Coordination, Differentiation and the Timing of Radio Commercials

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Running Head: The Timing of Radio Commercials

*This paper is a revised version of chapter 4 of my MIT Ph.D. thesis. Glenn Ellison, Jerry Hausman, Paul Joskow, Nancy Rose, Ken Wilbur, two anonymous referees, a coeditor and numerous participants at academic seminars, the 2003 National Association of Broadcasters/Broadcast Education Association Convention in Las Vegas and the 2004 Southern Economics Association meetings in New Orleans provided many useful comments. I thank Rich Meyer of Mediabase 24/7 for providing access to the airplay data and the National Association of Broadcasters for providing a research grant for the purchase of the BIAfn *MediaAccess Pro* database including the Arbitron share data. The views expressed in this paper and any errors are my own.

Abstract

This paper examines the timing of commercial breaks by contemporary music radio stations. A simple model shows that stations may prefer, all else equal, to choose the same times (coordination) or different times (differentiation) for breaks depending on how listeners behave. It also shows that how much commercials overlap in Nash equilibrium should vary in different ways with observable market characteristics, such as the number of stations, depending on whether stations prefer to coordinate or differentiate. Panel data on the timing of commercials by 1,094 stations provides consistent support for the hypothesis that stations prefer to coordinate on timing.

1 Introduction

This paper examines whether radio stations prefer to play their commercial breaks at the same or different times. The commercial radio industry had advertising revenues of $19.8 billion in 2000 and the value of commercials depends on how many people listen to them.[1] The timing of commercials is a potentially important strategic choice because many listeners seek to avoid commercials by switching stations. For example, the average in-car listener switches stations 29 times per hour primarily to avoid commercials and avoids approximately half of the commercials she would hear if she never switched stations (Abernethy (1991), McDowell and Dick (2003)). Avoidance by in-car listeners alone potentially costs the radio industry several billion dollars in revenue each year.[2] Television stations (revenues $44.8 billion in 2000) make similar timing choices and advertisers on both media have suggested that stations can reduce avoidance by playing commercials at the same time.[3]

[FIGURE 1 HERE. TITLE: HISTOGRAMS OF THE NUMBER OF STATIONS PLAYING COMMERCIALS EACH MINUTE 12-1 PM AND 5-6 PM]

Figure 1 shows, for two different hours of the day, that stations do tend to play commercials at the same time. In any hour roughly 15 times as many stations play commercials five minutes before the hour as play them five minutes after the hour. However, there is an obvious problem with claiming that Figure 1 is caused by stations preferring to choose the same times for commercials: it could also be caused by "common factors" which make certain parts of each hour attractive for all stations to play commercials independent of what other stations in the same local market are doing. People in the industry identify two common factors which are consistent with Figure 1: stations play music on the quarter-hours because of how Arbitron estimates station ratings and they do not play commercials at the start of each hour because this is when many listeners switch on and listeners are believed to particularly dislike hearing commercials as soon as they tune-in.[4]

I overcome this identification problem by exploiting the fact that radio stations operate in local markets with different observable characteristics. I use a theoretical model to show that stations may prefer, all else being equal, to play commercials at the same times (for the rest of the paper I call this a "preference to coordinate") or different times ("preference to differentiate") depending on exactly how listeners switch stations. The model shows that these different preferences give different predictions for how the equilibrium overlap of commercials on different stations should vary with observable market characteristics. To be precise, if stations prefer to coordinate then commercials should tend to overlap more in markets with fewer stations, less listening to stations located in nearby markets and more concentrated ownership. If one station attracts a particularly large share of listeners then smaller stations should tend to have their commercials at the same time as this large station. If stations prefer to differentiate then these expected relationships reverse. In either case overlap should be more sensitive to market characteristics during periods of the day when more listeners switch stations.

I test which set of relationships hold using panel data on the timing of commercials by 1,094 contemporary music stations. The relationships in the data are consistent with stations preferring to coordinate. For example, a one standard deviation decrease in the number of stations in a market increases the expected amount of overlap between two stations during drivetime by 7%. The relationships are more significant during drivetime, and to a lesser extent midday hours, than in the evening or at night. This is consistent with the model because in-car listeners, who are most numerous during drivetime, switch stations more than other listeners.[5] There is also some evidence that commercials overlap more when there is greater demand for advertising.

The paper contributes to a recent empirical literature studying timing decisions by firms. The main question in this literature is whether competing firms choose the same times because of business stealing incentives or whether they strategically differentiate to soften price competition. Most studies face an identification problem which is similar to mine because uneven consumer demand could also rationalize why firms choose the same times. Borenstein and Netz (1999) examine airline departure times. They find that competing airlines tend to have more similar departure times when they are likely to be constrained by either hubbing considerations or slot constraints suggesting that, absent constraints, they strategically differentiate. Corts (2001) and Einav (2004) examine the theater release date decisions of movie distributors. Einav estimates underlying consumer demand using an assumption on how a movie's appeal declines over time and finds that high observed demand on holiday weekends is partly due to so many new movies being released. Corts finds that films with a common producer and distributor are released further apart than other films. These results suggest that release dates are clustered because of business stealing. In my model, stations do not choose the same times because of business stealing incentives but rather to prevent listeners avoiding the part of the product they do not like but which advertisers pay for them to hear. There is a similarity with Borenstein and Netz and Corts in that I examine how observable characteristics, like ownership, affect how much commercials overlap.

The timing of commercials has attracted relatively little academic attention. Epstein (1998), Zhou (2000) and Kadlec (2001) provide theoretical models where two television stations choose to have their commercials at the same time in equilibrium. I show that a slightly different specification of listener behavior would lead to stations preferring to choose different times. Epstein finds that, during primetime, the major US television networks tend to have slightly later commercials in half-hour shows when the other networks have longer shows with later commercial breaks. This is consistent with coordination although he never calculates how much commercials overlap. Sweeting (2005) uses the same data as used here to estimate a timing game with multiple equilibria. This approach also finds evidence of coordination, on slightly different times in different markets, during drivetime and of more coordination in smaller markets.

Section 2 presents the model of station timing decisions. Sections 3 and 4 describe the data and the empirical specification. Section 5 provides the empirical results. Section 6 concludes.

2 A Model of Listener Behavior and Station Timing Decisions

I present a simple model which shows that stations may prefer to coordinate or differentiate depending on how listeners behave. These different preferences lead to different comparative statics for how the equilibrium overlap of commercials should vary with a number of observable market characteristics.

2.1 Station Payoffs

Time is divided into an infinite sequence of "even" and "odd" discrete intervals.[6] There are $N(\geq 2)$ stations in a market. Each station has commercials in alternate periods and its choice is whether to play them in even intervals or odd intervals. Stations play music when they are not playing commercials. I model common factors, such as the advantage of not playing commercials on the quarter-hour, by allowing even intervals to be, on average, more attractive for commercials. Station i's payoffs (π) from choosing even and odd are

$$\pi_{i,EVEN} = \beta + A(\theta, N, n) + \varepsilon_i^{EVEN} \quad (1)$$

$$\pi_{i,ODD} = A(\theta, N, n) + \varepsilon_i^{ODD} \quad (2)$$

where $\beta > 0$ reflects the additional attractiveness of even intervals, $A(\theta, N, n)$ is the average audience of a commercial break when n other stations in the market have their commercials at the same time and θ is a parameter which reflects listeners' switching behavior. Stations prefer to coordinate, all else equal, if this increases the audience of their commercials.[7] The εs are idiosyncratic components of preferences which are assumed to be IID across stations and intervals and to be normally distributed with mean zero and standard deviation $\frac{1}{2}$. They are assumed to be observed by all stations. The εs represent two features of stations' timing decisions. First, a station programmer may have an idiosyncratic preference over scheduled timing arrangements because, for example, he wants to develop a reputation for having "travel on the 3s". Second, other programming, such as songs, travel news or competitions, can vary in length and it could be costly for a station, in terms of the goodwill of its listeners, to cut short this programming in order to play commercials at their scheduled times. This effect can be seen in Figure 2 which shows when a Boston Rock station played commercials from 5-6 pm during a particular week. The times are similar but not identical from day-to-day even though station managers say that scheduled times are typically not changed daily.[8]

[FIGURE 2 HERE. TITLE: THE TIMING OF COMMERCIALS ON WROR-FM OCTOBER 29-NOVEMBER 2 2001 5-6 PM]

2.2 Listener Behavior

There are N units of listeners. I consider two simple formulations of listener behavior where the parameter θ reflects how many listeners consider switching stations.

Formulation 1 (Coordination). Every listener has a first choice station (the "P1" in radio jargon) and a second choice station. Each station is the first choice of one unit of listeners who are divided equally between the other stations for their second choice. Independent of station tastes, a proportion $1-\theta$ of listeners never switch and always listen to their first choice station. The remainder listen to their first choice unless it has commercials and their second choice has music in which case they listen to their second choice. The audience for a commercial break when n other stations choose the same interval is

$$A(\theta, N, n) = 1 - \theta + \theta \frac{n}{N-1} \tag{3}$$

so a station prefers, all else equal, to play its commercials at the same time as a greater proportion of other stations.

Formulation 2 (Differentiation). Every listener has two favorite stations. Each station is a favorite of 2 units of listeners who are split equally between the other stations for their other favorite station. Listeners' next preference is for an outside option, such as NPR or a CD, which never has commercials. When a listener is listening to one of her favorite stations she continues to listen to it when it is playing music, but when it plays commercials she switches with probability θ, to her other favorite station if it is playing music and otherwise to the outside option in which case she switches back to one of her favorite stations, chosen with equal probability, as soon as the commercials are over. The steady-state audience of a commercial break when n other stations choose the same interval is

$$A(\theta, N, n) = n\left(\frac{1-\theta}{N-1}\right) + (N-n-1)\left(\frac{2}{2-\theta}\frac{1-\theta}{N-1}\right) \tag{4}$$

which decreases in n for $\theta > 0$ so a station prefers, all else equal, to play its commercials at a different time to the majority of other stations. In this formulation a station's audience for its commercials is always a fixed proportion $(1-\theta)$ of its audience before a commercial break and this is increased by playing music when other stations have commercials.

