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**Working Paper**

## Coordination, differentiation and the timing of radio commercials

CSIO Working Paper, No. 0050

**Provided in Cooperation with:**

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*Suggested Citation:* Sweeting, Andrew (2004) : Coordination, differentiation and the timing of radio commercials, CSIO Working Paper, No. 0050, Northwestern University, Center for the Study of Industrial Organization (CSIO), Evanston, IL

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THE CENTER FOR THE STUDY  
OF INDUSTRIAL ORGANIZATION  
AT NORTHWESTERN UNIVERSITY

Working Paper #0050

Coordination, Differentiation and the Timing of  
Radio Commercials

By

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December 14, 2004

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## **Abstract**

This paper examines whether commercial radio stations try to play their commercials at the same time. A simple model shows that stations may want to choose the same times (coordination) or different times (differentiation) depending on how listeners behave. It also shows that how much commercials overlap in equilibrium should vary with observable market characteristics, such as the number of stations, and that how these characteristics affect equilibrium overlap should depend on whether stations want to coordinate or differentiate. Panel data on the timing of commercials by 1,094 contemporary music radio stations in 147 metro-markets provides consistent support for the version of the model where stations want to coordinate on timing with commercials overlapping more in markets with fewer stations, less listening to out-of-market stations, more concentrated ownership and more asymmetric distributions of listenership across stations.

# 1 Introduction

This paper examines whether commercial radio stations try to play their commercials at the same time. This question and my approach to answering it are interesting to a wide range of economists for three reasons. The first reason is that the timing of commercials plays a significant role in the economics of the large advertiser-funded radio and television industries which had revenues of \$19.8 and \$44.8 billion respectively in 2000.<sup>1</sup> The value of advertising time is determined by how many people listen to commercials but many listeners try to avoid commercials by switching stations. For example, the average in-car listener switches stations 29 times per hour primarily to avoid commercials and listens to less than half of the number of commercials she would hear if she never switched stations (Abernethy (1991), McDowell and Dick (2003)). The behavior of in-car listeners alone potentially costs the radio industry several billion dollars in revenue.<sup>2</sup> Advertisers have suggested that stations should agree to play commercials at the same time to reduce avoidance.<sup>3</sup> While Epstein (1998) and Zhou (2000) provide theoretical models where television stations placing commercial breaks within well-defined programs choose to have them at the same times, I show that listeners might, in theory, behave in ways which would make stations want to play them at different times.<sup>4</sup> My empirical results, which support the hypothesis that stations do try to choose the same times for commercials, therefore shed light on an important aspect of stations' strategic behavior.

The second reason is that while firm choices of location in product space play a very important role in theoretical models of competition there have been relatively few empirical studies of whether firms try to choose similar or different attributes to their competitors. Three recent exceptions are

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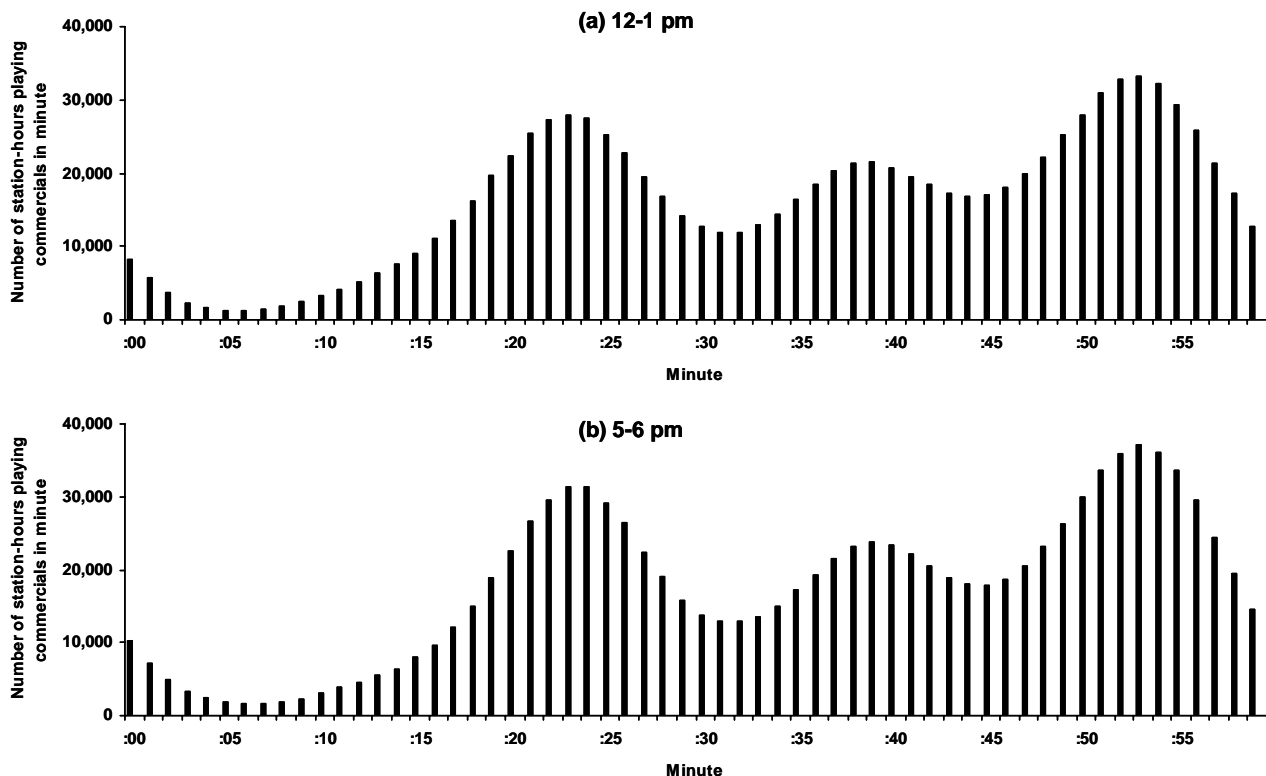
<sup>1</sup>Radio Advertising Bureau (2002), p. 4 and 8.

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

<sup>3</sup>Brydon (1994), an advertising consultant, argues 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 either stations should play very short breaks which would not make switching worthwhile or stations 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?"

<sup>4</sup>Epstein (1998) also provides empirical evidence that the major US television networks tend to play their commercials at the same time, especially at the beginning of programs.

Figure 1: Histograms of the Number of Stations Playing Commercials Each Minute 12-1pm and 5-6pm



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

Mazzeo (2002) (motel quality), Seim (2004) (video rental store location) and Augereau et al. (2004) (ISP adoption of 56K modem technology) all of which examine settings where firms differentiate from local competitors. Their basic approach is to show that, conditional on observable variables which affect demand, firms tend not to choose locations close to where their competitors are or are likely to be. In contrast I examine a situation in which firms may quite plausibly want to choose the same locations as their competitors. I also face a quite different kind of identification problem which is related to the third reason why my approach is interesting to economists in several different fields.

Figure 1 shows how many stations play commercials each minute for two different hours of the day based on a large sample of station-hours. Stations do tend to play commercials at the same time, but this could be explained either by stations trying to choose the same times or by unobservable “common factors” which make times, such as just before the end of the hour, attractive for all stations

independent of when other stations play their commercials. People in the industry identify two common factors which are consistent with Figure 1: stations sweep the quarter-hours with music because of how Arbitron estimates station ratings and they avoid playing 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 the first thing they hear when they tune-in.<sup>5</sup> The problem of identifying whether positively correlated behavior can be explained by interactions between agents, rather than individual or group characteristics, arises in a wide variety of settings such as the study of neighborhood crime rates (Glaeser et al. (1996)), network externalities (Goolsbee and Klenow (2002)), industrial agglomeration (Ellison and Glaeser (1997)) and retirement plan choices (Duflo and Saez (2002), (2003)). Manski (1993) and Brock and Durlauf (2001) explain why it is hard to identify the role of interactions and the empirical literature has typically either tried to show that there is more clustering of behavior than can be explained by observables (for example, Glaeser et al. (1996)) or exploited some kind of randomized experiment (for example, Duflo and Saez (2003)) which changes the behavior of some members of a group so that the effects on other members can then be studied. Sweeting (2004a) shows that stations in the same local metro-market are more likely to play commercials at the same time during drivetime than would be expected if common factors are the same across markets by estimating a game with multiple equilibria. This approach, which is a structural version of the excess clustering approach, allows stations' incentives to coordinate to be identified but it suffers from the potential problem that unobservable common factors might differ across markets and could also explain excess within-market clustering. There is no obvious experiment to exploit. The approach used here is to construct a theoretical model of station behavior which identifies observable features of radio markets, such as the number of stations and the concentration of station ownership, that should affect the degree to which commercials overlap in Nash equilibrium in different ways if stations want to coordinate (choose

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<sup>5</sup>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.

the same times as other stations) or differentiate (choose different times). If stations do not want to coordinate or differentiate then these features should have no effect on overlap.<sup>6</sup> I then test which set of comparative statics are supported by panel data on the timing of commercials by 1,094 contemporary music stations from 147 metro-markets with different market characteristics. This approach does not require that common factors are the same across markets but only that their importance does not vary in a way which is systematically correlated with the set of market characteristics I consider.

The results are consistent with stations trying to coordinate with commercials overlapping more in markets with fewer stations, less listening to out-of-market stations, more concentrated ownership and more asymmetric distributions of listenership across stations. For example, a one standard deviation increase in the number of music stations in a market decreases the expected amount of time that a pair of stations both play commercials by approximately 7%. In markets with asymmetric listenership I find that small stations tend to coordinate particularly closely with the largest station in the market. I also find some evidence that stations coordinate more when there is greater demand for advertising. These relationships are more significant during drivetime, and to a lesser extent midday hours, than in the evening or at night. This is to be expected because stations should care more about coordination or differentiation when more listeners switch stations and in-car listeners, who are more numerous during drivetime, switch stations more than those at home or at work.<sup>7</sup> There is no support for the hypothesis that stations want to differentiate.

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

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<sup>6</sup>A helpful analogy might be to the problem of inferring whether a disease is infectious from the fact that it only appears in certain neighborhoods when the individuals in those neighborhoods might have shared unobserved characteristics. The standard excess clustering approach would be to control for as many observables as possible while the approach in this paper would be to examine whether a neighborhood characteristic such as population density, which should affect the spread of an infectious disease but not individual susceptibility, is positively correlated to the spread of the illness.

<sup>7</sup>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](http://www.arbitron.com)).

## 2 A Model of Station Timing Decisions and Listener Behavior

I develop a simple model to show that stations may want to coordinate or differentiate on timing depending on how listeners behave. I show that the comparative statics of how much commercials overlap with respect to observed market characteristics, such as the number of stations, are different depending on whether stations want to coordinate or differentiate.

### 2.1 Station Payoffs

Time is divided into an infinite sequence of “even” and “odd” discrete intervals.<sup>8</sup> There are  $N(\geq 2)$  stations in a market and 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. Even intervals are on average more attractive for commercials because of common factors, such as the advantage of not playing commercials on the quarter-hour. Station  $i$ ’s payoffs ( $\pi$ ) from choosing even and odd are

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

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

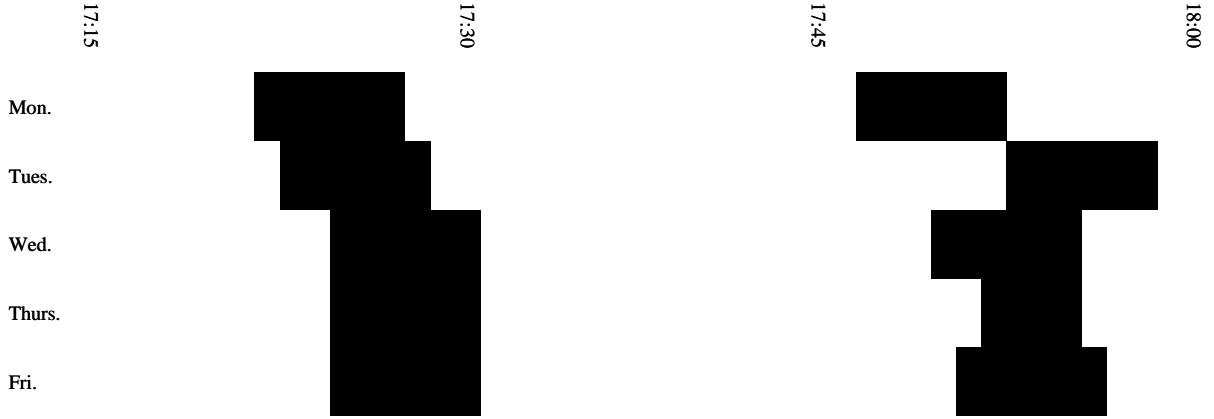
where  $\beta(> 0)$  reflects the additional attractiveness of even periods,  $A(\theta, N, n)$  is the average audience of a commercial break when  $n$  other stations in the market have their commercials at the same time and  $\theta$  is a parameter which reflects listeners’ switching behavior. Stations want to coordinate, all else equal, if this increases the audience of their commercials.<sup>9</sup> The  $\varepsilon$ s are idiosyncratic components of

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<sup>8</sup>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 before a commercial break (see sample schedules in Warren (2001), p. 27 and Lynch and Gillespie (1998), p. 111).

