative	CHR Pop	9.45	9.47
Adult Alternative	Hot Adult Contemporary	9.54	8.96
Alternative	CHR Pop	9.35	9.44
Alternative	Rock	8.23	8.33
CHR Pop	CHR Rhythm	8.84	8.49
CHR Pop	Hot Adult Contemporary	7.83	8.11
CHR Rhythm	Urban AC	8.21	9.41
CHR Rhythm	Urban	7.40	7.85
Urban AC	Urban	6.99	8.81

Eight of the thirteen cases displayed show increases in the average difference (more diversity) between top ten play lists. These format pairs include: Adult Alternative / Alternative, Adult Alternative / CHR Pop, Alternative / CHR Pop, Alternative / Rock,

[4] We therefore ignore for the moment those format pairs whose average distance is equal or higher than 9.5.

CHR Pop / Hot Adult Contemporary, CHR Rhythm / Urban AC, CHR Rhythm / Urban, and Urban AC / Urban.

The remaining five format pairs show reductions in song diversity, suggesting that play lists in AC / Hot AC, Active Rock / Alternative, Active Rock / Rock, Adult Alternative / Hot Adult Contemporary, and CHR Pop / CHR Rhythm share more songs in common in 2004 than in 1996.

In general, the differences between these averages for similar but different format pairs show smaller changes than those displayed in Table 2, given that we excluded all format pairs from our analysis here that have average differences greater than 9.5. Together, however, Tables 2 and 3 suggest that diversity may have declined between stations of the same format, while rising somewhat for stations across different formats. When we compute the average measure of diversity for our entire sample, we find that the overall diversity decreased very slightly, from 9.29 to 9.19, a decrease of 1.06%.[5] Song diversity appears very stable overall, with some significant changes occurring within formats and across some format pairs.

We use the distance function in a panel regression to determine the causes of these changes in diversity. In particular, we examine the role that market structure may have played, with particular focus on the consolidation of ownership that resulted from changes in ownership rules under the Telecom Act in 1996. In addition, we study the extent to which diversity reductions within formats reduce the alternatives available to listeners.

To answer these questions, we estimate a linear model of the change in distance

[5] Here we include all stations pairs, even those with categories that have no overlapping songs. This has a strong effect of raising the average and lowering the difference between the time periods.

between radio pairs using our R&R data. We then compute the percent change of distance across our time period for all possible pairs of these 245 stations. This generates $\sum_{i=1}^{244} i = 29{,}890$ station-pair distance observations.

We regress the change in distance between top ten play lists of station pairs) on variables indicating the status of format, market, and ownership between station pairs.[6] Our set of variables includes the following:

Same Format - an indication of whether or not both stations are within the same format during both periods.

Same City – indicates whether both stations broadcast within the same market or city during both periods.

Same Owner – indicates whether both stations share the same owner during both periods.

Same Format and City – indicates whether both stations share the same format and broadcast in the same city during both periods.

Same Owner and City – indicates whether both stations share same owner and broadcast in the same market.

Change in Ownership – indicates whether the station-pair switched from separate to common ownership or vice versa.

[6] We set each variable to 1 or 0 to indicate whether or not a particular condition is satisfied. For example, the variable "Same format" is set to 1 if both stations in a pair have the same R&R format; otherwise it is set to 0.

Change in Format – indicates whether the station-pair switched from different to common format or vice versa.

Change in Ownership and Format – indicates whether the station-pair switched from separate to common and ownership and switched from different to common format or vice versa.

Change in Ownership for Pair in Same Format - indicates whether a station-pair sharing the same format switched from separate to common ownership or vice versa.

Change in Ownership for Pair in Same City – indicates whether a station-pair in the same city switched from separate to common ownership or vice versa.

Change in Ownership for Pair in Same Format and Same City - indicates whether a station-pair in the same city and sharing the same format switched from separate to common ownership or vice versa.

Change in Format for Pair with Same Owner - indicates whether a commonly owned pair of stations switched from different to common format or vice versa.

Change in Format for Pair in Same City - indicates whether a pair of stations within the same city switched from different to common format or vice versa.

Change in Ownership and Change in Format for Pair in Same City – indicates whether a station-pair in the same city changes from separate to common ownership and changes from different to common format or vice versa.