2.3 Computing Nash Equilibrium Strategies and Equilibrium Overlap

I compute how much commercials on different stations overlap in static Nash equilibrium.[9] If a particular set of parameters and εs support multiple equilibria I use the pure strategy Nash equilibrium which maximizes joint station payoffs. The Appendix shows that a pure strategy Nash equilibrium always exists and describes the simple procedure which identifies the joint payoff maximizing equilibrium. Overlap is measured as the probability that two randomly chosen stations make the same timing choice. For example, if x out of N stations choose even then overlap is $\frac{x(x-1)+(N-x)(N-x-1)}{N(N-1)}$. I simulate the model by drawing 1,000 sets of εs and, for given parameters, calculate the average equilibrium overlap across these sets. The εs are kept the same as the parameters are changed.

2.4 Comparative Statics

I now describe how overlap varies with the parameters and observable market characteristics. I simulate the model for particular values of the parameters but the comparative statics are highly intuitive and are robust to considering a wide range of alternative parameter values.

θ (the propensity of listeners to switch stations). Figure 3(a) shows how equilibrium overlap changes under both formulations of listener behavior as θ varies from 0 to 1 with the other parameters held fixed at $\beta = 0.2$ and $N = 8$. When no listeners consider switching stations ($\theta = 0$) timing does not affect the audience of commercials and overlap is greater than $\frac{1}{2}$ only because most stations prefer even ($\beta > 0$). As θ increases commercials overlap more if stations prefer to coordinate. Commercials overlap less if stations prefer to differentiate until so many listeners avoid commercials that their audiences are small whenever they are played. As many listeners do hear commercials even during drivetime it is reasonable to assume that θ lies in the range where increasing θ slightly leads to less overlap.

[FIGURE 3 HERE: COMPARATIVE STATICS OF EQUILIBRIUM OVERLAP]

N (the number of stations). Figure 3(b) shows how equilibrium overlap changes as N increases from 2 to 16, for $\theta = 0, 0.2$ and 0.6. If no listeners switch stations ($\theta = 0$) then overlap is independent of N. If stations prefer to coordinate then overlap falls as N increases because with fewer stations, a station is more likely to be able to choose an interval which most of the other stations are also choosing. In this case it has a strong incentive to choose this interval as well. Overlap is more sensitive to N when listeners have a greater propensity to switch stations (θ higher).[10] If stations prefer to differentiate then overlap tends to increase with the number of stations and this effect is also larger when θ increases. With more stations, a station is more likely to be choosing between intervals chosen by similar proportions of other stations so that the incentive to differentiate has less effect on its timing decision.

In the model N is the number of active players. In my empirical work I treat the active players as the music stations classified by Arbitron as being "home" to the geographically local radio market. A station's home market is the market in which most of its listeners live so that a station's timing decision should reflect conditions in its home market.[11] However, in some markets people may avoid commercials by switching to "out of market" stations which are home to nearby markets. I expect an increase in the importance of these stations, measured by the proportion of listenership to out of market stations, to affect overlap in the same way as an increase in the number of home stations.

Common station ownership. A station's timing choice affects the audience of other stations. In many local markets several stations are commonly owned and commonly owned stations should internalize these externalities. Figure 3(c) shows how equilibrium overlap changes as the number of stations owned by a single firm increases with the total number of stations held fixed ($N = 8$). The remaining stations are owned by independents. The commonly owned stations choose their timing to maximize their joint payoffs. If stations prefer to coordinate on timing then overlap increases as ownership becomes more concentrated. Not only do commonly owned stations become more likely to choose the same interval, but so do the independents because choosing the same interval is a "strategic complement" (Bulow et al. (1985)) in this game. If stations prefer to differentiate then overlap falls with ownership concentration as the common owner tends to minimize how many of its stations are playing commercials at the same time. In both cases, overlap is more sensitive to common ownership when θ is higher.

Asymmetries in station listenership. In many medium and smaller markets one station has a particularly large share of listenership. This could affect timing decisions. I examine the effect of asymmetries by making the following adjustments to the symmetric model. There is one "big" station and $N-1$ "small" stations.

Formulation 1. There are N units of listeners and each station is the first choice of 1 unit of listeners. Listeners who have the big station for their first choice are equally divided between the small stations for their second choice. Proportion α_1 of listeners who have a small station for their first choice have the big station for their second choice with the remainder split between the other small stations. α_1 varies from $\frac{1}{N-1}$ (symmetry) to 1 (every listener has the big station as a first or second choice).

Formulation 2. There are N units of listeners and each listener has two favorite stations. α_2 listeners have the big station as one of their favorites so that each of the other stations is a favorite of $\frac{2N-\alpha_2}{N-1}$ listeners. β and the εs are scaled for each station in proportion to the number of listeners who have the station as a favorite so that common factors or idiosyncratic preferences over scheduling do not become more important when the station has fewer listeners. α_2 varies from 2 (symmetry) to N (every listener has the big station as one of their favorites).

[FIGURE 4 HERE: COMPARATIVE STATICS OF EQUILIBRIUM OVERLAP (CONT.)]

Figure 4(a) shows how overlap changes as α varies where $\alpha_2 = \alpha$ and $\alpha_1 = \frac{\alpha-1}{N-1}$ with $\beta = 0.2$ and $N = 12$. For both formulations average overlap increases with α, with a larger effect when θ is higher. In formulation 1 this is because each small station has a greater incentive to coordinate with the big station as asymmetry increases and this can be achieved more easily than coordinating with all of the other small stations which may be choosing different times. In formulation 2 the small stations want to choose a different time to the big station and and lose less from choosing the same time as each other as asymmetry increases. Therefore a prediction of the model is that small stations should overlap less with the big station as asymmetry increases if stations prefer to differentiate but more if they prefer to coordinate. This is illustrated in Figure 4(b) where overlap is measured as the probability that the big station chooses the same time as a randomly chosen small station. Once again the effects of asymmetry are larger when θ is higher.

2.5 Summary of Comparative Statics

I examine how the observed overlap of commercials varies across markets with different observable characteristics and whether the effects are stronger during drivetime when more listeners switch stations (θ higher). Table 1 summarizes the predictions of the model.

[TABLE 1 HERE]

Of course, overlap should also increase when unobserved common factors (β in the model) are more important. I construct a measure of overlap which controls for timing patterns which are the same across markets including any which vary across hours (for example, it might be more important to avoid the quarter-hours during drivetime). However, it is an identifying assumption that if the importance of unobserved common factors varies across markets, it does not do so in a way which is systematically correlated with the observable market characteristics that I examine.

3 Data

I now describe the data on the timing of commercials and market characteristics. Section 4 details the construction of the specific variables used in the analysis.

The timing data is derived from music station airplay logs provided by Mediabase 24/7, a company which electronically monitors stations to collect data on music airplay. Table 2 shows an extract from the airplay log of a Classic Hits station. The log lists the start time of each song and indicates whether there was a commercial break between songs. I use the following procedure to identify the minutes in which a station has commercials:

[TABLE 2 HERE]

1. estimate the length of each song by calculating the median number of minutes between the start time of the song and the start time of the next song when it is not followed by a commercial

break;[12]

2. create a minute-by-minute schedule (5:00, 5:01, 5:02 etc.) for the station, identifying the minute in which each song starts;

3. fill out the schedule assuming that each song is always played its median length unless this would overlap the start of another song or eliminate a commercial break where one is indicated. In the latter case, the previous song is shortened to allow at least one minute of commercials;

4. fill out commercial breaks into the resulting gaps between songs where "*Commercials and/or Recorded Promotions*" are indicated. A small sample of more detailed Mediabase logs, which include information on DJ talk, indicate that it is rare for a commercial break to last more than six minutes. If a gap is more than six minutes long then I assume that only the middle six minutes have commercials.[13]

The logs do not identify talk programming placed before or after a break so this procedure may incorrectly identify which minutes have commercials. There is more scope for error if the station is playing few songs so that the gaps around commercial breaks are large. I therefore only use station-hours with at least eight songs. This selection rule drops less than 5% of station-hours before 5 am and from 10 am to 9 pm but it drops 50% of station-hours between 6 am and 8 am as many morning shows are largely talk programming.[14]

The available logs contain information on the timing of commercials for 1,094 stations in the first five weekdays of each month in 2000 and 2001. The panel is unbalanced because the sample of stations expands over time and many individual station-days are missing. In 2000 there are 952 stations, 46,168 station-days and 929,498 station-hours with at least one commercial break and at least eight songs. In 2001 there are 1,094 stations, 51,601 station-days and 1,042,079 station-hours with at least one commercial break and at least eight songs.[15]

Arbitron estimates station listenership in geographically local radio markets. These markets correspond to Metropolitan Statistical Areas (MSAs), "subject to exceptions dictated by historical industry usage" (Arbitron (2002), p. 8.2). BIAfn's *MediaAccess Pro* database was used to collect data on each station's home market, Arbitron ratings in each ratings quarter in 2000 and 2001 and ownership history.[16] The airplay stations are home to 147 different markets although 14 of these markets only have one sample station so I cannot calculate overlap for these markets. However, these stations are used to help control for aggregate timing patterns as described below. BIAfn also classifies stations into programming categories. The airplay stations come from seven contemporary music categories: Adult Contemporary, Album Oriented Rock/Classic Rock, Contemporary Hit Radio/Top 40, Country, Oldies, Rock and Urban.[17] As I discuss below, in most of the analysis I pool stations from these seven categories together.