<sup>9</sup>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

Figure 2: The Timing of Commercials on WROR-FM October 29-November 2 2001 5-6pm



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

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  $\varepsilon$ s 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 between 5 pm and 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.<sup>10</sup>

## 2.2 Listener Behavior

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

**Formulation 1 (Coordination).** Every listener has a first choice station (the "P1" in radio the audience of TV commercials is also measured imperfectly (see Media Daily News (2004)).

<sup>10</sup>Warren (2001) p. 24 describes how sweeping 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".

jargon) and a second choice station. Each station is the first choice of one unit of listeners who are equally divided 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

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

so a station wants 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 equally split 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  $\theta$ , 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

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

which decreases in  $n$  for  $\theta > 0$  so a station wants to choose 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 Overlap

I examine the degree to which commercials overlap in static Nash equilibrium. For given parameters and realizations of the  $\varepsilon$ s there can be multiple equilibria. I focus on 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 allows the joint payoff maximizing equilibrium to be identified easily. I measure equilibrium overlap as the probability that two randomly drawn stations would be playing commercials at the same time. If there are  $N$  stations and  $x$  choose even then overlap is  $\frac{x(x-1)+(N-x)(N-x-1)}{N(N-1)}$ . The equilibrium depends on the realization of the  $\varepsilon$ s as well as the parameters so for each set of parameters I draw 1,000 sets of  $\varepsilon$ s and calculate average overlap across these sets. I keep the  $\varepsilon$ s the same as I change the parameters.

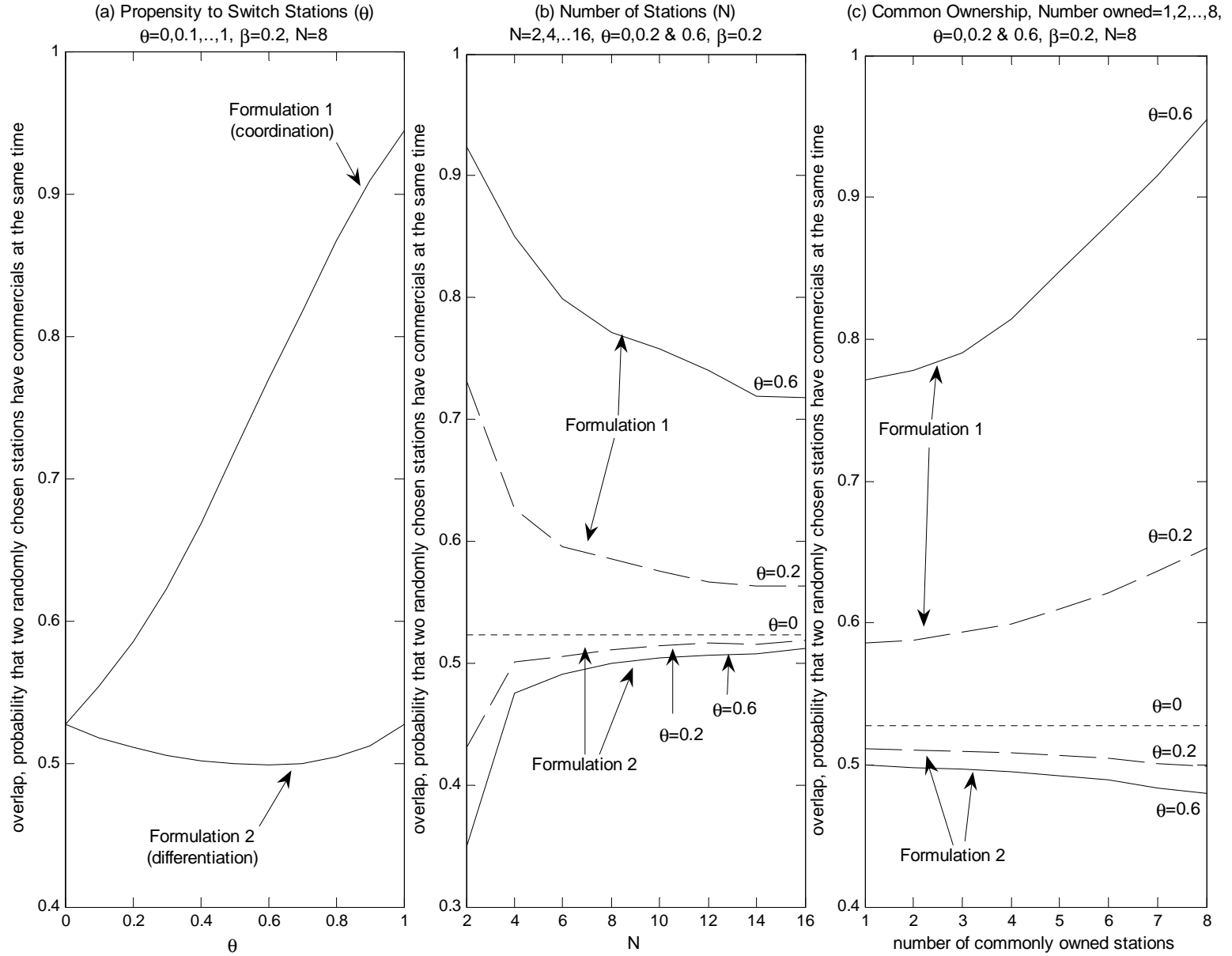
### 2.4 Comparative Statics

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

**$\theta$  (the propensity of listeners to switch stations).** Figure 3(a) shows how overlap changes under both formulations of listener behavior as  $\theta$  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 commercials overlap with probability greater than  $\frac{1}{2}$  only because stations are more likely to choose even ( $\beta > 0$ ). As  $\theta$  increases commercials overlap more if stations want to coordinate. Commercials tend to overlap less if stations want 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  $\theta$  lies in the range where increasing  $\theta$  slightly would give stations more incentive to differentiate.

**$N$  (the number of stations).** Figure 3(b) shows how the equilibrium overlap of commercials

Figure 3: Comparative Statics of Equilibrium Overlap



varies as the number of stations increases from 2 to 16, with  $\theta = 0, 0.2$  or  $0.6$ . If no listeners switch stations then overlap is independent of  $N$ . If stations want to coordinate then commercials overlap less as  $N$  increases. This is because when  $N$  is small it is more likely that a station will be able to choose an interval in which the vast majority of other stations are playing commercials giving it a strong incentive to choose this interval.<sup>11</sup> Overlap is more sensitive to  $N$  when listeners have a greater propensity to switch stations ( $\theta$  higher).<sup>12</sup> If stations want to differentiate on timing then overlap tends to increase with the number of stations and this effect is also larger when  $\theta$  increases. The intuition is that when the number of stations increases it is more likely that a station will choose between intervals with similar proportions of stations playing commercials so that the incentive to differentiate will have less effect on its timing decision. While  $N$  represents the number of stations in the market (the active players in the game) coordination would also become less effective for similar reasons if listeners can switch to stations in nearby markets which may play commercials at different times. I therefore examine the effect of differences in the number of stations and in the proportion of listening to home-market stations and expect increases in these variables to affect overlap in opposite directions.

Entry by a new station may have a different effect to an additional symmetric station. Lynch and Gillespie (1998) describe how a new entrant in Dayton, OH “counter-programmed” its commercials in order to appeal to first-time listeners even if this reduced the current audience of its commercials.<sup>13</sup>

This would tend to reduce the incentive of other stations to coordinate. Unfortunately, as I describe

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<sup>11</sup>The effect of  $N$  on overlap would be even larger if I assumed that listeners only listen to commercials if all stations are playing commercials at the same time because, in this case, once coordination is imperfect no station has any incentive to coordinate.

<sup>12</sup>I note that it is possible to construct examples where  $\beta$  and  $\theta$  are so high that overlap is almost perfect over a range of  $N$  and overlap is more sensitive to  $N$  for lower  $\theta$ . 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.

<sup>13</sup>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.

in Sections 3 and 4, my timing data does not contain information on small new entrants and there is only limited variation in the number of stations within markets over time.

**Common station ownership.** A station’s timing decision affects the audience of other stations as well as its own so that if, for example, stations want to coordinate then their commercials will tend to overlap less in Nash equilibrium than they would if stations maximized their joint payoffs. In many markets several stations have the same owner and commonly owned stations should internalize these externalities. I therefore examine what happens to overlap as the number of stations owned by a single firm increases with the total number of stations held fixed and the remaining stations owned by independents. The common owner chooses its stations’ intervals to maximize their joint payoffs. Figure 3(c) shows how overlap changes. If stations want to coordinate on timing then commercials overlap more as ownership becomes more concentrated. When commonly owned stations coordinate more there is also an indirect effect on the independent stations because coordination is a “strategic complement” (Bulow et al. (1985)) in this game. If stations want to differentiate then more concentrated ownership is associated with less overlap as the common owner tends to make sure that its stations do not play commercials at the same time. Under either formulation overlap is more sensitive to common ownership when  $\theta$  is higher.

**Asymmetries in station listenership.** In many medium and smaller markets the largest station has considerably more listeners than other stations. 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 have their second choices equally divided between the small stations. Proportion  $\alpha_1$  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.  $\alpha_1$  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.  $\alpha_2$  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.  $\beta$  and the  $\varepsilon$ s are scaled for each station in proportion to the number of listeners who have the station as a favorite because common factors or idiosyncratic preferences over scheduling do not become more important when the station has fewer listeners.  $\alpha_2$  varies from 2 (symmetry) to  $N$  (every listener has the big station as a favorite).

Figure 4(a) shows how overlap changes as  $\alpha$  varies where  $\alpha_2 = \alpha$  and  $\alpha_1 = \frac{\alpha}{N-1}$  and  $\beta = 0.2$  and  $N = 12$ . For both formulations commercials tend to overlap more when listenership becomes more asymmetric with a larger effect when  $\theta$  is higher. In formulation 1 this is because each small station attaches more importance to coordinating with the big station as asymmetry increases and this can be achieved more easily than coordinating with all of the other stations. In formulation 2 the small stations want to choose a different time to the big station and lose less from choosing the same time as each other. Therefore a prediction of the model is that small stations should overlap less with the big station as asymmetry increases if stations want to differentiate but more if they want to coordinate. This is shown in Figure 4(b) where overlap is now measured by the probability that the big station chooses the same time as a randomly chosen small station. The effects of asymmetry are also larger when  $\theta$  is higher.

## 2.5 Summary of Comparative Statics

In Section 5 I examine how the observed overlap of commercials varies across markets with different numbers of stations, listening to home-market stations, ownership concentration and asymmetries in station listenership. I also examine how the effect of these variables varies between drivetime, when listener switching is likely to be greater ( $\theta$  higher), and other parts of the day. The comparative static predictions of the model are summarized in Table 1.

Figure 4: Comparative Statics of Equilibrium Overlap (cont.)