Regression (1):

$$\text{Change in Distance} = \beta_1 + \beta_2(\text{Same Format}) + \beta_3(\text{Same Owner}) + \beta_4(\text{Same City}) + \beta_5(\text{Same Format and City})$$
$$+ \beta_6(\text{Same Owner and City}) + \beta_7(\text{Change in Ownership}) + \beta_8(\text{Change in Format})$$
$$+ \beta_9(\text{Change in Ownership and Format}) + \beta_{10}(\text{Change in Ownership in Same Format})$$
$$+ \beta_{11}(\text{Change in Ownership in Same City}) + \beta_{12}(\text{Change in Ownership in Same City and Same Format})$$
$$\beta_{13}(\text{Change in Format with Same Owner}) + \beta_{14}(\text{Change in Format in Same City})$$
$$+ \beta_{15}(\text{Change in Ownership and Change in Format in Same City}) + \varepsilon_1$$

We report the coefficients from the estimating Regression One on Table 4:

Table 4
OLS Regression on Change in Distance Between Radio Play lists, 1996-2004
(T-statistics in Parentheses)

	Change in Distance
Same Format	-0.63*** (11.85)
Same Owner	-0.04 (0.29)
Same City	-0.01 (0.28)
Same Format Same City	-0.16 (0.27)
Same Owner Same City	-0.32 (0.82)
Change to Common Owner	-0.06*** (3.30)
Change to Common Format	-2.26*** (35.18)
Change to Common Owner + Format	-1.23*** (6.98)
Change to Common Own Same Format	-0.57*** (5.66)
Change to Common Own Same City	0.24** (2.18)
Change to Common Own Same Format and City	-0.28 (0.41)
Change to Common Format Same Own	-0.28 (0.69)
Change to Common Format Same City	-0.26 (0.59)
Change to Common Owner + Format Same City	-0.61 (0.69)
Constant	-0.04*** (4.80)
R-Squared	0.21
F-Statistic	142.56***
Observations	29890

*** - significant at the 99% level. ** - significant at the 95% level

Station pairs within the same format saw a decrease in distance of -0.63 between 1996 and 2004, and this decrease was significant at the 1% level. This indicates that the top ten play lists of stations within the same format grew more similar between 1996 and 2004. Not surprisingly, station pairs that switched from different to the same formats grew more similar, decreasing in distance by 2.26.

Stations pairs that had common ownership in both periods did not show a statistically significant change in distance. However, stations that went from separate to common ownership decreased in distance by -.06. This decrease was significant at the 99% level. As a result, these results do provide evidence that owners tend to play similar songs across all of their stations across all markets.

If two stations within the same market went from separate to common ownership, the stations actually grew more different, increasing in distance by .24. This change was significant at the 95% level. We therefore observe evidence that owners differentiate play lists among their stations as long as those stations are within the same market.

This relationship does not appear to hold, however, for stations within the same format. If station pairs within the same format changed from separate ownership to common ownership, they grew more similar, with their distance decreasing by 0.57. This change was significant at the 99% level. If stations switched from separate to common ownership and changed from different to the same format(s), they grew more similar, with the distance decreasing by 1.23. This change was also significant at the 99% level. Thus stations that went from separate to common ownership within the same format and stations that switched from separate to common ownership AND format grew significantly more similar. This indicates that owners may have common play lists across

their stations within the same format. In addition, because the coefficients on *Change to Common Ownership Same Format and Same City* and *Change to Common Owner and Change to Common Format in Same City* are negative and insignificant, this pattern does not differ for stations within the same market. At most, the differentiating incentives for an owner of multiple stations within the same market only dampen the owner's overall incentive to play similar play lists across their stations within the same format, so that commonly owned stations within the same format and market may play more similar music. The negative and significant constant indicates that there was a slight drift towards similarity between 1996 and 2004.

Based on our results, we find that owners prefer to play similar music across their stations in different markets and across their stations within the same format, but tend to differentiate across their stations within the same market. In addition, the tendency to play more similar music across stations within the same format outweighs the tendency to differentiate play lists within the same market. Commonly owned stations within the same format and market play more similar music than separately-owned stations within the same format and market, because common ownership within format generates greater play list similarity.

As we mentioned before, the sample is restricted to only 245 stations (for a total of 29,890 station-pairs) out of thousands of stations. These stations represent the largest markets, and smaller markets are greatly under sampled. In addition, we observe only each station's ten most-played songs, and therefore do not observe a complete or even a majority of each station's total songs played. In addition, many of our results may face some endogeneity issues. Because we applied differences in differences analysis to each

station pair, our estimates adjust for any station-pair-specific heterogeneity. In addition, the change takes place over a large exogenous regulatory change in the rules governing radio consolidation (the 1996 Telecommunications Act) so a large part of the changes in ownership are exogenous. If, however, certain changes in station-pair ownership and format correlate with unobserved changes that also drive changes in differences in Top Ten play lists between stations, then our estimates may suffer from omitted variable bias.