[TABLE 3 HERE]

The airplay sample does not include every station in these seven categories in the sampled markets. Table 3 provides some summary statistics on the coverage of the sample in Fall 2001 when the sample is at its largest. As coverage varies with market size, the table divides the 133 markets with at least two home market sample stations into two groups of almost equal size based on their Arbitron market ranks, which reflect how many people aged 12 and above live in the market. There are 67 markets in the large market group and the smallest market in the group is Allentown-Bethlehem, PA with a 12+ population of 652,100.[18] On average, these markets have 14.7 home contemporary music stations with 10.6 of these stations appearing in the airplay sample. However, because Mediabase samples the most popular stations, the sample stations account for, on average, 87% of contemporary music listenership. The 711 airplay stations in these markets are spread across the seven music categories with Adult Contemporary having the most sample stations (161) and Oldies the least (44). There are 66 markets in the small market group and the smallest included market is Green Bay, WI with a 12+ population of 188,900. These markets have an average of 10.8 contemporary music stations, and just over half of these stations are in the airplay sample, accounting for 71% of contemporary music listenership. There is only one Oldies station in the sample from these markets, but there are at least 40 stations from each of the other categories. The sample stations also have a large number of listeners in absolute terms with over 12 million people listening to them, on average, at any point during Arbitron's broadcast week (Monday-Sunday 6am-midnight).

4 Empirical Specification and Summary Statistics

The main empirical specification for examining how market characteristics affect the overlap of commercials is

$$OVERLAP_{mdh} = X_{mdh}\beta_1 + D_d\beta_2 + W_d\beta_3 + H_h\beta_4 + \varepsilon_{mdh} \tag{5}$$

where d, h and m denote day, hour and market respectively and D, H and W are day of week, hour and week dummies. Observable market characteristics (X) are allowed to have different effects across three dayparts: drivetime (6-10 am and 3-7 pm), midday (10 am-3 pm) and night (7 pm-6 am).[19] The specification is estimated with and without market-hour fixed effects. With fixed effects, the coefficients reflect how the overlap of commercials changes when market characteristics, such as the concentration of ownership, change. The residuals (ε_{mdh}) are likely to be correlated for observations from the same market for different hours or different days. The standard errors are calculated to allow for these correlations.[20]

Two "market definition" issues arise in defining the variables. The first issue, noted in Section 2, is how out of market stations should be treated.[21] Stations should determine their timing given conditions in their home market which is where most of their listeners live. In this sense, only home stations should be considered active players in the timing game. On the other hand, some listeners may avoid commercials by switching to out of market stations. I define overlap and the market characteristics using only home stations but also include the proportion of listening to out of market stations as an explanatory variable. I expect an increase in out of market listening to affect overlap in the same way as an increase in the number of home stations. The qualitative results are the same if I define the variables using all stations with listening in the market or exclude those markets with a high proportion of listening to out of market stations.

The second issue is whether it makes sense to look at overlap between stations in different categories. The answer depends on how many listeners switch categories to avoid commercials. I examine overlap between all contemporary music stations for two reasons. First, many markets have only one station in a category and listeners to this station who want to avoid commercials would have to switch between categories.[22] Second, the evidence suggests that even where there are several stations in a category, people listen to stations in different contemporary music categories. For example, in Fall 2002 there were 6 Rock and 9 non-Rock home contemporary music stations in Boston. On average 15.6% of the listeners to a Rock station listened to each of the other Rock stations and 15.3% of the listeners to a Rock station listened to each of the non-Rock stations.[23] As a robustness check, I also report results from defining variables at the market-category level and they are qualitatively similar.

$OVERLAP_{mdh}$ measures how much commercials on different stations overlap. Simulations are used to control for how much commercials would be expected to overlap because of aggregate hour-category-quantity specific timing patterns. An example illustrates the variable's construction. Suppose I observe a market where from 5-6 pm a Rock station has 8 minutes of commercials and a Country station has 12 minutes of commercials. First, I calculate a measure of the concentration of the commercials, $CONC_{mdh}^{ACTUAL} = \sum_{j=0}^{59} \left(\frac{\sum_{i=1}^{N} I_{ijmdh}}{\sum_{j=0}^{59} \sum_{i=1}^{N} I_{ijmdh}} \right)^2$ where I_{ijmdh} is an indicator variable equal to 1 if station i plays a commercial in minute j. Second, I estimate this variable's expected value given aggregate timing patterns. I create a simulated observation by drawing a station-hour (with replacement) from the set of all Rock station-hours with 8 minutes of commercials from 5-6 pm and a station-hour from the set of all Country station-hours with 12 minutes of commercials from 5-6 pm. I calculate $CONC$ for each of 50 simulated observations. Finally, I calculate $OVERLAP$ as

$$OVERLAP_{mdh} = \frac{CONC_{mdh}^{ACTUAL} - \overline{CONC}_{mdh}^{SIM}}{SD(CONC_{mdh}^{SIM})} \tag{6}$$

where $\overline{CONC}_{mdh}^{SIM}$ and $SD(CONC_{mdh}^{SIM})$ are the mean and standard deviation of $CONC$ for the simulated observations.[24]

Table 4 shows summary statistics on $OVERLAP$ for each of the dayparts. The mean values of $OVERLAP$ are positive showing that commercials on stations in the same market overlap more than would be expected given aggregate (cross-market) timing patterns. This provides some initial evidence that stations do not prefer to choose different times for commercials. $OVERLAP$ varies within market-hours because each station's timing of commercials varies from day-to-day.

A simple example, which I use in presenting the results, illustrates the magnitude of $OVERLAP$. Suppose two Rock stations have 12 minutes of commercials from 5-6 pm. If any minute was equally likely to have a commercial break then the commercials would be expected to overlap for 144 seconds. Aggregate timing patterns for Rock stations with 12 minutes of commercials would give expected overlap of 191.2 seconds and $OVERLAP$ would be zero.[25] The drivetime mean of $OVERLAP$ (0.0633) corresponds to overlap of 201.8 seconds, a 6% increase from 191.2 seconds. This means that someone who only listened to commercials when both stations were playing them would listen to 6% more commercials than would be expected given aggregate timing patterns. If aggregate timing patterns are partly explained by stations in different markets coordinating on very similar times, which is very plausible, then this 6% increase understates the effect of coordination on overlap. On the other hand, because common factors almost certainly explain some of the aggregate pattern, the 58 second (40%) increase in overlap from 144 seconds overstates the effect of coordination.

A simple and conservative "back of the envelope" calculation shows that even small changes in overlap can have large effects on industry revenues. As noted in the introduction, annual industry revenues from selling commercials are around \$20 billion and in-car listeners, who make up 34% of all radio listening, avoid approximately 50% of the commercials they would hear if they never switched stations. Suppose that only in-car listeners avoid commercials and increased overlap would cause in-car listeners to avoid 49%, rather than 50%, of commercials. If industry revenues were to rise proportionally with the number of listeners to commercials then they would increase by approximately \$90 million per year. If greater overlap also reduced how many non-car listeners avoided commercials or reduced avoidance by in-car listeners by more than one percentage point then the effect on revenues would be even larger.

I construct the following market characteristic variables to test the predictions of the model in Section 2. The variables are calculated using all of the home contemporary music stations in the market, including those which are not in the airplay sample.[26]

$NUMBER\_STATIONS$: the number of contemporary music stations.

$OUT\_LISTENING$: the proportion of contemporary music listening which is to out of market stations.

HHI: the Herfindahl-Hirschman Index measuring the ownership concentration of contemporary music stations.[27]

$LISTENERSHIP\_ASYMMETRY$: the asymmetry in listening shares of the contemporary music stations. This is calculated as $\frac{\sum_{i=1}^{N} s_i^2}{\frac{1}{NUMBER\_STATIONS}}$ where s_i is station i's share of listening to contemporary music stations. The variable is equal to 1 if stations' shares are equal and increases as they become more asymmetric.

In the model the number of commercials was fixed. However, the quantity of commercials could affect equilibrium overlap so I also include:

$MEAN\_QUANTITY$: average number of minutes of commercials played on the sample stations with at least one minute of commercials.

$QUANTITY\_ASYMMETRY$: calculated as $\frac{\sum_{i=1}^{AIR} q_{imdh}^2}{\frac{1}{AIR}}$ where q_i is station i's share of the commercials played by sample stations and AIR is the number of airplay stations with at least one minute of commercials. The variable is equal to 1 if all stations have the same number of minutes of commercials and increases as quantities become more asymmetric.

[TABLE 4 HERE]

Table 4 shows summary statistics for these variables. An average station-hour has around 10 minutes of commercials, with more commercials during drivetime than during the rest of the day. The drivetime mean of the quantity asymmetry variable corresponds to three stations playing 6, 8 and 12 minutes of commercials.

The non-quantity market characteristics vary more across markets than within markets because the time series is relatively short and station entry and exit is relatively infrequent. The markets with the most contemporary music stations in Fall 2001 were Salt Lake City (24 stations), Wilkes-Barre/Scranton (23), Chicago (22) and Pittsburgh (22). At the other extreme, Akron, OH had only 3 contemporary music stations with 80% of contemporary music listening to out of market stations. Knoxville, TN had the most asymmetric listenership with the largest of 15 contemporary music stations having a 34% share of contemporary music listenership. Ownership concentration reflects the growth of common station ownership following the 1996 Telecommunications Act. It varies within markets during the sample period due to mergers and station sales including the AMFM-Clear Channel merger, approved by the FCC in August 2000, which affected 152 contemporary music stations in my markets.[28]

5 Empirical Results

Section 5.1 presents the results from estimating the specification outlined in Section 4. The results are consistent with stations preferring to coordinate. The model suggested that in this case, in markets with a particularly large station we should see more overlap between commercials on this station and those on smaller stations. Section 5.2 examines this hypothesis.

5.1 Market-Level Overlap

If stations prefer to coordinate then I expect more overlap in markets with fewer stations, less listening to out of market stations and more concentrated station ownership. I expect the opposite relationships if stations prefer to differentiate. In both cases there should be more overlap in markets where listenership is more asymmetric and all of these relationships should be stronger during drivetime when more listeners switch stations. I focus on the results for these characteristics before discussing how the quantity of commercials affects overlap.