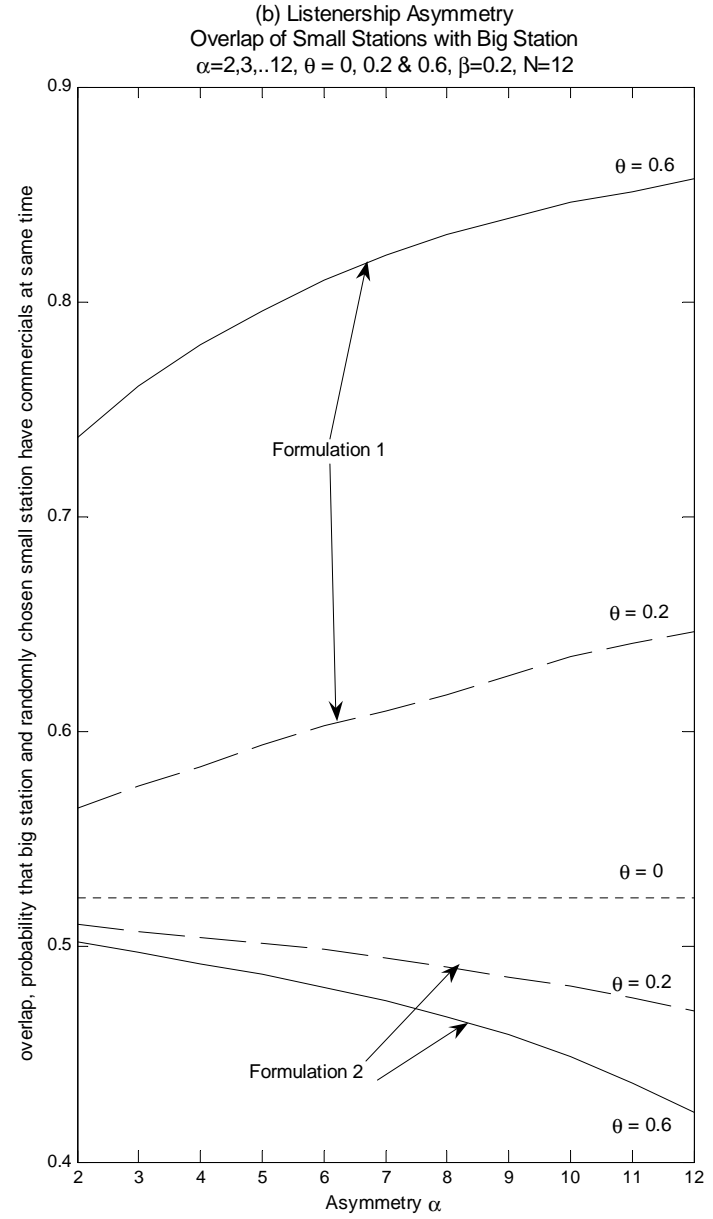
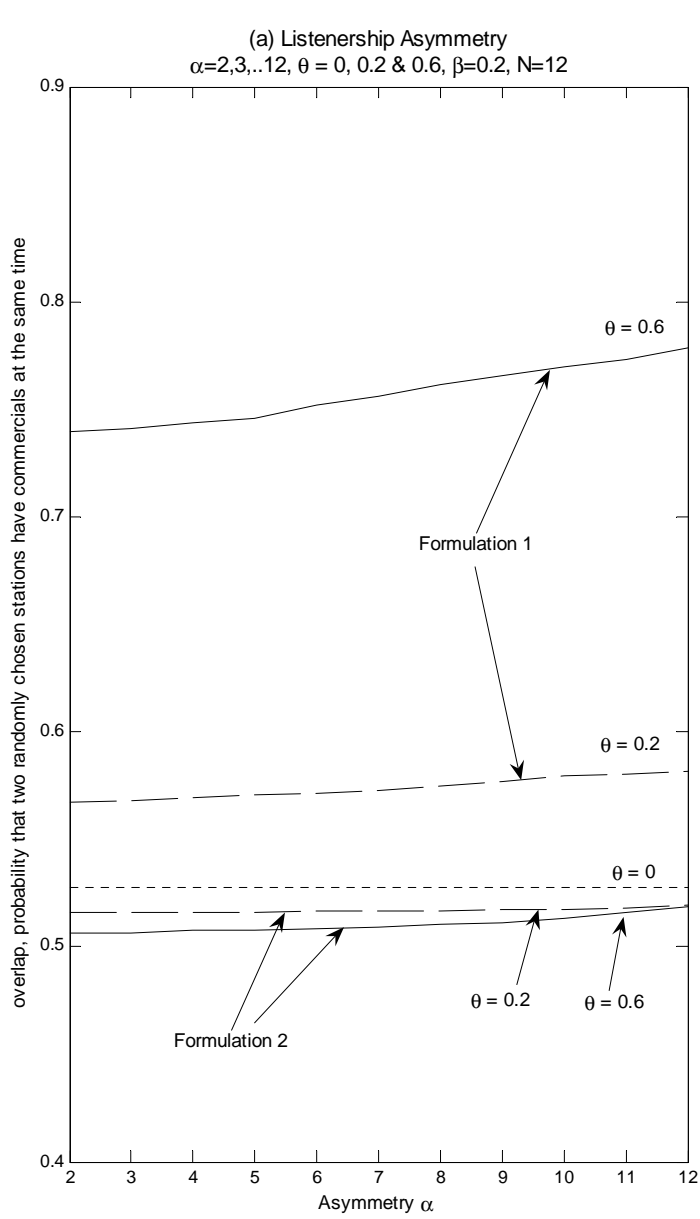


Table 1: Predicted Effects of Market Characteristics on Overlap

	$\theta = 0$	Coordination & $\theta > 0$	Differentiation & $\theta > 0$
Number of stations	no effect	↓ (stronger in drivetime)	↑ (stronger in drivetime)
Proportion of listenership to home-market stations	no effect	↑ (stronger in drivetime)	↓ (stronger in drivetime)
Ownership concentration	no effect	↑ (stronger in drivetime)	↓ (stronger in drivetime)
Listenership asymmetry all station overlap	no effect	↑ (stronger in drivetime)	↑ (stronger in drivetime)
Listenership asymmetry big-small station overlap	no effect	↑ (stronger in drivetime)	↓ (stronger in drivetime)

Of course overlap should also vary with unobserved common factors ( $\beta$ ). I measure how much commercials overlap in a market in a way which controls for the effect of common factors which are the same across markets including any which might vary across hours (for example, it might be more important to avoid the quarter-hours during drivetime). However it is an identifying assumption that the importance of unobserved common factors does not vary across markets in a way which is systematically correlated with the market characteristics I examine.

### 3 Data

The data on timing is derived from music station airplay logs provided by Mediabase 24/7, which electronically monitors stations to collect data on music airplay. Section 3.1 describes how I use the airplay logs and Section 3.2 describes the coverage of the sample.

#### 3.1 Construction of the Timing Data

Table 2 shows an extract of an airplay log for a Classic Hits station. The log lists the start time of each song and indicators for whether there is a commercial break between songs. I estimate which minutes have commercials in the following way:

1. estimate the length of each song as the median number of minutes before the next song when

Table 2: Extract from a Daily 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
<i>Stop Set</i>	<i>BREAK</i>	<i>Commercials and/or Recorded Promotions</i>	-
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
<i>Stop Set</i>	<i>BREAK</i>	<i>Commercials and/or Recorded Promotions</i>	-
5:56PM	JOEL, BILLY	Movin' Out (Anthony's Song)	1977

there is no commercial break;<sup>14</sup>

- create a minute-by-minute schedule (5:00, 5:01, 5:02 etc.) for each station and mark the start of each song on the schedule;
- fill out the schedule assuming that each song is played its median length unless this would overlap the start of another song or would eliminate a commercial break where one is indicated in the log, in which case the song is shortened to allow at least one minute of commercials.
- 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, show that there are very rarely more than six minutes of commercials in a row. If the gap is more than six minutes I assume that only the six minutes in the middle of the gap have commercials.<sup>15</sup>

<sup>14</sup>If there are less than 10 plays when the song is not followed by a commercial I assume that the song is 4 minutes long which is the median length of all songs.

<sup>15</sup>For example, if the gap is 8 minutes long then I assume that the commercial break aired between the 2<sup>nd</sup> and 7<sup>th</sup> minutes (inclusive). If the gap is, for example, 9 minutes in length I assume that the break aired from the 3<sup>rd</sup> to the 8<sup>th</sup> minute (slightly later than the middle).

The logs do not identify if there is talk around a commercial break, so the length and exact timing of a break may be mismeasured. This problem is more severe if stations play only a few songs so I only use station-hours with at least eight songs. This selection rule drops less than 5% of station-hours each hour before 5 am and from 10 am to 9 pm but it drops 50% of station-hours between 6 am and 8 am when stations have a lot of weather and travel news and some stations have entirely talk programming, such as “The Howard Stern Show”. In Section 5.2 I show that this rule and my definitions of when commercials are played do not affect the results.

### 3.2 Coverage of the Sample

The logs contain information on the timing of breaks for 1,094 contemporary music stations in 2000 and 2001. I have logs from the first five weekdays of each month for these years, although the panel of stations is unbalanced because the number of stations for which commercial breaks are identified 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.<sup>16</sup> 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.

I identify each station’s home metro-market (as defined by Arbitron) and its music category in each ratings quarter using BIAfn’s *MediaAccess Pro* database. The sample stations are home to 147 different metro-markets although 14 of these markets only have one sample station so I cannot calculate overlap for these markets. The stations are in seven contemporary music categories: Adult Contemporary, Album Oriented Rock/Classic Rock, Contemporary Hit Radio/Top 40, Country, Oldies, Rock and Urban.<sup>17</sup> A category aggregates similar music formats (for example, BIAfn classifies the Classic Hits format station in Table 2 in the Rock category). The music categories with no stations

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<sup>16</sup>3.2% of stations have at least 8 songs and no commercial break during an hour between 6 am and 6 pm compared with 11.7% between 7 pm and 5 am.

<sup>17</sup>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.

in the sample are Classical, Easy Listening, Jazz and Nostalgia/Big Band which appeal mainly to different demographics than contemporary music stations. The sample does not include every station in these categories in the 147 markets but, as shown in Table 3, it does include stations which account for the majority of listenership especially in the largest markets and in categories other than Oldies. In Section 5 I focus on the degree of overlap between all of the contemporary music stations in a metro-market but in Section 5.3 I examine overlap between those sub-groups of stations which are in the same category as well as the same metro-market. The BIAfn database also provides data on Arbitron's estimate of each station's share of radio listenership in its market and the ownership history of each station.<sup>18</sup>

## 4 Empirical Specification and Summary Statistics

I use a simple linear specification

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

where  $d$ ,  $h$  and  $m$  denote day, hour and market respectively and  $D$ ,  $H$  and  $W$  are day of week, hour and week dummies. I use this specification with and without market-hour dummies (fixed effects). I describe the construction of *OVERLAP* shortly.  $X_{mdh}$  are market characteristics and I allow them to have different effects for three different dayparts: drivetime (6:00 am - 9:59 am and 3:00 pm to 6:59 pm), midday (10:00 am - 2:59 pm) and night (7:00 pm to 5:59 am). The drivetime and midday dayparts are used by Arbitron in estimating radio ratings while night aggregates evening and nighttime hours. The characteristics are:

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<sup>18</sup>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. 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.

*NUMBER\_STATIONS*: the number of rated commercial stations in the seven contemporary music categories which are home to the metro-market (rated home music stations). This includes stations which are not in the airplay sample. A station is rated if Arbitron lists it as having a strictly positive share of radio listenership.

*HOME\_LISTENING*: the proportion of music listenership in the metro-market which is accounted for by home stations.