Conclusion

We investigate the change in diversity among play lists within the radio industry since the passage of the Telecom Act in 1996. For this purpose, we introduce a straightforward measure of diversity. Overall, we found that song diversity, whether measured as the number of unique songs or the difference between top ten play lists has remained stable between March 1996 and March 2004. Play lists for stations within the same format have grown more uniform across and within local markets. We found evidence that owners play similar music across markets and within formats, but differentiate songs within markets.

Further study could employ more comprehensive play lists. With those more comprehensive play lists, researchers could assess diversity within stations and examine whether stations that increased their diversity saw increases in ratings. In addition, it is possible that future study, even with an unrepresentative sample, could use some sort of weighted least squares approach to adjust for sample bias.

Technical Appendix

Proof of Proposition One: While $0 \leq k$ is obvious, we must prove $k \leq m - |i - j|$. First, assume that $i = j$. Clearly, $k \leq m = m - |i - j|$. Now, let $i \neq j$. Without loss of generality, we assume that $i > j$, and consider i characteristics such that $a_n = b_n$. Note that there are at most j number of characteristics such that $a_n = b_n = c_n$, and there are at most $m - i$ characteristics such that $a_n \neq b_n = c_n$. Thus,

$k \leq m - |i - j| = j + (m - i)$.

Q.E.D.

Proof of Proposition Two: When $n = 1$, $nd_{\min} = nd_{\max} = 0$. Now, assume that $n > 1$. We consider two cases, $m = 1$ and $m > 1$.

Case 1: $m = 1$. We have n cases $X_i(x_i)$ which can take on a value of 0 or 1 and k objects such that $x_i = 1$ and $n - k$ objects such that $x_i = 0$.

Lemma 1: When the dimensionality $m = 1$, the nominal (analogous degree of) diversity in the binary system is given by $nd = k(n - k)$, where k is the number of objects that have the same characteristic values.

Proof of Lemma 1: Let k be the number of objects with characteristic values $x_1 = x_2 = \ldots x_k = 1$. Note that we originally designated these objects as $X_1, X_2, \ldots X_k$. Thus, there are $n - k$ number of objects $X_{k+1}, \ldots, X_n$ such that $x_{k+1}, \ldots, x_n = 0$. Notice that $\sum_{j=1}^{n} |x_1 - x_j| = \sum_{j=1}^{n} |x_k - x_j|$ and $\sum_{j=1}^{n} |x_{k+1} - x_j| = \sum_{j=1}^{n} |x_n - x_j|$. Therefore,

$nd = \sum_{i=1}^{n} \sum_{j=1}^{n} |x_i - x_j| / 2 = k(n - k)$. *Q.E.D.*

As we stated in Lemma 1, $nd = k(n-k)$, where n is given, and $0 \le k \le n$. Noting that $\delta nd/\delta k = n - 2k$, the function is maximized when $k = \frac{1}{2}n$. Note that when n is even, k is an integer, and $nd_{\max} = k(n-k) = \frac{1}{2}n(n-\frac{1}{2}n) = \frac{1}{4}n^2$. If n is odd, the closet possible k to $\frac{1}{2}n$ is $\frac{1}{2}(n-1)$ or $\frac{1}{2}(n+1)$. In either case, $nd = \frac{1}{2}(n+1)\frac{1}{2}(n-1) = \frac{1}{4}(n^2-1)$. This represents the maximum (nominal) diversity of the system when n is odd. However, if k is not $n+1$ or $n-1$, then $k = \pm q$ where q is a natural number greater than 1, and $nd = \frac{1}{4}(n^2 - q^2) < \frac{1}{4}(n^2-1)$. Clearly, $nd_{\min} = 0$ when $k = n$ or $k = m$.

Case 2: $m > 1$. Now we consider the case where $m > 1$. We begin by noting that $nd = \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{m} | x_{ik} - x_{jk} | /2 = \sum_{i=1}^{n}\sum_{j=1}^{n} | x_{i1} - x_{j1} | /2 + \ldots + \sum_{i=1}^{n}\sum_{j=1}^{n} | x_{im} - x_{jm} | /2$. It is then immediately clear that $nd \le \frac{1}{4}n^2 + \ldots + \frac{1}{4}n^2$ when n is even;

$nd \le \frac{1}{4}(n^2-1) + \ldots + \frac{1}{4}(n^2-1)$ when n is odd; and $nd = m(\frac{1}{4}n^2)$ when n is even and

$nd = m(\frac{1}{4}(n^2-1))$ when n is odd.

Q.E.D.

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