Table 5 presents the results. Column (1) pools all of the observations and the coefficients are identified from both between and within-market variation in market characteristics. The signs of the coefficients on the four variables of major interest during drivetime and midday hours are all consistent with stations preferring to coordinate and during drivetime all of them except ownership concentration are statistically significant at the 5% level. The midday coefficients are similar in size to the drivetime coefficients but only the listenership asymmetry variable is significant at the 5% level. At night, ownership concentration has a different sign but is insignificant. The number of stations and listenership asymmetry coefficients are both significant at the 10% level.

[TABLE 5 HERE]

The effects implied by the drivetime coefficients can be illustrated using the example of the two Rock stations playing 12 minutes of commercials during an hour. The drivetime average of $OVERLAP$ implies that the commercials overlap for 201.8 seconds. A one standard deviation increase in the number of stations (4.1 stations) decreases the expected overlap of commercials by 14.2 seconds per hour, or 7% of the average overlap. Putting this another way, someone who only listens to commercials when both stations are playing them would be expected to listen to 7% more commercials when there are four fewer stations in the market. A one standard deviation increase in the proportion of listening to out of market stations (0.20) reduces expected overlap by 16.7 seconds per hour (8% of average overlap) and a one standard deviation increase in ownership concentration (for example, taking HHI from its average of 0.24 to 0.32) increases expected overlap by 6.9 seconds, although this effect is statistically insignificant. A one standard deviation increase in the listenership asymmetry variable (0.22) increases expected overlap by 9.4 seconds (4.6% of average overlap).

Column (2) presents the results from the between market-hour regression. The coefficients are identified only by variation in market characteristics across markets which, as shown in Table 4, is where most of the variation in market characteristics comes from. The most noticeable change is that greater ownership concentration is associated with a larger and statistically significant increase in the expected overlap of commercials during drivetime and midday hours. The drivetime coefficient implies that a one standard deviation increase in ownership concentration increases the expected overlap of the two Rock stations by 12.5 seconds per hour (6.2% of average overlap). The coefficient on the number of stations is slightly smaller than in column (1) and is just insignificant at the 10% level during drivetime. All of the night coefficients are statistically insignificant.

In column (3) market-hour fixed effects are included so that the coefficients are identified from within market variation in market characteristics. Most of the coefficients have the same signs as in column (1), consistent with coordination, but are statistically insignificant which is not surprising given that there is relatively little within-market variation in characteristics. Increases in ownership concentration are, however, associated with statistically significant increases in the overlap of commercials during drivetime. The size of the coefficient is almost identical to column (2).[29] Brown and Williams (2002) find that increases in local market ownership concentration since 1996 have been associated with small increases in the per minute price of radio commercials. One possible explanation for this is that increased overlap has resulted in more people listening to the commercials making advertising time more valuable.

Column (4) presents the results of a robustness check where variables are defined at the market-category level.[30] As discussed in Section 4, this would be the appropriate specification if most listeners only switched between stations in the same category. The results are from the pooled regression, comparable to column (1) and the pattern of coefficients in the two columns is broadly similar. This is also true for the within-market and between results (not reported). Consistent with coordination, there is significantly more overlap during drivetime in market-categories with less out-of-market listening and more asymmetric station listenership. An increase in the number of stations reduces overlap, but the effect is not significant, and ownership concentration has a very small effect on overlap.[31]

In columns (1)-(4) the coefficients on the average quantity of commercials are negative or insignificant. There are two potential problems with interpreting these coefficients as implying that stations have less incentive to coordinate when they play more commercials. The first problem is correlated error in measuring how much commercials overlap and the quantity of commercials. The length and position of the commercial break may be mismeasured if non-commercial talk programming is placed before or after a commercial break. When there is more talk programming it is plausible that I both overestimate the quantity of commercials and, if stations are trying to overlap their commercials, underestimate how much commercials overlap. The second problem is that unobservable factors, which I have not controlled for, may affect both overlap and the quantity of commercials. For example, if listeners in a market are particularly likely to avoid commercials then stations may respond by playing fewer commercials and trying to overlap their commercials more with those of other stations. Both problems could lead to negative average quantity coefficients.

Instrumenting for the quantity of commercials avoids these problems. The ideal instruments are observable variables which shift advertising demand but do not otherwise affect overlap. I use week and day of week dummies, interacted with daypart dummies, as instruments. These dummies were included in columns (1)-(4) as controls but there is no theoretical reason why overlap should vary with season or the day of the week and the other coefficients change very little if they are left out. On the other hand, retailer demand for advertising should vary over the year and over the week if retailers prefer to advertise close to a consumer's time of purchase because there is more retail activity towards the end of the week and in the fourth quarter.[32] Consistent with this, the stations in my sample have 15% more commercials in December than in January, and 10% more commercials on Thursdays than on Mondays. Unfortunately there is no obvious instrument for the variable measuring the asymmetry in the quantity of commercials across stations. The coefficients on the other variables change little if this variable is excluded.

Column (5) shows the 2SLS results for the pooled regression with variables defined at the market level. The coefficients on the non-quantity variables are clearly robust to instrumenting for average quantity. In each daypart increases in the quantity of commercials are associated with more overlap. The drivetime coefficient, which is significant at the 1% level, implies that a one standard deviation increase in the average quantity of commercials by stations in a market (3.6 minutes) increases the expected overlap of commercials on two Rock stations which keep playing 12 minutes of commercials by 16.1 seconds (8% of average overlap). One interpretation of the positive coefficient is that stations have more incentive to coordinate when they play more commercials because the increased quantity makes listeners more likely to switch stations.

5.2 Overlap in Markets with Asymmetric Listenership

The results in Table 5 indicate that commercials overlap more in markets with more asymmetric listenership. This is consistent with stations preferring to coordinate on timing but it is also consistent with differentiation if in these markets small stations choose the same times as each other but different times to most popular station in the market. I examine the overlap between pairs of stations to make sure that this is not the case.

The specification is

$$OVERLAP_{ijdh} = X_{ijdh}\beta_1 + D_d\beta_2 + W_d\beta_3 + H_h\beta_4 + \varepsilon_{ijdh} \qquad (7)$$

where i and j are a pair of stations which are home to the same market. Pairs in different markets are not included. D, H and W are day of week, hour and week dummies. $OVERLAP$ is calculated as before except that, because there are only two stations in a pair, I use a simple count of the number of minutes in which both stations are playing commercials in place of the $CONC$ measure. The pair characteristic (X) variables are a dummy for whether the stations are home to a market in the top quartile of asymmetric markets (based on the market's average value of $LISTENERSHIP\_ASYMMETRY$), a dummy for whether one of the pair is the largest contemporary music station in the market (based on its listenership share), the interaction of these dummies and a dummy for whether the stations are commonly owned. If smaller stations choose different times to the largest station in asymmetric markets then the coefficient on the interaction should be negative. The same owner dummy is included as an additional test for whether common ownership leads to more overlap.

Column (1) of Table 6 presents the results using all station pairs. Consistent with Table 5 commercials on pairs in asymmetric markets overlap more. Pairs including the largest station in asymmetric markets have commercials which overlap more than other pairs in these markets during drivetime and midday hours. This is inconsistent with differentiation and consistent with coordination, although only the midday coefficient is statistically significant. The drivetime coefficient implies that commercials on two Rock stations with 12 minutes of commercials from 5-6 pm in an asymmetric market are expected to overlap for 6.5 seconds more if one of them is the largest station in the market. Column (2) drops pairs where one of the stations is the second or third largest contemporary music station in the market in order to focus on the overlap between the largest station and significantly smaller stations. The drivetime and midday coefficients on the interaction are larger than in column (1) and they are both significant at the 5% level.

[TABLE 6 HERE]

In both columns the same owner coefficients are small and insignificant, although they are positive during drivetime. This is consistent with the weak results for ownership concentration in the pooled regressions in Table 5 and it is disappointing because, if stations prefer to coordinate, commonly owned stations should have a stronger incentive to do so than other stations. One possible explanation is that commonly owned stations differentiate their programming to avoid competing for the same listeners (Berry and Waldfogel (2001), Sweeting (2005)) and this reduces how important it is for them to overlap their commercials. In addition, if it is difficult for stations to overlap commercials because of scheduling issues which arise in real time (for example, the length of a competition cannot be accurately predicted in advance) then commonly owned stations may find it as hard as separately owned stations to consistently overlap their commercials.

6 Conclusion

The timing of commercials is a potentially important strategic choice for stations because many listeners try to avoid commercials by switching stations. The empirical evidence supports the hypothesis that commercial radio stations prefer, all else equal, to choose the same times for commercial breaks. Commercials on stations in a market overlap more than would be expected given aggregate, cross-market timing patterns. Commercials also overlap more in markets with fewer stations, less listening to out of market stations, more concentrated ownership and where one station has a particularly high share of listenership. These relationships are most significant during drivetime hours, when more listeners tend to switch stations, and least significant at night. This pattern matches the predictions of a model where stations prefer to choose the same times for commercials.

Two issues deserve further comment. The first issue is whether the results have any implications for welfare. Stations prefer to play commercials at the same time because, by doing so, fewer listeners avoid commercials and the value of advertising time is increased. If the average effect of coordination on timing is (probably conservatively) estimated by the difference between how much commercials overlap in a market and how much they would be expected to overlap given cross-market timing patterns then the effect seems to be fairly small, increasing overlap between a pair of stations by approximately 6%. However, the radio advertising market is so large that even small proportional increases in how many people hear commercials could have large dollar effects on advertising revenues. For example, as discussed in Section 4, if coordination increases the number of commercials heard by in-car listeners by just one percentage point then annual industry advertising revenues should increase by roughly $90 million. If stations cannot fully extract increases in the value of commercial time then coordination on timing will also increase the welfare of advertisers.