*HHI*: the Herfindahl-Hirschman Index of rated home music stations including stations which are not in the airplay sample.<sup>19</sup>

*LISTENERSHIP\_ASYMMETRY*: the asymmetry in listenership shares of rated home music stations. This is calculated as  $\frac{\sum_{i=1}^N s_i^2}{\frac{1}{N}}$  where  $s_i$  is station  $i$ 's share of rated home music listenership in the ratings-quarter and  $N$  is the number of rated home music stations.<sup>20</sup> The measure is the ratio of the sum of squared listenership shares and the value this sum would have if each station had equal listenership.

I also include controls for the quantity of commercials and the asymmetry in quantities across the stations.

*MEAN\_QUANTITY*: the average number of minutes of commercials played on the airplay stations with at least one commercial break.

*QUANTITY\_ASYMMETRY*: calculated as  $\frac{\sum_{i=1}^{N^{AIR}} q_{imdh}^2}{\frac{1}{N^{AIR}}}$  where  $q_i$  is station  $i$ 's share of the commercials played by the airplay stations and  $N^{AIR}$  is the number of airplay stations with at least one minute of commercials.

*OVERLAP* measures how much commercials in a market-day-hour overlap controlling for how much they would be expected to overlap given the number of commercials on each station, the hour of the day and the aggregate pattern that commercials tend to be played at particular times. The

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<sup>19</sup>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.

<sup>20</sup>Most markets in the sample are rated in each quarter, but for those small markets which are rated in only Spring and Fall I use the shares from the following ratings quarter.

construction of the variable is most easily explained through an example. Suppose I observe a market where between 5 pm and 6 pm there is a Rock station with 8 minutes of commercials and a Country station with 12 minutes of commercials. The first step is to 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 which is equal to 1 if station  $i$  plays a commercial in minute  $j$ . The second step is to calculate the benchmark of how much concentration would be expected given the aggregate pattern of timing choices of Rock and Country stations between 5 pm and 6 pm. 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 between 5 pm and 6 pm and a station-hour from the set of all Country station-hours with 12 minutes of commercials between 5 pm and 6 pm. I calculate  $CONC$  for this simulated observation. This simulation process is repeated 50 times for each market-day-hour observation. The final step is to calculate  $OVERLAP$  as

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

where  $\overline{CONC}_{mdh}^{SIM}$  and  $SD(CONC_{mdh}^{SIM})$  are the mean and standard deviation of  $CONC$  for the 50 simulated observations. If  $CONC$  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.<sup>21</sup>  $OVERLAP$  is positive if commercials overlap more than expected given aggregate timing patterns for that hour. As  $OVERLAP$  controls for hour-specific timing patterns  $OVERLAP$  may be higher outside drivetime than during drivetime even if, on average, commercials overlap more during drivetime.

Table 4 presents summary statistics.  $OVERLAP$  is, on average, positive in each daypart indicating that commercials on music stations in the same market tend to overlap more than would be expected

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<sup>21</sup>The results are not affected by using 100 simulations per observation so that fewer observations are dropped or by changing the seed value of the random number generator so that different observations are dropped.

given aggregate (across-market) timing patterns. This provides some initial evidence that stations in a market do not try to choose different times for commercial breaks. A simple example illustrates the size of the variable. Suppose that two Rock stations play 12 minutes of commercials between 5 pm and 6 pm. If their commercials were timed by drawing minutes from a uniform distribution then they would be expected to overlap for 144 seconds. Based on the actual times chosen by Rock stations with 12 minutes of commercials between 5 pm and 6 pm, they would be expected to overlap for 191.2 seconds and *OVERLAP* would be zero.<sup>22</sup> The mean value of *OVERLAP* during drivetime (0.0633) corresponds to overlap of 201.8 seconds, a 6% increase from 191.2 seconds and a 40% increase from 144 seconds. *OVERLAP* varies considerably within markets over time reflecting the randomness in individual stations' timing of commercials which means that commercials may overlap a great deal in a market one day and very little the next. On average stations play around 10 minutes of commercials per hour with more commercials during drivetime than at other times of the day. The quantity of commercials also varies with retail activity with more commercials at the end of the week than at the beginning of the week and in the months leading up to Christmas. I use these facts to instrument for quantity in Section 5.2. Different stations play different numbers of commercials, although the differences are not particularly large on average. For example, if four stations played 12, 8, 6 and 6 minutes of commercials then *QUANTITY\_ASYMMETRY* would be 1.094, greater than its mean value during drivetime. The remaining explanatory variables vary more across markets than within markets reflecting the relative short time-series and the fact that station entry and exit is relatively infrequent and listening patterns are relatively stable over time. In Fall 2001 the markets with the most rated home music stations were Salt Lake City (with 24 stations), Wilkes-Barre/Scranton (23), Chicago (22) and Pittsburgh (22). The only one of these markets with significant out-of-market listening was Wilkes-Barre/Scranton (11%). In contrast, Akron, OH had only 3 rated home music stations and more

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<sup>22</sup>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.

than 80% of music listening was accounted for by out-of-market stations, mainly in Cleveland. The highest values of *LISTENERSHIP\_ASYMMETRY* tend to occur in medium and smaller markets. The highest value in Fall 2001 was in Knoxville, TN where the largest of 15 rated home music stations accounted for 34% of music listenership. The mean value of *HHI* (0.237) reflects widespread common ownership of stations by 2000. *HHI* does vary within markets over time due to mergers and station sales. The largest transaction is Clear Channel’s merger with AMFM (approved by the FCC in August 2000) which involved 152 music stations in my markets (78 of them in the airplay sample).<sup>23</sup>

## 5 Empirical Results

### 5.1 Basic Specification

Table 5(a) presents the results from the basic specification. Column (1) pools observations from different market-day-hours. Column (2) uses market-hour averages (between regression) and column (3) includes market-hour dummies (fixed effects or within regression). All standard errors are calculated to allow the residuals to be heteroskedastic and correlated across observations from the same metro-market. I discuss the sign and significance of the coefficients in the basic specification before examining their size. Section 5.2 presents robustness checks and uses instruments for the quantity of commercials. Section 5.3 examines overlap between stations in the same music category and Section 5.4 analyzes the effect of asymmetries in station listenership more closely.

If stations want to coordinate then I expect more overlap in metro-markets with fewer stations, more home-market listening, more concentrated ownership and greater asymmetries in station listenership, particularly during drivetime. The signs of the first four coefficients in column (1) for drivetime and midday hours are consistent with these predictions and all of these coefficients except *HHI* (ownership) are statistically significant at the 5% level during drivetime. *LISTENERSHIP\_ASYMMETRY*

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<sup>23</sup>Federal Communications Commission (2000)

(5%) and *HOME\_LISTENING* (10%) are significant during midday and *NUMBER\_STATIONS* and *LISTENERSHIP\_ASYMMETRY* (both 10%) are significant at night when *HHI* has a different sign. The *MEAN\_QUANTITY* coefficient is negative in all three dayparts and significant during midday and at night. This may be because I estimate that there are more commercials when there are longer gaps between songs and this is when I am likely to measure the overlap of commercials with less precision. I address this possibility below using instruments for quantity. The between regression in column (2) identifies the coefficients from variation in the average overlap of commercials and the explanatory variables across market-hours. This regression is of interest because most of the variation in the explanatory variables, apart from the quantity variables, is across markets. The coefficients are generally very similar in size and significance to column (1) except that *HHI* is significant at the 5% level during drivetime and midday hours and the *NUMBER\_STATIONS* coefficient for drivetime is just insignificant at the 10% level. The within regression in column (3) identifies the coefficients from how overlap within a market-hour changes when the explanatory variables change. Given the very limited within-market variation in most of the explanatory variables it is not surprising that all but two of the coefficients are statistically insignificant but most of their signs are the same as in the pooled and between regressions. The *HHI* coefficient is positive and significant at the 5% level during drivetime showing that when station ownership becomes more concentrated in a market commercials tend to overlap more.<sup>24</sup>

Table 5(b) shows how much a one standard deviation change from the mean of each of the explanatory variables changes the predicted number of seconds of commercial overlap between two Rock stations each playing 12 minutes of commercials between 5 pm and 6 pm based on the drivetime coefficients in column (1). Recall from Section 4 that overlap of 191.2 seconds corresponds to *OVERLAP*

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<sup>24</sup>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. The *QUANTITY\_ASYMMETRY* coefficient is also significant and negative during midday but as its sign varies across specifications and dayparts it is hard to interpret this result.

being zero and overlap of 201.8 seconds corresponds to *OVERLAP* of 0.0633. The commercials would overlap for 144 seconds if they were timed randomly with any minute equally likely to be chosen. A one standard deviation increase in the number of stations is associated with a 14.2 second decrease in overlap, equal to 7% of the average overlap of stations in the same market or 25% of the difference between the average overlap and the overlap with random timing. The quantity variables are predicted to have only small effects. The drivetime *HHI* coefficient in column (3) implies that a one standard deviation increase in ownership concentration increases overlap by 12.7 seconds (6% of average overlap).

## 5.2 Robustness Checks

Table 6 presents the results of a number of robustness checks on the pooled regression in column (1). The results are similar for the between and within regressions and these are available on request. Columns (2)-(4) examine whether how I define when commercials are played affects the results. In column (2) the maximum break length is limited to four minutes rather than six and in column (3) a commercial break is allowed to fill the entire gap between songs without any restrictions on break length.<sup>25</sup> Column (4) keeps station-hours with less than eight songs. The coefficients on the four main variables of interest are almost identical across these columns showing that the results are robust to alternative definitions. Column (5) uses the natural logs of *NUMBER\_STATIONS*, *HOME\_LISTENING* and *MEAN\_QUANTITY*. The *NUMBER\_STATIONS* coefficients become more statistically significant in every daypart and their negative signs are consistent with stations trying to coordinate on timing and commercials overlapping less when there are more stations.

The four main explanatory variables are calculated based on all of the rated home music stations in the metro-market rather than just the subset of stations in my airplay data. While the theory

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<sup>25</sup>When a break lies at the very beginning or end of an hour shortening the break length can mean that a station-hour no longer has commercials so that there are a few market-day-hour observations which no longer have two stations playing commercials. This explains why the number of observations is lower in column (2) and higher in column (3) than in column (1).

predicts that, for example, it is the total number of stations in the market which affect overlap, it also suggests that commonly owned or particularly asymmetric groups of stations may be more coordinated. Column (6) includes additional variables for *HHI* and *LISTENERSHIP\_ASYMMETRY* calculated using only stations in the airplay sample. None of the coefficients on the sample variables are statistically significant. The *SAMPLE\_HHI* coefficients are positive during drivetime and midday, as expected, but the *SAMPLE\_ASYMMETRY* coefficients are negative. As small stations are not included in the airplay sample *SAMPLE\_ASYMMETRY* may tend to systematically mismeasure the importance of the largest station. I examine asymmetric markets in more detail in Section 5.4. Column (7) drops observations from the ten largest metro-markets, based on suggestions that the largest markets may have so many stations that they are qualitatively different to smaller markets. The results are very similar to column (1) except that the *HHI* coefficients are slightly larger and significant at the 10% level during drivetime and midday.

*MEAN\_QUANTITY* could be endogenous to the degree of overlap and, as explained above, mismeasurement of this variable may be correlated with mismeasurement in the dependent variable. I address these problems using instruments for quantity. The quantity of commercials varies by month and by day of the week which is explained by increased retail activity at weekends, during the summer and before Christmas.<sup>26</sup> For example, stations have, on average, 15% more commercials in early December than in early January, and 10% more commercials on Thursdays than on Mondays. The regressions in Table 5(a) included day of week and week dummies as controls but there is no obvious theoretical reason why they should affect coordination and the coefficients on the variables of interest are almost unchanged if I exclude these dummies. I therefore use these dummies interacted with daypart dummies as instruments for quantity and do not include them in the second-stage overlap regression. The incentive to coordinate may vary by hour so I do not use the hour dummies as instruments. I do not have instruments for how the quantity of commercials varies across stations

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<sup>26</sup>The US Census Bureau's Monthly Retail Trade Survey shows how retail activity varies by month (<http://www.census.gov/mrts/www/mrts.html>).