As an individual station ignores how the timing of its commercials affects the audience of other stations, there is likely to be too little overlap from the industry's perspective. If common ownership of stations in the same market increases overlap, as at least some of the results suggest, then this is likely to increase industry revenues. Of course, because listeners are not paid to listen to commercials they dislike there may be too much overlap from their perspective. On the other hand, any welfare loss to listeners from hearing more commercials may be offset if the resulting increases in industry revenues allow more and better quality stations to be supported. An individual listener is likely to ignore this effect when deciding to switch stations.

The second issue is why commercials do not overlap more given how many listeners seek to avoid commercials. The lack of overlap may seem particularly surprising given that the same stations interact repeatedly. While this paper does not provide a full explanation for this puzzle, at least four factors are likely to be important. First, it is hard for stations to play commercials at precise times because they have to be fitted in around other programming, such as songs and competitions, which cannot be interrupted regularly without alienating listeners. Gross (1988) explains that while television stations can prevent avoidance by all playing commercials at exactly the same time executing this strategy "may be a nightmare". Execution may be even harder for radio stations as they use less pre-recorded programming, in which commercials can be placed quite precisely, than most television stations.

Second, while the results suggest that most listeners switch in ways which make stations prefer to choose the same times for commercial breaks, others may switch in ways which would justify choosing different times. In this case, even if many listeners switch, stations' incentives to play commercials at the same time may be relatively weak. Investigation of how different listeners switch requires more detailed individual-level data then is currently available. If advertisers had better data on how many people listen to commercials then they might also provide stations with sharper incentives to coordinate. This may happen in the future as better audience measurement technology is introduced.[33]

Third, while well-established stations may prefer to coordinate, some stations may deliberately adopt "counter-programming" strategies. Lynch and Gillespie (1998) describe how a new entrant in Dayton, OH did this to get first-time listeners to sample its music even though this may have reduced the current audience of its commercials which were played when other stations had music.[34] Counter-programming by new entrants may reduce the incentive of well-established stations to coordinate with each other. Unfortunately my timing data contains too few new entrants to examine whether counter-programming is a widespread phenomenon.

Finally, while this paper provides the most extensive analysis of the timing of commercials to date, it is restricted to analyzing timing in markets where listeners can switch between a reasonably large number of stations. The empirical results suggest that commercials overlap more in markets where there are fewer stations and it would be particularly interesting to study timing decisions in isolated markets where only one or two stations are available.

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Notes

[1]Radio Advertising Bureau (2002, p. 4).

[2]Arbitron and Edison Media Research (2003, p. 11) estimate that 34% of radio listening takes place in-car.

[3]Brydon (1994), an advertising consultant, explains that "for advertisers, the key point is this: if, at the touch of a button, you can continue to listen to that [music] for which you tuned in, why should you listen to something which is imposing itself upon you, namely a commercial break." He suggests that radio stations should either play very short breaks which would make switching not worthwhile or they should "transmit breaks at universally agreed uniform times. Why tune to other stations if it's certain that they will be broadcasting commercials as well?". Gross (1988), writing about advertising on television, argues that standardizing "commercial pod timing can cut off all flipper escape routes. Imagine the poor flipper; wherever he turns, horrors...a commercial! Once the flipper learns that there is no escape, he will capitulate and watch the advertising". Gross describes the creation of "roadblocks" by stations having commercials at the same time as a "time-honored media tactic". Television revenues from Radio Advertising Bureau (2002, p. 8).

[4]Arbitron's method is based on five minutes of listening within a quarter-hour so that listeners who can be kept over the quarter-hours points (:00, :15, :30 and :45) are likely to count for two quarter-hours (Warren (2001), p. 23-24). Keith (2000, p. 96) discusses the connection between the timing of commercials and when listeners tune-in.

[5]MacFarland (1997, p. 89), reports that, based on a 1994 survey, 70% of in-car listeners switch at least once during a commercial break compared with 41% of at home and 29% of at work listeners. Arbitron estimates that 39.2% of listening is in-car during drivetime compared with 27.4% 10 am-3 pm and 25.0% 7 pm-midnight (Fall 2001 data from the Listening Trends section of Arbitron's website, www.arbitron.com).

[6]While time is continuous the scheduling of commercials on music stations has a strong element of discreteness because it involves planning the order of songs and commercial breaks, so that, for example, a programmer must decide whether to play one or two songs between a commercial break and the end of the hour (see sample schedules in Warren (2001, p. 27) and Lynch and Gillespie (1998, p. 111)).

[7]It is an assumption that stations seek to maximize the audience of their commercials rather than, for example, total audience. Advertisers would like stations to try to maximize the audience of the commercials, although advertisers and stations are only able to measure the audience of commercials imperfectly. Dick and McDowell (2003) discuss how advertisers can estimate commercial avoidance on different stations from standard ratings numbers. Models of television station timing choices, such as Epstein (1998), Zhou (2000) and Kadlec (2001), make similar assumptions even though the audience of TV commercials is also measured imperfectly (Mandese (2004)).

[8]Warren (2001, p. 24) describes how playing music on the quarter-hours "can be done some of the time. But it can't be done consistently by very many stations. Few songs are 2:30 minutes long any more".

[9]I assume static and non-cooperative behavior but as stations make repeated timing decisions a much richer set of outcomes could be sustained if dynamic strategies were allowed.

[10]I note that it is possible to construct examples where β and θ are so high that overlap is almost perfect over a range of N and overlap is more sensitive to N for lower θ. In practice we do not observe almost perfect overlap so it is sensible to focus on the comparative statics for moderate degrees of overlap. A similar comment applies to the other comparative static predictions.

[11]On average, 79% (70%) of the audience of a station rated in at least two (five) local markets comes from its home market (author's calculation using Arbitron Average Quarter Hour Persons listenership data for Fall 2001).

[12]If there are less than 10 observations where the song is played without being followed by a com-

mercial break I assume that the song is 4 minutes long which is the median length of all songs.

[13]For example, if the gap is 8 minutes long then I assume that the commercial break aired between the 2^{nd} and 7^{th} minutes (inclusive). If the gap is, for example, 9 minutes in length I assume that the break aired from the 3^{rd} to the 8^{th} minute (slightly later than the middle).

[14]The qualitative results are unaffected if all station-hours are used. They are also unaffected by changing the assumptions on the maximum length of a commercial break. These results are contained in Sweeting (2004a).

[15]3.2% of station-hours have at least 8 songs and no commercial breaks between 6 am and 6 pm compared with 11.7% between 7 pm and 5 am.

[16]A station's share is its average share of radio listening by people aged 12 and above during a broadcast week of Monday to Sunday 6 am - 12 pm. Arbitron estimates ratings in most markets every quarter but in some smaller markets it only estimates ratings in the Spring and Fall quarters in which case I use the following quarter's estimates for the missing quarters. If a group owns several radio companies I define ownership at the group level. The ownership data lists the announcement date rather than the completion date for all but the most recent transaction for each station. The ownership data comes from early 2002 and few stations had changed ownership more than once in the previous two years. For these stations I use the announcement date for earlier transactions although the results are not sensitive to assuming that transactions were completed several months after the announcement date.

[17]If BIAfn classifies a station in the airplay sample outside of these categories then it is dropped from the sample for these ratings quarters. This only affects two stations. I also drop station-quarters if the station is estimated to have a zero share of market listenership. This also only affects two stations. The music categories with no stations in the sample are Classical, Easy Listening, Jazz and Nostalgia/Big Band which appeal mainly to older listeners than contemporary music stations.

[18]Allentown-Bethlehem is Arbitron's 69^{th} largest market. The two larger markets without 2 sample

stations are Puerto-Rico, which is not monitored by Mediabase, and Middlesex-Somerset-Union, which has only one sample station reflecting the fact that over 80% of listening is to stations from the New York market.

[19]The drivetime and midday dayparts are used by Arbitron in estimating station ratings while night aggregates the evening and nighttime hours.

[20]The standard errors are clustered on the market following the approach of Rogers (1993). Petersen (2005) shows that the clustering approach provides accurate standard errors in panel data settings with a number of different forms of dependence.

[21]A specific example illustrates the issues. In Providence, RI in Fall 2002 25% of radio listening was to Boston stations, partly reflecting the fact that many Providence residents work in Boston. However, only 8% of the listeners to Boston stations live in Providence and 82% of the listeners to Providence stations live in Providence. The FCC's contour maps of radio signals also show that many people in Providence cannot receive most Boston stations.

[22]This can be true even in the largest markets. For example, of Arbitron's ten largest markets by population, 6 have only one home market Album Oriented Rock/Classic Rock station with enough listeners to be rated by Arbitron, 6 have only one Oldies station, 5 have only one Country station, 2 have only one Contemporary Hit Radio and 2 have only one Rock station.

[23]Statistics calculated using the "cume duplication percent" estimates in Arbitron (2003).

[24]If $CONC^{SIM}$ is the same for every simulation then $OVERLAP$ cannot be calculated, so the observation is dropped. This affects 2% of market-day-hour observations, all with only two observed stations playing a small number of commercials. The coefficients are almost identical using 100 simulations per observation so that fewer observations are dropped.

[25]Based on 10,000 simulations where pairs of Rock stations with 12 minutes of commercials were drawn with replacement. The values of $CONC$ for 2, 3 and 4 minutes of overlap were 0.0486, 0.0521 and 0.0556 respectively and the standard deviation of $CONC$ was 0.0097.

[26]If only a very small number of listeners report listening to a station then Arbitron does not give it a market share in its ratings report. These marginal stations, together with non-commercial stations, are not included when defining the variables.

[27]I calculate an owner's share as its share of stations, but results are very similar if stations are weighted by their share of listenership.

[28]Federal Communications Commission (2000).

[29]The HHI coefficient is positive for drivetime hours in all three regressions but it is smaller, and statistically insignificant, in the pooled regression. The interpretation of this pattern is that markets with more concentrated ownership have greater overlap of commercials and that overlap increases in markets where ownership becomes more concentrated but, for a given increase in HHI, these increases in overlap are larger in markets where HHI is relatively low. As the coefficients are not significantly different across the regressions it is inappropriate to over-interpret this finding.