(*QUANTITY\_ASYMMETRY*) but the other coefficients do not change if I leave this variable out of the regression. Column (8) shows the results. A higher quantity of commercials is associated with greater overlap of commercials. The effect is largest during drivetime when the coefficient is significant at the 1% level. The drivetime coefficient implies that, based on the two Rock station example in Table 5(b), a one standard deviation increase in quantity is associated with a 16.1 second (8% of average overlap) increase in overlap. This positive effect could be explained by either listeners being more likely to switch stations when they play more commercials or by it being more expensive for stations to lose listeners when demand for advertising time, and therefore advertising prices, are higher. The *QUANTITY\_ASYMMETRY* coefficient is also positive and significant during drivetime and implies that a one standard deviation increase in this variable is associated with a 6 second (3%) increase in overlap. However, without an instrument for this variable it is hard to interpret this result.

### 5.3 Overlap Within Music Categories

If listeners switch primarily between stations in the same music category then it may be more appropriate to examine how the overlap between these sub-groups of stations depends on metro-market music category (MMMC) characteristics. The results are shown in Table 7, with columns (1) and (2) containing the pooled and within regressions. The signs and sizes of the coefficients are similar to Table 5(a) with the exception of the smaller *HHI* coefficients but fewer coefficients are statistically significant. There are at least two reasons why the MMMC results are relatively weak. First, because I need at least two stations in the same MMMC with commercials to calculate *OVERLAP*, more of the MMMCs in the regression come from the largest metro-markets where the metro-market results appear to be slightly weaker. Column (3) drops MMMCs from the 10 largest metro-markets and three of the four coefficients of main interest, particularly *NUMBER\_STATIONS*, become larger during drivetime. Second, there is, perhaps surprisingly, considerable switching across music categories even in markets where there are several stations in a category. Arbitron (2003) contains estimates of the

number of listeners to one station who also listen to another station for the Boston market in Fall 2002. There were 6 Rock stations and 8 non-Rock contemporary music stations which were in the airplay sample in Fall 2001. On average, 15.8% of the listeners to a Rock station listened to each of the other Rock stations and 17.1% of the listeners to a Rock station listened to each of the non-Rock stations.<sup>27</sup> Cross-category switching may reflect listeners' taste for music variety as well as the fact that stations in the same MMMC tend to differentiate their music offerings so that stations classified in the same MMMC may play quite different kinds of music (Sweeting (2004b)).

## 5.4 Coordination in Asymmetric Markets

A particularly robust result is that commercials overlap more in markets with asymmetric listenership. This is potentially consistent with stations wanting to differentiate if small stations choose the same times as each other but different times to the largest station (assuming that it is the largest station with which each of them competes most directly for listeners). I therefore examine asymmetric markets more closely to find which pairs of stations choose the same times for commercials. I measure the overlap between a pair of stations in the same metro-market in a similar way to market level *OVERLAP* (i.e., using simulation methods to control for aggregate timing patterns), except that, because there are only two stations in a pair, I replace the *CONC* measure with a simple count of the number of minutes in which both stations are playing commercials. I regress the pair overlap measure on a dummy for whether the pair's metro-market is in the top quartile of asymmetric markets (based on the market's average value of *LISTENERSHIP\_ASYMMETRY*), a dummy for whether one of the stations in the pair is the largest contemporary music station in the market, the interaction of these dummies and a dummy for whether the stations are commonly owned. I also include hour, week and day of week dummies. I am most interested in the sign of the coefficient on the interaction of the asymmetric market dummy and the leader station dummy. In particular, if this coefficient is

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<sup>27</sup>Rock listeners were more likely to listen to other contemporary music stations than non-contemporary music stations apart from news/talk station WBZ-AM which is the largest station in Boston.

negative and significant then the largest station in asymmetric markets would appear to be choosing different times to smaller stations. The results are shown in Table 7 column (1). As expected, pairs in asymmetric markets are more coordinated and, more importantly, pairs involving the largest station in asymmetric markets are more coordinated than other pairs from these markets during drivetime and midday. Based on the two Rock station example discussed above, commercials overlap for 7.5 seconds more, on average, on pairs containing the largest station than other pairs in asymmetric markets during drivetime. The coefficient on the interaction is only statistically significant during midday but it becomes larger and significant at the 5% level during drivetime in column (2) where I drop pairs containing the second and third largest music station in the market in order to focus on the overlap between the largest station and significantly smaller stations. These results are consistent with stations wanting to coordinate on timing. The insignificant common ownership coefficients are consistent with the relatively weak results for the *HHI* variable in the earlier pooled regressions.<sup>28</sup>

## 6 Conclusion

This paper provides evidence that stations want to choose the same times for commercial breaks by comparing the relationship between how much commercials overlap and observable market characteristics with the comparative static predictions of a simple theoretical model. This approach allows the identification problem that commercials might overlap either because stations want to coordinate or because unobserved common factors make certain times more attractive for commercials to be over-come. Commercials tend to overlap more in markets with fewer stations, less listening to out-of-market stations, more concentrated ownership and greater asymmetries in station listenership. These relationships are particularly significant during drivetime, which is expected because in-car listeners tend

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<sup>28</sup>It is surprising that we do not observe more coordination between commonly owned stations given that it should be easier for them to coordinate their scheduled timing. One possible explanation is that commonly owned stations differentiate their music to reduce the extent to which they are competing for the same listeners (Sweeting (2004b) provides evidence of this change in music offerings).

to switch stations more, and are least significant at night. The instrumental variables results also suggest that stations coordinate more when they play more commercials.

Two issues deserve further comment. The first issue is why coordination on timing is so imperfect if stations are trying to play commercials at the same time. There are at least four probable explanations. First, it is hard for stations to play commercials at precise times because they have to be fitted in around other kinds of programming which cannot be cut short without alienating listeners. This makes coordination imperfect which, in turn, reduces stations' incentive to try to coordinate on timing. It is interesting to compare radio with television in this regard, because television has more pre-recorded programming which allows commercials to be placed more precisely, and television commercials appear to overlap more than radio commercials. Second, station audiences are measured imprecisely and only limited estimates of listener switching are available to advertisers (see footnote 9). This weakens a station's incentive to coordinate on timing although the evidence in this paper shows that it does not erase it entirely. Third, a proportion of listeners who switch might actually do so in ways which would lead stations to want to choose different times for commercials. This would weaken the incentive to coordinate. Investigation of exactly how different types of listener switch requires individual-level data on switching in addition to data on station timing decisions. Fourth, as described in Section 2.4, there may be stations, particularly new entrants, who want to choose different times for commercials ("counter-programming") even though most stations want to coordinate. Counter-programming by some stations would weaken the incentives of the remaining stations to coordinate. Unfortunately, a more detailed analysis of how new entrants behave requires more data on smaller stations than the current data contains.

The second issue is how the degree of coordination in a market affects welfare. The externalities in the coordination game suggest that advertising time would become more valuable if there was more coordination because fewer listeners would avoid commercials. Stations would extract this value through higher prices to advertisers and increased listenership to commercials is one possible reason

why increases in local market concentration have been associated with small increases in advertising prices (Brown and Williams (2002)). A large increase in revenues might indirectly benefit listeners by encouraging station entry, which would increase variety, and by encouraging investments in station quality. The free-rider problem means that listeners ignore these effects when switching stations. However, welfare maximization would also take into account listeners' disutility from hearing commercials they do not value and which they are currently unable to pay to avoid.

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## A Calculation of Nash Equilibria

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  $\tilde{\varepsilon} = \varepsilon^{EVEN} - \varepsilon^{ODD}$  and order stations,  $1, 2, \dots, N$  where  $\tilde{\varepsilon}_1 \geq \tilde{\varepsilon}_2 \geq \dots \geq \tilde{\varepsilon}_N$ . For each station  $i$  (in  $\tilde{\varepsilon}$  order) assume that stations  $1, \dots, i-1$  choose even and that stations  $i+1, \dots, N$  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  $1, \dots, i^*$  choose even and players  $i^*+1, \dots, N$  choose odd.<sup>29</sup> 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, in which case there is a PSNE where all stations choose odd, *or* it is a best response for player  $N$  to 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 want to coordinate, the PSNE which maximizes joint payoffs has the form that stations with  $\tilde{\varepsilon}$  above some value choose even and all stations with  $\tilde{\varepsilon}$  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  $\tilde{\varepsilon}_k > \tilde{\varepsilon}_j$ . Suppose that  $x$  stations other than station  $j$  also choose even. I show that this cannot be a PSNE. If it was then

$$\beta + A(\theta, N, x) + \tilde{\varepsilon}_j \geq A(\theta, N, N - x - 1) \quad (7)$$

and

$$\beta + A(\theta, N, x + 1) + \tilde{\varepsilon}_k \leq A(\theta, N, N - x - 2) \quad (8)$$

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

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

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<sup>29</sup> If it is a best response for station  $i^*$  to choose even when stations  $1, \dots, i^*-1$  choose even and stations  $i^*+1, \dots, N$  choose odd then  $\beta + A(\theta, N, i^*-1) + \tilde{\varepsilon}_{i^*} \geq A(\theta, N, N - i^*)$  which implies that  $\beta + A(\theta, N, i^*-1) + \tilde{\varepsilon}_j \geq A(\theta, N, N - i^*)$  for all  $\tilde{\varepsilon}_j \geq \tilde{\varepsilon}_{i^*}$  so each station  $1, \dots, i^*-1$  would also be playing a best response to stations  $1, \dots, i^*$  choosing even and stations  $i^*+1, \dots, N$  choosing odd. Similar logic shows that if station  $i^*+1$  is playing a best response by choosing odd then so are all stations  $i^*+2, \dots, N$ .

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

$$\beta + A(\theta, N, x) + \tilde{\varepsilon}_j \geq A(\theta, N, N - x - 1) \quad (9)$$

$$\beta + A(\theta, N, x + 1) + \tilde{\varepsilon}_k \leq A(\theta, N, N - x - 2) \quad (10)$$

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 (10) and  $\tilde{\varepsilon}_k > \tilde{\varepsilon}_j$  imply that

$$\beta + A(\theta, N, x + 1) + \tilde{\varepsilon}_j < A(\theta, N, N - x - 2) \quad (11)$$

and (9) and  $\tilde{\varepsilon}_k > \tilde{\varepsilon}_j$  imply that

$$\beta + A(\theta, N, x) + \tilde{\varepsilon}_k > A(\theta, N, N - x - 1) \quad (12)$$

and the payoffs of all other stations from both choices are unchanged. Joint station payoffs are  $\tilde{\varepsilon}_k - \tilde{\varepsilon}_j$  higher in this equilibrium. ■

**TABLE 3: Coverage of the Airplay Sample  
Based on Fall 2001 Music Categories and Station Ratings**

Category	Number of Metro-Market Music Categories (MMMCs) with Home to MMC Stations in the Airplay Sample	Number of Home to MMC Rated Stations	Number of Home to MMC Stations in Airplay Sample	Average % of Listening to Home to MMC Stations Accounted for by the Airplay Sample
<i>Arbitron Metro-Markets Ranked 1-70 (1 is New York City and 70 is Ft. Myers, FL)</i>				
All contemporary music	69	1003	720	86.1
Adult Contemporary (AC)	66	221	162	89.2
Album Oriented Rock/Classic Rock (AOR)	65	111	98	95.9
Contemporary Hit Radio/Top 40 (CHR)	64	131	112	95.6
Country	64	141	94	92.1
Oldies	44	64	44	92.1
Rock	61	147	122	94.0
Urban	44	133	88	86.0
<i>Arbitron Metro-Markets Ranked 70 and above (71 is Knoxville, TN)</i>				
All contemporary music	78	759	374	68.8
Adult Contemporary (AC)	56	135	78	78.7
Album Oriented Rock/Classic Rock (AOR)	34	66	45	82.5
Contemporary Hit Radio/Top 40 (CHR)	59	96	75	91.4
Country	60	137	76	85.7
Oldies	1	3	1	40.7
Rock	42	81	60	86.7
Urban	27	58	39	86.2

Notes:

Arbitron markets are ranked by population. To understand how to read the table consider the example of the Country music category in the largest 70 Arbitron metro-markets. In 64 of these 70 metro-markets I have airplay data on at least one 1 station which was home to the metro-market and in the Country music category in Fall 2001. There were 141 home to the metro-market Country music stations with non-zero listening shares in these 64 metro-markets and I have airplay data on 94 of these stations. The 94 airplay stations, on average, accounted for 92.1% of rated listening to Country music stations in their metro-markets.

TABLE 4: Summary Statistics

Variable	Daypart	Number of Observations	Mean	Standard Deviation			Minimum	Maximum
				Total	Between Market-Hours	Within Market-Hours		
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
HOME_LISTENING	All	323,198	0.8761	0.2012	0.2267	0.0127	0.1542	1.0000
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(a): Determinants of Commercial Overlap in a Metro-Market

	Coefficient Sign Predicted By Coordination Model	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>				
NUMBER_STATIONS	-	-0.0203** (0.0098)	-0.0171 (0.0108)	-0.0070 (0.0172)
HOME_LISTENING	+	0.4912*** (0.1811)	0.4848*** (0.1765)	0.2824 (0.6964)
HHI	+	0.5057 (0.3706)	0.9162** (0.3572)	0.9346** (0.3970)
LISTENERSHIP_ASYMMETRY	+	0.2433** (0.1006)	0.2368** (0.1146)	0.1281 (0.1717)
MEAN_QUANTITY		-0.0048 (0.0057)	-0.0143 (0.0169)	0.0016 (0.0028)
QUANTITY_ASYMMETRY		0.0501 (0.1038)	0.3746 (0.5027)	0.0207 (0.0599)
<u>MIDDAY*</u>				
NUMBER_STATIONS	-	-0.0161 (0.0132)	-0.0105 (0.0143)	-0.0188 (0.0253)
HOME_LISTENING	+	0.4574* (0.2357)	0.4333* (0.2320)	-0.5881 (0.8380)
HHI	+	0.7332 (0.5138)	1.1409** (0.5536)	1.0325 (0.7170)
LISTENERSHIP_ASYMMETRY	+	0.3859** (0.1549)	0.3502** (0.1625)	0.2501 (0.2147)
MEAN_QUANTITY		-0.0258** (0.0130)	-0.0393 (0.0388)	-0.0004 (0.0064)
QUANTITY_ASYMMETRY		-0.0160 (0.2008)	0.7659 (1.1320)	-0.2037** (0.0935)
<u>NIGHT*</u>				
NUMBER_STATIONS	-	-0.0209* (0.0115)	-0.0175 (0.0119)	-0.0121 (0.0164)
HOME_LISTENING	+	0.1014 (0.1971)	0.1056 (0.1912)	0.0602 (0.5450)
HHI	+	-0.3955 (0.2963)	-0.2796 (0.3142)	-0.1176 (0.5133)
LISTENERSHIP_ASYMMETRY	+	0.1859* (0.0974)	0.1698 (0.1074)	0.1019 (0.1309)
MEAN_QUANTITY		-0.0192*** (0.0068)	-0.0359*** (0.0115)	0.0009 (0.0040)
QUANTITY_ASYMMETRY		-0.0052 (0.0561)	-0.1668 (0.2330)	0.0096 (0.0357)
Dummies		Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)		0.0090	0.1172	0.1477
Number of observations		323,198	323,198	323,198

Notes:

Standard errors in parentheses, corrected for heteroskedasticity and correlation across observations from the same metro-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<sup>2</sup> for between regression is for between market-hour variation (3,190 market -hours). \*\*\*,\*\* and \* denote significance at 1%, 5% and 10% levels respectively.

**TABLE 5(b): Implied Effect of Market Characteristics on Overlap of 2 Rock Stations  
with 12 Minutes of Commercials 5 - 6 pm**

Variable	Standard Deviation	Drivetime Coefficient (Table 5(a) column 1)	Expected change in overlap from 1 standard deviation increase in variable (seconds)	Expected change as % of average overlap for stations in same market	Expected change as % of difference between average overlap and overlap with random timing
<i>NUMBER_STATIONS</i>	4.1255	-0.0203	-14.23	-7.05%	-24.61%
<i>HOME_LISTENING</i>	0.2012	0.4912	16.78	8.31%	29.02%
<i>HHI</i>	0.0805	0.5057	6.91	3.42%	11.96%
<i>LISTENERSHIP_ASYMMETRY</i>	0.2278	0.2433	9.41	4.66%	16.28%
<i>MEAN_QUANTITY</i>	3.5631	-0.0048	-2.90	-1.44%	-5.02%
<i>QUANTITY_ASYMMETRY</i>	0.0888	0.0501	0.76	0.37%	1.31%

Note: based on the actual times of commercials on Rock stations with 12 minutes of commercials between 5 pm and 6 pm commercials would be expected to overlap for 191.2 seconds. The drivetime mean of *OVERLAP* (0.063) corresponds to overlap of 201.8 seconds of overlap for stations in the same market. Overlap with random timing (each minute equally likely to be chosen) would be 144 seconds.

**TABLE 6: Determinants of Commercial Overlap in a Metro-Market: Robustness Checks**

	(1) Basic Specification Table 5 column (1)	(2) Maximum break length 4 minutes	(3) No maximum break length	(4) Use station-hours with any number of songs	(5) Natural logs of certain variables	(6) Sample characteristics of certain variables	(7) Exclude 10 largest markets	(8) Instrument for Quantity
<b>DRIVETIME*</b>								
NUMBER_STATIONS	-0.0203** (0.0098)	-0.0199** (0.0090)	-0.0194** (0.0090)	-0.0242*** (0.0092)	-0.3175*** (0.1066)	-0.0213** (0.0106)	-0.0211** (0.0086)	-0.0203** (0.0098)
HOME_LISTENING	0.4912*** (0.1811)	0.4426*** (0.1666)	0.5136*** (0.1688)	0.5136*** (0.1667)	0.4362*** (0.1099)	0.5311*** (0.2020)	0.5218*** (0.1714)	0.5095*** (0.1816)
HHI	0.5057 (0.3706)	0.4391 (0.3450)	0.5248 (0.3458)	0.4929 (0.3045)	0.4031 (0.3883)	0.3805 (0.4491)	0.6349* (0.3811)	0.5672 (0.3736)
SAMPLE_HHI	-	-	-	-	-	0.1155 (0.3255)	-	-
LISTENERSHIP_ASYMMETRY	0.2433** (0.1006)	0.2503** (0.0962)	0.1693* (0.0966)	0.2575*** (0.0963)	0.2415** (0.0977)	0.2759** (0.1291)	0.2621** (0.1028)	0.2519** (0.1030)
SAMPLE_ASYMMETRY	-	-	-	-	-	-0.1946 (0.3221)	-	-
MEAN_QUANTITY	-0.0048 (0.0057)	0.0035 (0.0070)	-0.0063* (0.0036)	-0.0088 (0.0062)	-0.0819 (0.0726)	-0.0050 (0.0056)	-0.0055 (0.0057)	0.0266*** (0.0079)
QUANTITY_ASYMMETRY	0.0501 (0.1038)	0.2131* (0.1146)	-0.0395 (0.0701)	0.0565 (0.1033)	0.0306 (0.1040)	0.0640 (0.1030)	-0.0225 (0.1052)	0.4045*** (0.1400)
<b>MIDDAY*</b>								
NUMBER_STATIONS	-0.0161 (0.0132)	-0.0162 (0.0121)	-0.0103 (0.0130)	-0.0160 (0.0132)	-0.2462* (0.1475)	-0.0186 (0.0143)	-0.0155 (0.0117)	-0.0158 (0.0134)
HOME_LISTENING	0.4574* (0.2357)	0.3960* (0.2129)	0.4568* (0.2377)	0.4643* (0.2349)	0.3817** (0.1516)	0.5701** (0.2569)	0.4706* (0.2238)	0.5012** (0.2391)
HHI	0.7332 (0.5138)	0.5952 (0.4696)	0.8673* (0.5230)	0.7464 (0.5124)	0.6621 (0.5443)	0.3400 (0.5853)	0.8760* (0.5253)	0.8404 (0.5258)
SAMPLE_HHI	-	-	-	-	-	0.3838 (0.4312)	-	-
LISTENERSHIP_ASYMMETRY	0.3859** (0.1549)	0.4041*** (0.1495)	0.3184** (0.1550)*	0.3898** (0.1552)	0.3822** (0.1520)	0.4758** (0.1897)	0.3899** (0.1594)	0.4098** (0.1616)
SAMPLE_ASYMMETRY	-	-	-	-	-	-0.5749 (0.4140)	-	-
MEAN_QUANTITY	-0.0258** (0.0130)	-0.0095 (0.0196)	-0.0215** (0.0091)	-0.0268** (0.0130)	-0.2500** (0.1117)	-0.0256** (0.0123)	-0.0261** (0.0129)	0.0249* (0.0146)
QUANTITY_ASYMMETRY	-0.0160 (0.2008)	0.1819 (0.2354)	0.0597 (0.1462)	-0.0074 (0.1981)	-0.0118 (0.1975)	0.0468 (0.1914)	-0.0360 (0.2042)	0.4669 (0.2889)
<b>NIGHT*</b>								
NUMBER_STATIONS	-0.0209* (0.0115)	-0.0246** (0.0105)	-0.0187* (0.0112)	-0.0211* (0.0113)	-0.2871** (0.1226)	-0.0227* (0.0123)	-0.0226** (0.0092)	-0.0221* (0.0117)
HOME_LISTENING	0.1014 (0.1971)	0.1674 (0.1812)	0.0693 (0.1957)	0.1062 (0.1941)	0.1644 (0.1295)	0.1486 (0.2144)	0.1327 (0.1792)	0.1127 (0.2005)
HHI	-0.3955 (0.2963)	-0.4496 (0.2822)	-0.3486 (0.3025)	-0.3914 (0.2946)	-0.4542 (0.3131)	-0.4453 (0.3814)	-0.3111 (0.3009)	-0.3333 (0.3094)
SAMPLE_HHI	-	-	-	-	-	0.0122 (0.2883)	-	-
LISTENERSHIP_ASYMMETRY	0.1859* (0.0974)	0.1898** (0.0921)	0.1716* (0.0980)	0.1804* (0.0966)	0.1917** (0.0957)	0.2497** (0.1246)	0.1943* (0.1000)	0.2296** (0.1017)
SAMPLE_ASYMMETRY	-	-	-	-	-	-0.2816 (0.3179)	-	-
MEAN_QUANTITY	-0.0192*** (0.0068)	-0.0199** (0.0083)	-0.0168*** (0.0049)	-0.0193*** (0.0068)	-0.1136** (0.0485)	-0.0189*** (0.0066)	-0.0192*** (0.0070)	0.0218** (0.0106)
QUANTITY_ASYMMETRY	-0.0052 (0.0561)	-0.0139 (0.0616)	0.0394 (0.0339)	-0.0017 (0.0549)	0.0293 (0.0562)	-0.0002 (0.0563)	-0.0003 (0.0568)	0.0709 (0.0659)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Hour Week Day of Week	Hour Week Day of Week	Hour Week Day of Week	Hour Week Day of Week	Hour Week Day of Week	Hour
Adjusted R <sup>2</sup> (incl. dummies)		0.0074	0.0095	0.0095	0.0097	0.0099	0.0095	-
Number of observations		323,143	331,045	331,896	323,198	323,198	295,832	323,198

Notes (in addition to notes at bottom of Table 5(a)):

All columns use the pooled market-hours regression, equivalent to column 1 of Table 5(a). Instruments in column (8) are day of week and week dummies interacted with the daypart.