[30]This regression uses 300 market-categories with at least two sample stations. There are at least 36 market-categories included from each of the seven music categories except Oldies (3). 217 of the market-categories are from the largest 67 markets in the sample (the "large" markets in Table 3).

[31]The number of stations coefficient is larger (-0.0474) and statistically significant at the 5% level if observations from the largest 10 markets are excluded from the regression. The market level results also become larger in this case. This suggests that the largest markets may be so large, providing so many options for listeners to switch to, that coordination cannot be effective.

[32]The US Census Bureau's Monthly Retail Trade Survey shows how retail activity varies by month (http://www.census.gov/mrts/www/mrts.html). Williams (2003) describes advertisers' "obsession" with Thursday and Friday advertising to "reach the customer just before she goes shopping". Kobliski (2001) describes how demand for radio advertising is low in the first and third quarters.

[33]Arbitron is currently testing portable people meters which should increase the accuracy with which radio ratings are measured (http://www.arbitron.com/portable_people_meters/home.htm).

[34]Lynch and Gillespie (1998, p. 214) discuss the entry of WAZU-FM which was focused on taking listeners from Active Rock station WTUE-FM. WAZU would try to choose different times for its commercials and would actually encourage its listeners to switch to WTUE when WTUE was playing commercials to give the impression that WTUE was always playing commercials. Both stations are in my data, some years after WAZU's entry, and it is interesting to note that by 2000 both stations were unusual in having breaks in the first quarter of drivetime hours. This suggests that once it was established WAZU's incentive may have become to choose similar times to WTUE.

APPENDIX

In Section 2 I examine how equilibrium overlap changes with model parameters and observable market characteristics under two different formulations of listener behavior. There can be multiple Nash equilibria and I focus on the pure strategy Nash equilibrium (PSNE) which maximizes joint station payoffs. In this Appendix I show that a simple procedure always identifies a PSNE and that one of the PSNE it identifies will be the PSNE which maximizes joint stations payoffs.

Proposition 1 *With either formulation of listener behavior a pure strategy Nash equilibrium always exists.*

Proof. I show that a simple procedure always identifies a pure strategy Nash equilibrium (PSNE). For each station calculate $\widetilde{\varepsilon} = \varepsilon^{EVEN} - \varepsilon^{ODD}$ and order stations 1,2,...,N where $\widetilde{\varepsilon_1} \geq \widetilde{\varepsilon_2} \geq ... \geq \widetilde{\varepsilon_N}$. For each station i (in $\widetilde{\varepsilon}$ order) assume that stations 1,..,$i-1$ choose even and that stations $i+1,..,N$ choose odd and test whether it is a best response for i to choose even (i.e., its payoff is no lower than its payoff from choosing odd) given the assumed strategies of other stations. If this procedure shows that it is a best response for some station i^* to choose even and it is not a best response for i^*+1 to choose even then there is a PSNE where stations 1,..,i^* choose even and stations $i^*+1,..,N$ choose odd.[35] Straightforward logic shows that if there is no such i^* then it must be the case that *either* it is not a best response for station 1 to choose even (when all other stations choose odd), in which case there is a PSNE where all stations choose odd, *or* it is a best response for station N to choose even (when all other stations choose even), in which case there is a PSNE where all stations choose even. Therefore, a PSNE must exist. ■

I use the procedure described in the proof to identify PSNEs. There may be PSNEs which it does not identify. However, the following propositions show that it will identify the PSNE which maximizes joint station payoffs.

Proposition 2 *In formulation 1, where stations prefer to coordinate, the PSNE which maximizes joint payoffs has the form that stations with $\widetilde{\varepsilon}$ above some value choose even and all stations with $\widetilde{\varepsilon}$ below this value choose odd.*

Proof. Suppose not so that joint payoffs are maximized in a PSNE where station j chooses even and station k chooses odd where $\widetilde{\varepsilon_k} > \widetilde{\varepsilon_j}$. Suppose that x stations other than station j also choose even. I show that this cannot be a PSNE. If it was then

$$\beta + A(\theta, N, x) + \widetilde{\varepsilon_j} \geq A(\theta, N, N - x - 1) \tag{8}$$

and

$$\beta + A(\theta, N, x + 1) + \widetilde{\varepsilon_k} \leq A(\theta, N, N - x - 2) \tag{9}$$

These inequalities cannot both be satisfied as $\widetilde{\varepsilon_k} > \widetilde{\varepsilon_j}$ and $A(\theta, N, n)$ is increasing in n for this formulation (see equation (3)). ■

Proposition 3 *In formulation 2, where stations prefer to differentiate, the PSNE which maximizes joint payoffs has the form that all stations with $\widetilde{\varepsilon}$ above some value choose even and all stations with $\widetilde{\varepsilon}$ below this value choose odd.*

Proof. Suppose not so that joint payoffs are maximized in a PSNE where station j chooses even and station k chooses odd where $\widetilde{\varepsilon_k} > \widetilde{\varepsilon_j}$. Suppose that x stations other than station j also choose even. This implies that

$$\beta + A(\theta, N, x) + \widetilde{\varepsilon_j} \geq A(\theta, N, N - x - 1) \tag{10}$$

$$\beta + A(\theta, N, x + 1) + \widetilde{\varepsilon_k} \leq A(\theta, N, N - x - 2) \tag{11}$$

I show that there must be another PSNE with higher joint payoffs. In particular suppose that station

k chooses even and station j chooses odd and all other stations choose the same actions as before. This must be a PSNE because (11) and $\widetilde{\varepsilon_k} > \widetilde{\varepsilon_j}$ imply that

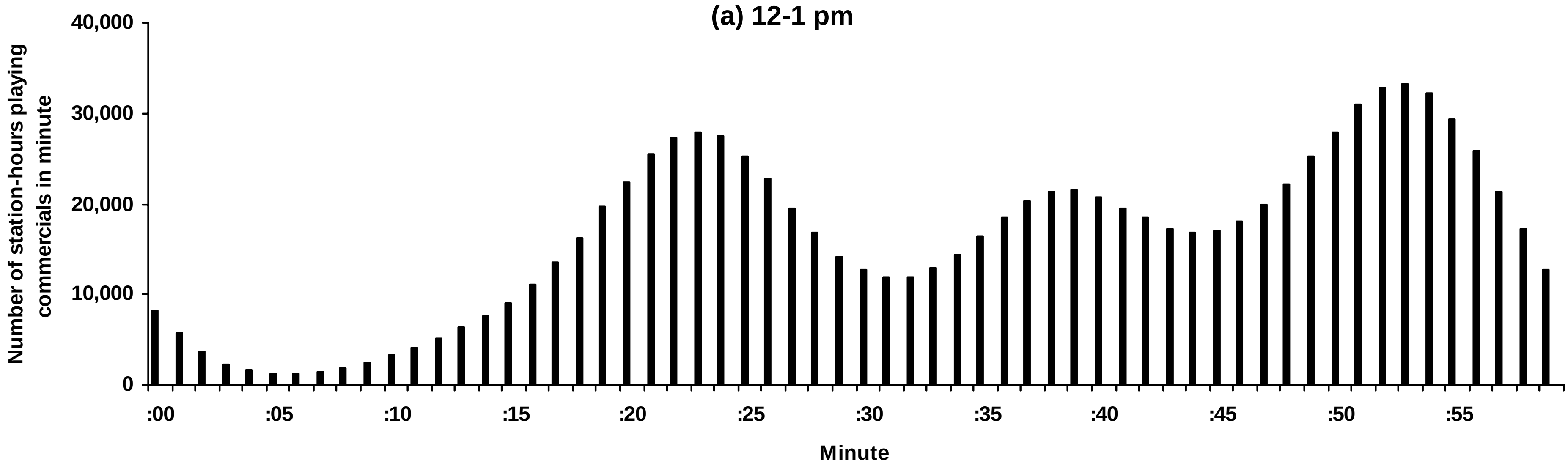
$$\beta + A(\theta, N, x+1) + \widetilde{\varepsilon_j} < A(\theta, N, N-x-2) \tag{12}$$

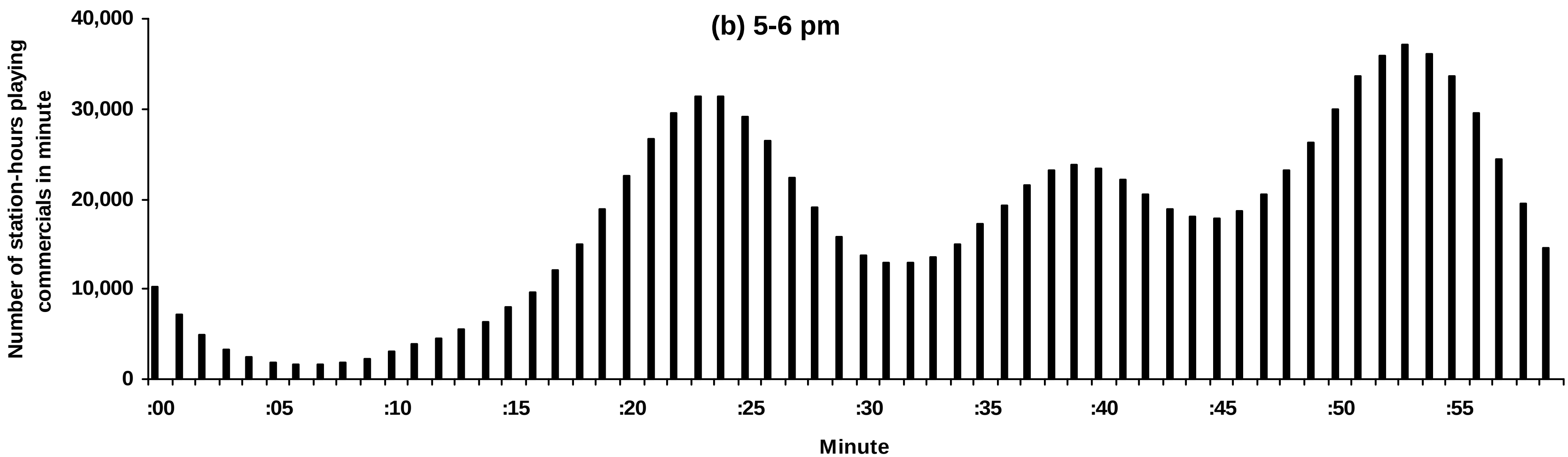
and (10) and $\widetilde{\varepsilon_k} > \widetilde{\varepsilon_j}$ imply that

$$\beta + A(\theta, N, x) + \widetilde{\varepsilon_k} > A(\theta, N, N-x-1) \tag{13}$$

and the payoffs of all other stations from both choices are unchanged. Joint station payoffs are $\widetilde{\varepsilon_k} - \widetilde{\varepsilon_j}$ higher in this equilibrium. ■

FIGURE 1: HISTOGRAMS OF THE NUMBER OF STATIONS PLAYING COMMERCIALS EACH MINUTE 12-1PM AND 5-6 PM





Note: based on airplay data (described in Section 3) from 1,094 contemporary music stations in 147 local radio markets. 12-1 pm and 5-6 pm histograms based on 98,270 and 97,809 station-hours respectively.