**TABLE 7: Determinants of Commercial Overlap in a Metro-Market Music Category**

	(1) Pooled Market-Hours	(2) Within Market-Hours (Fixed Effects)	(3) Pooled Excluding 10 Largest Markets
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.0319 (0.0212)	-0.0544 (0.0387)	-0.0474** (0.0207)
HOME_LISTENING	0.5479** (0.2655)	0.8302 (0.5330)	0.5082* (0.2879)
HHI	0.0166 (0.1458)	0.1771 (0.1663)	0.0821 (0.1466)
LISTENERSHIP_ASYMMETRY	0.1937** (0.0942)	0.2177* (0.1216)	0.2557** (0.1024)
MEAN_QUANTITY	0.0030 (0.0045)	0.0048* (0.0026)	0.0026 (0.0047)
QUANTITY_ASYMMETRY	0.0304 (0.0893)	0.1350** (0.0555)	0.0470 (0.0981)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.0300 (0.0239)	-0.0312 (0.0369)	-0.0397 (0.0254)
HOME_LISTENING	0.3655 (0.2923)	0.9068 (0.5646)	0.3214 (0.3254)
HHI	0.0573 (0.1629)	0.4386* (0.2243)	0.1163 (0.1607)
LISTENERSHIP_ASYMMETRY	0.2203* (0.1131)	0.3007** (0.1389)	0.2927** (0.1268)
MEAN_QUANTITY	0.0027 (0.0060)	0.0008 (0.0036)	0.0010 (0.0063)
QUANTITY_ASYMMETRY	-0.0537 (0.1037)	0.0258 (0.0680)	-0.0476 (0.1145)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.0303 (0.0188)	-0.0115 (0.0243)	-0.0438** (0.0177)
HOME_LISTENING	0.3503 (0.2601)	0.7839** (0.3531)	0.2603 (0.2987)
HHI	-0.0051 (0.0975)	0.1143 (0.1159)	0.0526 (0.0868)
LISTENERSHIP_ASYMMETRY	0.0785 (0.0809)	0.0527 (0.0877)	0.1149 (0.0838)
MEAN_QUANTITY	-0.0118*** (0.0038)	-0.0078*** (0.0026)	-0.0139*** (0.0040)
QUANTITY_ASYMMETRY	-0.0088 (0.0389)	0.0109 (0.0281)	0.0095 (0.0409)
Dummies	Hour Week Day of Week Music Category	Week Day of Week Metro-Market-Music Category-Hour	Hour Week Day of Week Music Category
Adjusted R <sup>2</sup> (incl. dummies)	0.0046	0.1416	0.0063
Number of observations	450,198	450,198	374,934

Notes (in addition to notes at bottom of Table 5 (a)):

Standard errors in parentheses, corrected for heteroskedasticity and correlation across observations from the same metro-market music category.

**TABLE 8: Overlap between Pairs of Stations in the Same Metro-Market**

	(1) All Pairs	(2) Drop pairs including 2nd or 3rd largest station
<u>DRIVETIME*</u>		
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	0.0380 (0.0300)	0.0702** (0.0354)
Stations have the same owner	0.0071 (0.0141)	0.0053 (0.0164)
<u>MIDDAY*</u>		
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	0.0605* (0.0343)	0.0994** (0.0391)
Stations have the same owner	0.0101 (0.0159)	-0.0079 (0.0184)
<u>NIGHT*</u>		
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	-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 <sup>2</sup> (including dummies)	0.0007	0.0006
Observations	6,345,692	3,953,314

Notes (in addition to notes at bottom of Table 5(a)):

Standard errors in parentheses, corrected for heteroskedasticity and correlation across observations for the same pair of stations.

# **ADDITIONAL TABLES**

A. Additional Summary Statistics

B. - H. Additional Regressions for Robustness Tests in Table 6 of text

TABLE A: Additional Summary Statistics

Variable	Daypart	Number of Observations	Mean	Standard Deviation			Minimum	Maximum
				Total	Between Market-Hours	Within Market-Hours		
<u>Maximum break length is 4 minutes</u>								
OVERLAP	All	323,143	0.0726	1.0874	0.4009	1.0136	-3.0934	14.0007
MEAN_QUANTITY	All	323,143	8.0324	2.5892	2.3763	1.3324	1.0000	24.0000
QUANTITY_ASYMMETRY	All	323,143	1.1181	0.1205	0.0781	0.0946	1.0000	2.5425
<u>Maximum break length unlimited</u>								
OVERLAP	All	331,045	0.0790	1.0869	0.4457	0.9943	-3.1918	14.0007
MEAN_QUANTITY	All	331,045	12.6569	6.5913	6.0121	2.8232	1.0000	53.0000
QUANTITY_ASYMMETRY	All	331,045	1.1868	0.2160	0.1320	0.1721	1.0000	5.7975
<u>Use hours with any number of songs</u>								
OVERLAP	All	331,896	0.0788	1.0882	0.4380	0.9992	-3.5880	14.0007
MEAN_QUANTITY	All	331,896	10.5193	3.9629	3.6175	1.8128	1.0000	31.5000
QUANTITY_ASYMMETRY	All	331,896	1.1395	0.1410	0.0937	0.1089	1.0000	2.9548
SAMPLE_HHI	All	323,198	0.3217	0.1126	0.1325	0.0159	0.1479	1.0000
SAMPLE_ASYMMETRY	All	323,198	1.1458	0.0927	0.0848	0.0413	1.0001	1.6596
<u>Metro-market music category markets</u>								
OVERLAP	All	450,198	0.0010	1.0516	0.4399	0.9674	-4.7660	16.4236
MEAN_QUANTITY	All	450,198	10.1758	3.5701	3.3420	2.1066	1.0000	31.0000
QUANTITY_ASYMMETRY	All	450,198	1.0845	0.1245	0.0746	0.1070	1.0000	2.3909
NUMBER_STATIONS	All	450,198	3.1396	1.2022	1.0349	0.4508	2.0000	9.0000
HOME_LISTENING	All	450,198	0.9693	0.0778	0.0812	0.0161	0.3507	1.0000
HHI	All	450,198	0.5049	0.2121	0.1887	0.0801	0.1837	1.0000
LISTENERSHIP_ASYMMETRY	All	450,198	1.2032	0.2376	0.2175	0.1177	1.0000	3.0469

Station Pairs in the Same Metro-Market

Variable	Daypart	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
OVERLAP	All	6,345,692	0.0150	1.0486	-4.7660	21.0718
Market has asymmetric listenership dummy	All	6,345,692	0.1638	0.3701	0	1
One station is largest station dummy	All	6,345,692	0.2170	0.4122	0	1
Asymmetric market and largest station dummy	All	6,345,692	0.0437	0.2044	0	1

TABLE B: Maximum 4 Commercials in Block

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.0199** (0.0090)	-0.0151 (0.0098)	-0.0083 (0.0163)
HOME_LISTENING	0.4426*** (0.1666)	0.4398*** (0.1623)	0.1665 (0.6259)
HHI	0.4391 (0.3450)	0.9047*** (0.3272)	0.7445** (0.3707)
LISTENERSHIP_ASYMMETRY	0.2503** (0.0962)	0.2412** (0.1129)	0.1033 (0.1644)
MEAN_QUANTITY	0.0035 (0.0070)	0.0093 (0.0194)	-0.0035 (0.0035)
QUANTITY_ASYMMETRY	0.2131* (0.1146)	0.9559* (0.5246)	0.0163 (0.0641)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.0162 (0.0121)	-0.0082 (0.0138)	-0.0166 (0.0230)
HOME_LISTENING	0.3960* (0.2129)	0.3814* (0.2099)	-0.7523 (0.7518)
HHI	0.5952 (0.4696)	1.0910** (0.5151)	0.9347 (0.6467)
LISTENERSHIP_ASYMMETRY	0.4041*** (0.1495)	0.3494** (0.1622)	0.2645 (0.1983)
MEAN_QUANTITY	-0.0095 (0.0196)	0.0145 (0.0460)	-0.0139 (0.0091)
QUANTITY_ASYMMETRY	0.1819 (0.2354)	1.7545 (1.0859)	-0.3330*** (0.1064)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.0246** (0.0105)	-0.0209** (0.0109)	-0.0175 (0.0152)
HOME_LISTENING	0.1674 (0.1812)	0.1757 (0.1775)	0.0460 (0.5092)
HHI	-0.4496 (0.2822)	-0.2878 (0.2857)	-0.2336 (0.4711)
LISTENERSHIP_ASYMMETRY	0.1898** (0.0921)	0.1869* (0.1015)	0.0996 (0.1214)
MEAN_QUANTITY	-0.0199** (0.0083)	-0.0316** (0.0144)	-0.0041 (0.0053)
QUANTITY_ASYMMETRY	-0.0139 (0.0616)	-0.1119 (0.2531)	-0.0173 (0.0420)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)	0.0074	0.1160	0.1240
Number of observations	323,143	323,143	323,143

Notes: see Table 5(a)

**TABLE C: Any Number of Commercials in Break**

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
<i>NUMBER_STATIONS</i>	-0.0194** (0.0090)	-0.0192* (0.0098)	-0.0075 (0.0169)
<i>HOME_LISTENING</i>	0.5136*** (0.1688)	0.4965*** (0.1642)	-0.0755 (0.6237)
<i>HHI</i>	0.5248 (0.3458)	0.7467** (0.3573)	0.5700 (0.3976)
<i>LISTENERSHIP_ASYMMETRY</i>	0.1693* (0.0966)	0.1653 (0.1126)	0.1081 (0.1609)
<i>MEAN_QUANTITY</i>	-0.0063* (0.0036)	-0.0129 (0.0078)	0.0000 (0.0015)
<i>QUANTITY_ASYMMETRY</i>	-0.0395 (0.0701)	-0.0624 (0.2620)	-0.0054 (0.0374)
<u>MIDDAY*</u>			
<i>NUMBER_STATIONS</i>	-0.0103 (0.0130)	-0.0059 (0.0138)	-0.0134 (0.0260)
<i>HOME_LISTENING</i>	0.4568* (0.2377)	0.3874 (0.2380)	-0.396 (0.8599)
<i>HHI</i>	0.8673* (0.5230)	1.1006** (0.5460)	1.1985 (0.7452)
<i>LISTENERSHIP_ASYMMETRY</i>	0.3184** (0.1550)*	0.2631 (0.1650)	0.2126 (0.2119)
<i>MEAN_QUANTITY</i>	-0.0215** (0.0091)	-0.0526** (0.0217)	0.0047 (0.0044)
<i>QUANTITY_ASYMMETRY</i>	0.0597 (0.1462)	0.2748 (0.4362)	-0.0420 (0.0683)
<u>NIGHT*</u>			
<i>NUMBER_STATIONS</i>	-0.0187* (0.0112)	-0.0148 (0.0117)	-0.0110 (0.0168)
<i>HOME_LISTENING</i>	0.0693 (0.1957)	0.0046 (0.1984)	0.1051 (0.5152)
<i>HHI</i>	-0.3486 (0.3025)	-0.2620 (0.3338)	-0.0835 (0.5263)
<i>LISTENERSHIP_ASYMMETRY</i>	0.1716* (0.0980)	0.1421 (0.1107)	0.0946 (0.1336)
<i>MEAN_QUANTITY</i>	-0.0168*** (0.0049)	-0.0367*** (0.0092)	0.0016 (0.0025)
<i>QUANTITY_ASYMMETRY</i>	0.0394 (0.0339)	0.0541 (0.1345)	-0.0090 (0.0213)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)	0.0095	0.129	0.1569
Number of observations	331,045	331,045	331,045

Notes: see Table 5(a)

TABLE D: Any number of songs

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.0242*** (0.0092)	-0.0245** (0.0101)	-0.0090 (0.0180)
HOME_LISTENING	0.5136*** (0.1667)	0.4994*** (0.1669)	0.2390 (0.6450)
HHI	0.4929 (0.3045)	0.6706* (0.3465)	0.6430* (0.3510)
LISTENERSHIP_ASYMMETRY	0.2575*** (0.0963)	0.2446** (0.1150)	0.1520 (0.1620)
MEAN_QUANTITY	-0.0088 (0.0062)	-0.0088 (0.0149)	-0.0030 (0.0030)
QUANTITY_ASYMMETRY	0.0565 (0.1033)	0.7027 (0.5142)	-0.0060 (0.0600)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.0160 (0.0132)	-0.0117 (0.0143)	-0.0150 (0.0250)
HOME_LISTENING	0.4643* (0.2349)	0.4495* (0.2377)	-0.5910 (0.8460)
HHI	0.7464 (0.5124)	1.0601 (0.5598)	1.1180 (0.7240)
LISTENERSHIP_ASYMMETRY	0.3898** (0.1552)	0.3483** (0.1631)	0.2560 (0.2170)
MEAN_QUANTITY	-0.0268** (0.0130)	-0.0432 (0.0371)	0.0000 (0.0060)
QUANTITY_ASYMMETRY	-0.0074 (0.1981)	0.6249 (1.1044)	-0.1630* (0.0940)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.0211* (0.0113)	-0.0170 (0.0115)	-0.0130 (0.0160)
HOME_LISTENING	0.1062 (0.1941)	0.0738 (0.1929)	0.1340 (0.5370)
HHI	-0.3914 (0.2946)	-0.3416 (0.3371)	-0.0760 (0.5040)
LISTENERSHIP_ASYMMETRY	0.1804* (0.0966)	0.1509 (0.1085)	0.0960 (0.1310)
MEAN_QUANTITY	-0.0193*** (0.0068)	-0.0337*** (0.0113)	0.0020 (0.0040)
QUANTITY_ASYMMETRY	-0.0017 (0.0549)	-0.1431 (0.2320)	0.0080 (0.0360)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)	0.0095	0.1298	0.1508
Number of observations	331,896	331,896	331,896

Notes: see Table 5(a)

**TABLE E: Natural Logs for the Number of Stations, Proportion of Listening to Home Market Stations and Quantity of Commercials**

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.3175*** (0.1066)	-0.3012** (0.1158)	-0.0679 (0.2492)
HOME_LISTENING	0.4362*** (0.1099)	0.4407*** (0.1112)	0.1354 (0.2731)
HHI	0.4031 (0.3883)	0.7877** (0.3815)	0.9392** (0.4294)
LISTENERSHIP_ASYMMETRY	0.2415** (0.0977)	0.2386** (0.1110)	0.1183 (0.1803)
MEAN_QUANTITY	-0.0819 (0.0726)	-0.2754 (0.2072)	0.0331 (0.0334)
QUANTITY_ASYMMETRY	0.0306 (0.1040)	0.2618 (0.4870)	0.0326 (0.0593)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.2462* (0.1475)	-0.2272 (0.1458)	-0.1982 (0.3535)
HOME_LISTENING	0.3817** (0.1516)	0.3925*** (0.1413)	-0.5015* (0.2887)
HHI	0.6621 (0.5443)	1.0240* (0.5719)	1.0476 (0.7613)
LISTENERSHIP_ASYMMETRY	0.3822** (0.1520)	0.3551** (0.1600)	0.2459 (0.2210)
MEAN_QUANTITY	-0.2500** (0.1117)	-0.4261 (0.3614)	-0.0026 (0.0552)
QUANTITY_ASYMMETRY	-0.0118 (0.1975)	0.6961 (1.1408)	-0.2021** (0.0929)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.2871** (0.1226)	-0.2393* (0.1226)	-0.0105 (0.2305)
HOME_LISTENING	0.1644 (0.1295)	0.1467 (0.1213)	-0.0998 (0.2191)
HHI	-0.4542 (0.3131)	-0.3208 (0.3222)	-0.0011 (0.5302)
LISTENERSHIP_ASYMMETRY	0.1917** (0.0957)	0.1813* (0.1071)	0.0533 (0.1405)
MEAN_QUANTITY	-0.1136** (0.0485)	-0.1811** (0.0829)	0.0061 (0.0270)
QUANTITY_ASYMMETRY	0.0293 (0.0562)	-0.0634 (0.2378)	0.0082 (0.0354)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)	0.0097	0.1216	0.1477
Number of observations	323,198	323,198	323,198

Notes: see Table 5(a)

TABLE F: Excluding the Ten Largest Metro-Markets

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.0211** (0.0086)	-0.0192** (0.0094)	0.0037 (0.0175)
HOME_LISTENING	0.5218*** (0.1714)	0.5321*** (0.1661)	0.1380 (0.7100)
HHI	0.6349* (0.3811)	1.0242*** (0.3592)	0.9802** (0.4064)
LISTENERSHIP_ASYMMETRY	0.2621** (0.1028)	0.2748** (0.1158)	0.0473 (0.1633)
MEAN_QUANTITY	-0.0055 (0.0057)	-0.0201 (0.0171)	0.0019 (0.0029)
QUANTITY_ASYMMETRY	-0.0225 (0.1052)	0.1161 (0.5085)	-0.0056 (0.0617)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.0155 (0.0117)	-0.0110 (0.0125)	-0.0121 (0.0267)
HOME_LISTENING	0.4706* (0.2238)	0.4613** (0.2176)	-0.7836 (0.8398)
HHI	0.8760* (0.5253)	1.2678** (0.5570)	1.0647 (0.7279)
LISTENERSHIP_ASYMMETRY	0.3899** (0.1594)	0.3746** (0.1675)	0.1790 (0.2094)
MEAN_QUANTITY	-0.0261** (0.0129)	-0.0441 (0.0392)	-0.0003 (0.0065)
QUANTITY_ASYMMETRY	-0.0360 (0.2042)	0.5378 (1.1375)	-0.1921** (0.0943)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.0226** (0.0092)	-0.0188** (0.0094)	-0.0148 (0.0187)
HOME_LISTENING	0.1327 (0.1792)	0.1350 (0.1713)	-0.0277 (0.5476)
HHI	-0.3111 (0.3009)	-0.1913 (0.3116)	-0.0998 (0.5276)
LISTENERSHIP_ASYMMETRY	0.1943* (0.1000)	0.1858* (0.1100)	0.1126 (0.1342)
MEAN_QUANTITY	-0.0192*** (0.0070)	-0.0348*** (0.0116)	-0.0004 (0.0041)
QUANTITY_ASYMMETRY	-0.0003 (0.0568)	-0.1617 (0.2333)	0.0112 (0.0367)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)	0.0095	0.1318	0.1390
Number of observations	295,832	295,832	295,832

Notes: see Table 5(a)

TABLE G: Metro-Market and Airplay Sample Characteristics

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.0213** (0.0106)	-0.0188 (0.0113)	-0.0031 (0.0177)
HOME_LISTENING	0.5311*** (0.2020)	0.5202*** (0.1953)	0.2979 (0.6770)
HHI	0.3805 (0.4491)	0.7613* (0.4569)	0.6704 (0.4492)
SAMPLE_HHI	0.1155 (0.3255)	0.1293 (0.3003)	0.7434 (0.6381)
LISTENERSHIP_ASYMMETRY	0.2759** (0.1291)	0.2718** (0.1361)	0.0186 (0.1954)
SAMPLE_ASYMMETRY	-0.1946 (0.3221)	-0.1917 (0.3794)	0.2487 (0.2826)
MEAN_QUANTITY	-0.0050 (0.0056)	-0.0152 (0.0166)	0.0016 (0.0028)
QUANTITY_ASYMMETRY	0.0640 (0.1030)	0.4456 (0.5040)	0.0217 (0.0598)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.0186 (0.0143)	-0.0130 (0.0156)	-0.0231 (0.0279)
HOME_LISTENING	0.5701** (0.2569)	0.5628** (0.2537)	-0.5667 (0.8428)
HHI	0.3400 (0.5853)	0.6578 (0.5974)	0.8043 (0.7465)
SAMPLE_HHI	0.3838 (0.4312)	0.4731 (0.4266)	0.7303 (1.2151)
LISTENERSHIP_ASYMMETRY	0.4758** (0.1897)	0.4533* (0.1972)	0.2722 (0.2729)
SAMPLE_ASYMMETRY	-0.5749 (0.4140)	-0.6818 (0.4909)	-0.0930 (0.4166)
MEAN_QUANTITY	-0.0256** (0.0123)	-0.0373 (0.0352)	-0.0005 (0.0064)
QUANTITY_ASYMMETRY	0.0468 (0.1914)	1.1862 (1.1036)	-0.2030** (0.0936)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.0227* (0.0123)	-0.0198 (0.0127)	-0.0191 (0.0191)
HOME_LISTENING	0.1486 (0.2144)	0.1241 (0.2073)	0.0943 (0.5430)
HHI	-0.4453 (0.3814)	-0.2654 (0.4113)	-0.2984 (0.5857)
SAMPLE_HHI	0.0122 (0.2883)	-0.0739 (0.2385)	0.5829 (0.7526)
LISTENERSHIP_ASYMMETRY	0.2497** (0.1246)	0.2245* (0.1285)	0.1755 (0.1705)
SAMPLE_ASYMMETRY	-0.2816 (0.3179)	-0.2018 (0.3501)	-0.2232 (0.2786)
MEAN_QUANTITY	-0.0189*** (0.0066)	-0.0375*** (0.0117)	0.0008 (0.0040)
QUANTITY_ASYMMETRY	-0.0002 (0.0563)	-0.1491 (0.2309)	0.0109 (0.0358)
Dummies	Hour Week Day of Week	Hour Week Day of Week	Week Day of Week Metro-Market-Hour Market-Hour
Adjusted R <sup>2</sup> (incl. dummies)	0.0099	0.1231	0.1478
Number of observations	323,198	323,198	323,198

Notes: see Table 5(a)

TABLE H: Instrumenting For Quantity

	(1) Pooled Market-Hours	(2) Between Market-Hours	(3) Within Market-Hours (Fixed Effects)
<u>DRIVETIME*</u>			
NUMBER_STATIONS	-0.0203** (0.0098)	-0.0188* (0.0105)	-0.0205 (0.0177)
HOME_LISTENING	0.5095*** (0.1816)	0.4642** (0.2066)	0.2736 (0.6765)
HHI	0.5672 (0.3736)	0.7545* (0.4532)	0.7216* (0.3947)
LISTENERSHIP_ASYMMETRY	0.2519** (0.1030)	0.2470** (0.1128)	0.2098 (0.1674)
MEAN_QUANTITY	0.0266*** (0.0079)	0.0200 (0.0314)	0.0264*** (0.0077)
QUANTITY_ASYMMETRY	0.4045*** (0.1400)	0.5890 (0.6848)	0.2844*** (0.1031)
<u>MIDDAY*</u>			
NUMBER_STATIONS	-0.0158 (0.0134)	-0.0082 (0.0144)	-0.0330 (0.0264)
HOME_LISTENING	0.5012** (0.2391)	0.4516* (0.2471)	-0.5652 (0.8215)
HHI	0.8404 (0.5258)	1.2765** (0.6049)	0.8404 (0.7196)
LISTENERSHIP_ASYMMETRY	0.4098** (0.1616)	0.3455** (0.1735)	0.3481* (0.2115)
MEAN_QUANTITY	0.0249* (0.0146)	0.0315 (0.0811)	0.0116 (0.0123)
QUANTITY_ASYMMETRY	0.4669 (0.2889)	2.4216 (1.8385)	-0.1403 (0.1257)
<u>NIGHT*</u>			
NUMBER_STATIONS	-0.0221* (0.0117)	-0.0175 (0.0119)	-0.0267 (0.0175)
HOME_LISTENING	0.1127 (0.2005)	0.0714 (0.2043)	0.1006 (0.5487)
HHI	-0.3333 (0.3094)	-0.3055 (0.3351)	-0.2953 (0.5487)
LISTENERSHIP_ASYMMETRY	0.2296** (0.1017)	0.1663 (0.1104)	0.2075* (0.1247)
MEAN_QUANTITY	0.0218** (0.0106)	-0.0368 (0.0397)	0.0104 (0.0107)
QUANTITY_ASYMMETRY	0.0709 (0.0659)	0.0800 (0.2246)	0.0111 (0.0435)
Dummies	Hour	Hour	Market-Hour
Instruments	Day of Week * Daypart Week * Daypart	Day of Week * Daypart Week * Daypart	Day of Week * Daypart Week * Daypart
Number of observations	323,198	323,198	323,198

Notes: see Table 5(a)