FIGURE 2: THE TIMING OF COMMERCIALS ON WROR-FM OCTOBER 29-NOVEMBER 2, 2001 5-6 PM

Note: based on airplay data described in Section 3. Shaded areas are commercial breaks.

FIGURE 3: COMPARATIVE STATICS OF EQUILIBRIUM OVERLAP

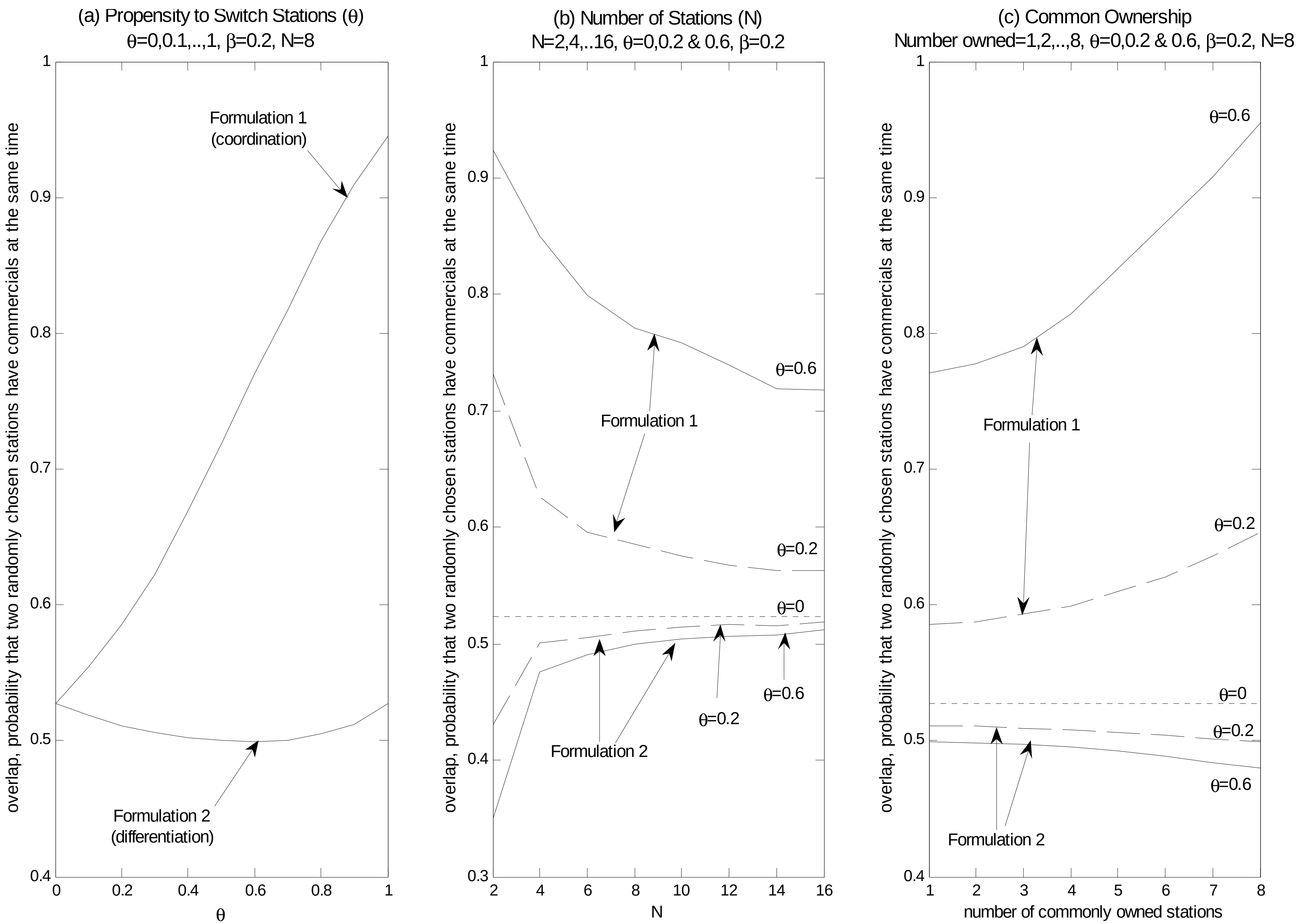


FIGURE 4: COMPARATIVE STATICS OF EQUILIBRIUM OVERLAP (cont.)

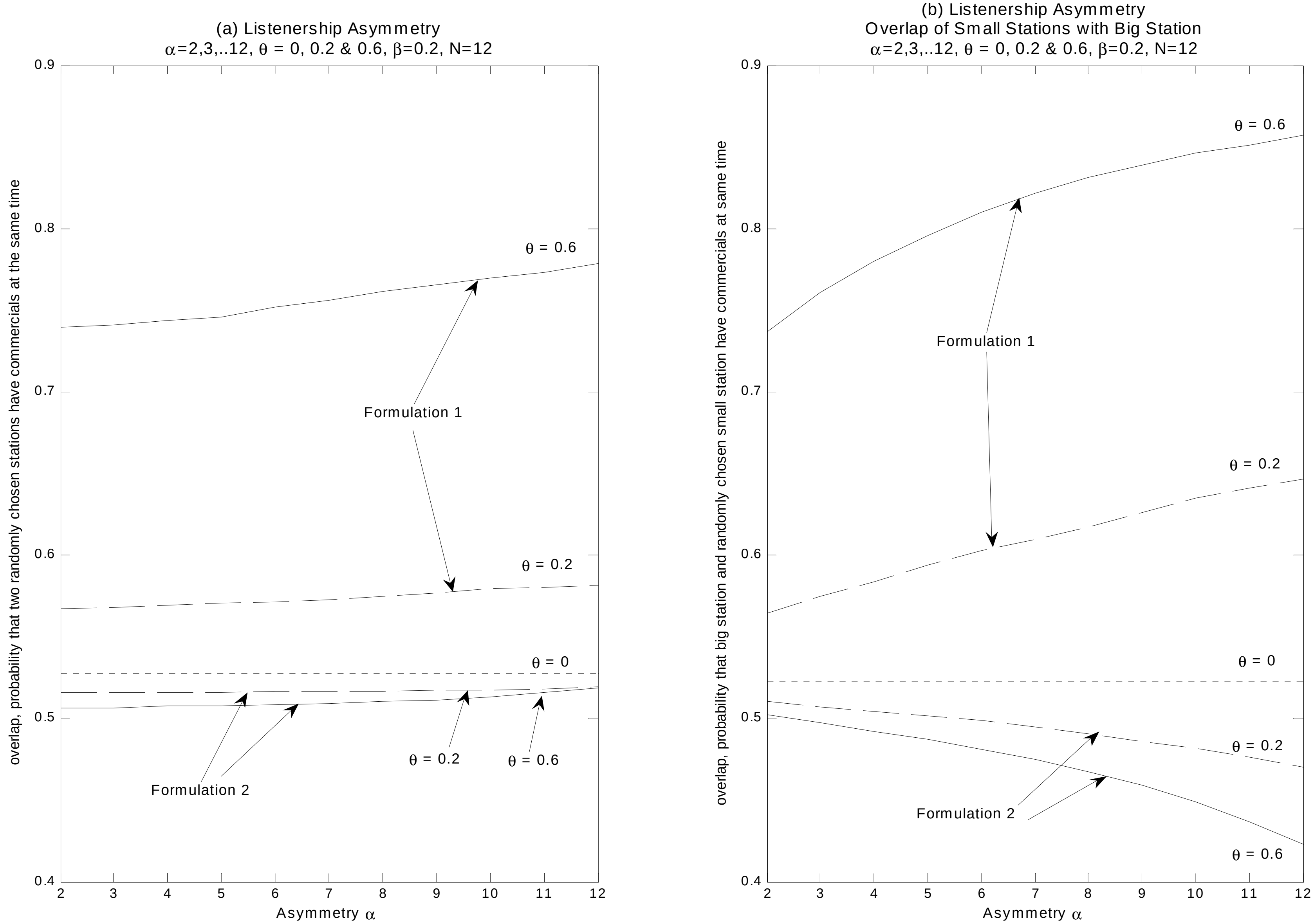


TABLE 1: PREDICTED EFFECTS OF INCREASES IN OBSERVABLE MARKET CHARACTERISTICS ON EQUILIBRIUM OVERLAP

		Effect on Equilibrium Overlap if	
Increase in	θ=0	Stations Prefer to Coordinate & θ>0	Stations Prefer to Differentiate & θ>0
Number of stations	no effect	↓	↑
Proportion of listenership to out of market stations	no effect	↓	↑
Ownership concentration	no effect	↑	↓
Listenership asymmetry all station overlap	no effect	↑	↑
Listenership asymmetry big-small station overlap	no effect	↑	↓

Note: All of the comparative statics are expected to be stronger during drivetime than outside drivetime if θ>0.

TABLE 2: EXTRACT FROM A DAILY AIRPLAY LOG OF A CLASSIC HITS (ROCK) STATION

Time	Artist	Title	Release Year
5:00PM	CLAPTON, ERIC	Cocaine	1980
5:04PM	BEATLES	While My Guitar Gently Weeps	1968
5:08PM	GRAND FUNK	Some Kind of Wonderful	1974
5:12PM	TAYLOR, JAMES	Carolina in My Mind	1976
5:16PM	RARE EARTH	Get Ready	1970
5:18PM	EAGLES	Best of My Love	1974
Stop Set	*BREAK*	*Commercials and/or Recorded Promotions*	-
5:30PM	BACHMAN-TURNER	Let It Ride	1974
5:34PM	FLEETWOOD MAC	You Make Loving Fun	1977
5:38PM	KINKS	You Really Got Me	1965
5:40PM	EDWARDS, JONATHAN	Sunshine	1971
5:42PM	ROLLING STONES	Start Me Up	1981
5:46PM	ORLEANS	Dance with Me	1975
Stop Set	*BREAK*	*Commercials and/or Recorded Promotions*	-
5:56PM	JOEL, BILLY	Movin' Out (Anthony's Song)	1977

TABLE 3: COVERAGE OF AIRPLAY SAMPLE IN FALL 2001
(based on markets with 2 stations in the airplay sample)

	Large Markets	Small Markets
Number of markets	67	66
Average number of home market contemporary music stations	14.7	10.8
Average number of sample stations	10.6	5.6
Average proportion of home contemporary music listenership accounted for by sample stations	0.87	0.71

Notes:
Sample markets divided into two groups by Arbitron market ranks which are based on population aged 12 and above. The table is based on commercial contemporary music stations which are home to the market and which have enough listeners to be rated by Arbitron in Fall 2001. Contemporary music stations are stations listed by BIAfn in categories Adult Contemporary, Album Oriented/ Classic Rock, Contemporary Hit Radio/Top 40, Country, Oldies, Rock and Urban.

TABLE 4: SUMMARY STATISTICS

Variable	Daypart	Number of Observations	Mean	Standard Deviation Total	Standard Deviation Between Market-Hours	Standard Deviation Within Market-Hours	Minimum	Maximum
OVERLAP	Drivetime	104,354	0.0633	1.0682	0.4484	0.9725	-3.0062	14.0007
	Midday	70,384	0.1030	1.0868	0.4756	0.9815	-3.1332	8.6490
	Night	148,460	0.0808	1.1042	0.4003	1.0308	-3.2013	14.0007
MEAN_QUANTITY	Drivetime	104,354	13.0909	3.5631	2.9010	2.2336	1.5000	29.5000
	Midday	70,384	10.4189	1.8941	1.1705	1.5747	1.0000	21.0000
	Night	148,460	8.1557	2.9989	2.5853	1.6811	1.0000	24.5000
QUANTITY_ASYMMETRY	Drivetime	104,354	1.0846	0.0888	0.0440	0.0797	1.0000	2.2099
	Midday	70,384	1.0829	0.0787	0.0376	0.0713	1.0000	2.1901
	Night	148,460	1.2002	0.1707	0.1001	0.1415	1.0000	2.9548
NUMBER_STATIONS	All	323,198	13.3770	4.1255	4.3326	0.7736	3.0000	24.0000
OUT_LISTENING	All	323,198	0.1239	0.2012	0.2267	0.0127	0.0000	0.8458
HHI	All	323,198	0.2417	0.0805	0.0868	0.0226	0.1050	0.6250
LISTENERSHIP_ASYMMETRY	All	323,198	1.3750	0.2278	0.2092	0.0846	1.0000	2.7403

TABLE 5: OVERLAP OF COMMERCIALS AND OBSERVABLE MARKET CHARACTERISTICS

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)	(4) Pooled Market-Category Hours	(5) Pooled Market-Hours Instrument for *MEAN_QUANTITY*
DRIVETIME*					
NUMBER_STATIONS	-0.0203**	-0.0171	-0.0070	-0.0319	-0.0203**
	(0.0098)	(0.0108)	(0.0172)	(0.0212)	(0.0098)
OUT_LISTENING	-0.4912***	-0.4848***	-0.2824	-0.5479**	-0.5095***
	(0.1811)	(0.1765)	(0.6964)	(0.2655)	(0.1816)
HHI	0.5057	0.9162**	0.9346**	0.0166	0.5672
	(0.3706)	(0.3572)	(0.3970)	(0.1458)	(0.3736)
LISTENERSHIP_ASYMMETRY	0.2433**	0.2368**	0.1281	0.1937**	0.2519**
	(0.1006)	(0.1146)	(0.1717)	(0.0942)	(0.1030)
MEAN_QUANTITY	-0.0048	-0.0143	0.0016	0.0030	0.0266***
	(0.0057)	(0.0169)	(0.0028)	(0.0045)	(0.0079)
QUANTITY_ASYMMETRY	0.0501	0.3746	0.0207	0.0304	0.4045***
	(0.1038)	(0.5027)	(0.0599)	(0.0893)	(0.1400)
MIDDAY*					
NUMBER_STATIONS	-0.0161	-0.0105	-0.0188	-0.0300	-0.0158
	(0.0132)	(0.0143)	(0.0253)	(0.0239)	(0.0134)
OUT_LISTENING	-0.4574*	-0.4333*	0.5881	-0.3655	-0.5012**
	(0.2357)	(0.2320)	(0.8380)	(0.2923)	(0.2391)
HHI	0.7332	1.1409**	1.0325	0.0573	0.8404
	(0.5138)	(0.5536)	(0.7170)	(0.1629)	(0.5258)
LISTENERSHIP_ASYMMETRY	0.3859**	0.3502**	0.2501	0.2203*	0.4098**
	(0.1549)	(0.1625)	(0.2147)	(0.1131)	(0.1616)
MEAN_QUANTITY	-0.0258**	-0.0393	-0.0004	0.0027	0.0249*
	(0.0130)	(0.0388)	(0.0064)	(0.0060)	(0.0146)
QUANTITY_ASYMMETRY	-0.0160	0.7659	-0.2037**	-0.0537	0.4669
	(0.2008)	(1.1320)	(0.0935)	(0.1037)	(0.2889)
NIGHT*					
NUMBER_STATIONS	-0.0209*	-0.0175	-0.0121	-0.0303	-0.0221*
	(0.0115)	(0.0119)	(0.0164)	(0.0188)	(0.0117)
OUT_LISTENING	-0.1014	-0.1056	-0.0602	-0.3503	-0.1127
	(0.1971)	(0.1912)	(0.5450)	(0.2601)	(0.2005)
HHI	-0.3955	-0.2796	-0.1176	-0.0051	-0.3333
	(0.2963)	(0.3142)	(0.5133)	(0.0975)	(0.3094)
LISTENERSHIP_ASYMMETRY	0.1859*	0.1698	0.1019	0.0785	0.2296**
	(0.0974)	(0.1074)	(0.1309)	(0.0809)	(0.1017)
MEAN_QUANTITY	-0.0192***	-0.0359***	0.0009	-0.0118***	0.0218**
	(0.0068)	(0.0115)	(0.0040)	(0.0038)	(0.0106)
QUANTITY_ASYMMETRY	-0.0052	-0.1668	0.0096	-0.0088	0.0709
	(0.0561)	(0.2330)	(0.0357)	(0.0389)	(0.0659)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Market-Hour Day of Week	Hour Week Day of Week Music Category	Hour
Adjusted R^2 (incl. dummies)	0.0090	0.1172	0.1477	0.0046	-
Number of observations	323,198	323,198	323,198	450,198	323,198

Notes:
Standard errors in parentheses, corrected for heteroskedasticty and correlation across observations from the same market.
Drivetime hours are 6:00 - 9:59 am and 3:00 - 6:59 pm, midday hours are 10:00 am - 2:59 pm and night hours are 7:00 pm - 2:59 am. R^2 for between regression is for between market-hour variation (3,190 market-hours). ***,** and * denote significance at 1%, 5% and 10% levels respectively. Instruments in column (5) are day of week and week dummies interacted with the daypart.

TABLE 6: OVERLAP BETWEEN STATION PAIRS IN THE SAME LOCAL MARKET

	(1) All Pairs	(2) Drop pairs including 2nd or 3rd largest station
DRIVETIME*		
Market has asymmetric listenership	0.0484*** (0.0146)	0.0402** (0.0180)
One of the stations is largest station in market	0.0072 (0.0120)	-0.0049 (0.0141)
Asymmetric market and largest station interaction	0.0380 (0.0300)	0.0702** (0.0354)
Stations have the same owner	0.0071 (0.0141)	0.0053 (0.0164)
MIDDAY*		
Market has asymmetric listenership	0.0571*** (0.0172)	0.0440** (0.0220)
One of the stations is largest station in market	0.0059 (0.0136)	-0.0071 (0.0159)
Asymmetric market and largest station interaction	0.0605* (0.0343)	0.0994** (0.0391)
Stations have the same owner	0.0101 (0.0159)	-0.0079 (0.0184)
NIGHT*		
Market has asymmetric listenership	0.0417*** (0.0128)	0.0235 (0.0176)
One of the stations is largest station in market	0.0077 (0.0093)	-0.0016 (0.0106)
Asymmetric market and largest station interaction	-0.0007 (0.0226)	0.0240 (0.0281)
Stations have the same owner	-0.0027 (0.0112)	-0.0090 (0.0133)
Dummies	Hour Week Day of Week	Hour Week Day of Week
Adjusted R^2 (including dummies)	0.0007	0.0006
Observations	6,345,692	3,953,314

Notes (in addition to notes at bottom of Table 5):
Standard errors in parentheses, corrected for heteroskedasticty and correlation across observations for the same pair of stations.