Alternating Advertising and Tacit Collusion:
Evidence in advertising channels

by

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Abstract

I propose a theoretical model, in which firms share the market intertemporally and use advertisements to monitor other members' compliance to the collusive strategy. In this case, they are predicted to choose a minimal level of advertising in equilibrium. Using the Nielsen Ad Intel data, I found evidence of firms advertising in alternating periods on three major platforms: spot TV, network TV, and radio. These firms found to spend less than competitive firms on each ad occurrence.

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1 Introduction

Collusion between firms creates market inefficiencies and ultimately hurts consumers. When competition is low, firms are not incentivized to innovate, and they can charge consumers a hefty mark-up with their market power. Thus, economists and the antitrust authority has been trying to prevent and detect collusion. There have been new programs and policies in place to combat anti-competitive behaviors, such as the Corporate Leniency Program, in which firms are granted full immunity from criminal prosecution if they cooperate with the authority. The topic of collusion indeed attracts interest from many economists; however, most papers assume firms follow the market sharing strategy when colluding. The alternating monopoly strategy still remains relatively less studied.

Unlike the market sharing strategy, firms do not compete in every period in the alternating monopoly strategy. Instead, each firm waits until its 'assigned' period and acts as a monopoly in that period. Although this strategy does not obviously seem to bring in more profit for firms, there are some advantages, most notably an easier way to monitor other firms. Instead of trying to find out which prices the other firms are offering, colluders under alternating monopoly only need to use their presence in the market as a signal for deviation. A famous example that can illustrate this strategy is the "Electrical Conspiracy" case in the 1950s. In this case, 29 industrial electrical generators and equipment suppliers colluded in first-price sealed-bid procurement auctions. This bidding ring used a rotation scheme, in which each ring member was assigned a phase of the Moon. Using the Moon cycle, the ring determined which member would have the right to bid, and other ring members would not participate, which decreased the level of competition. This paper investigates how advertising works under this less traditional collusive strategy.

Advertising is often, if not always, thought of as a signal of competition in the market. However, this may not always be the case. When firms advertise simultaneously, the effect of advertising is partially canceled out. Economic models [1] have proved that when firms compete by advertising, the price and sale volume may not change from the pre-ad level; however, the competing firms still have to pay for the advertising costs, so advertising is socially wasteful in this case. While these models share a very extreme view, the economic intuition holds. Firms may want to avoid this unfavorable situation by tacitly colluding: instead of advertising simultaneously, firms may want to do so intertemporally.

As mentioned above, one advantage of the alternating monopoly strategy is more accessible monitoring. Firms may use advertising, which is publicly observable, as a coordination device. The model later discussed in this paper will present the role of advertising in the alternating monopoly equilibrium. For the empirical

[1] One example is the Hotelling model that studies the persuasive role of advertising. Products from firms spending more on ads seem to be of higher quality to consumers, which increases their demand. However, for two symmetric firms with similar products, they will choose the same level of advertising in equilibrium. Thus, their products before and after advertising are always of the same quality, and no firm gains any competitive advantage as a result.

exercise, in which I attempt to find evidence of tacit collusion, the Nielsen Ad Intel data will be used. This data set covers both local and national advertising from 2010 to 2019 at the occurrence level. A wide variety of platforms and channels such as cable TV, radio, or digital are covered by Nielsen. Each ad occurrence on these tracked channels is recorded using about 20 variables, including the exact time and date of the occurrence, the brand behind each ad, and how much firms spent on each occurrence. These variables will be used later to help identify potential colluders from each industry and market.

The paper is organized as follows. In section 2, I will discuss related works that were done. In section 3, the theoretical model is proposed. In section 4, I propose the data set and empirical methods to detect collusion. In section 5, I will discuss the results. Section 6 is the conclusion.

2 Literature Review

This paper closely relates to other literature on collusion and repeated games. The alternating monopoly equilibrium was found by Maskin and Tirole (1988), and the model in this paper was the founding framework for the model in my paper.

Previous literature pointed out examples of intertemporal market division, and how firms may be tacitly colluding. A book by Dixit and Nalebuff (1991), 'Thinking Strategically,' referred to the case of Coca-Cola and Pepsi. In a span of 52 weeks, the two firms offered 26 weeks of price promotions; however, there was no overlap between any of them. The chance of this occurring by luck, as calculated by the authors, is 1/495,918,532,948,104, which raises a red flag that there may be collusive behavior between the two firms.

Other examples of this strategy were also suggested. One less obvious instance is the taxis at airports or hotels (Herrings et al., 2002). The drivers will have to line up every time they serve a passenger, and the infrastructures at airports and hotels also do not allow cheating by skipping the line. The movie industry is another potential example that is more closely related to advertising (Amelio, 2010). Firms typically advertise their movies even a year earlier than their actual release dates. These early advertising campaigns may help firms signal their entries so that other firms can avoid competition.

Economists have attempted to model the alternating monopoly strategy and proved that it is theoretically possible to maintain. Amelio and Biancini (2010) compared the alternating monopoly strategy to the market sharing strategy. They found that if firms have a low expectation of the future market state and have a high enough discount factor or patience, the alternating strategy is preferable and, in many cases, the only feasible collusive equilibrium. Moreover, this strategy also suffers less from the introduction of more firms, and it is more desirable when there is a fixed cost of entry.

Another attempt to model alternating monopoly was done by Herings, Peeters, and Schinkel (2005). They showed that the alternating monopoly equilibrium is Markov perfect, and for all discount factors that can support this strategy, it is strictly payoff dominant. Furthermore, the authors also investigated how different discount factors lead to different speeds of convergence to alternating monopoly. This conclusion may suggest that there are industries where this collusive equilibrium is easier to sustain than others.

Zillante did a more experimental approach to seek evidence for alternating monopoly. The author conducted an experiment where participants chose the release date of their products. He found that these 'firms' show tendencies towards collusive behavior: they coordinated to span out the releases so that each could enjoy the monopoly in their 'assigned' periods. To expand this paper, Zillante investigated the baseball card industry to find evidence of release date coordination; however, there was no statistically significant evidence of tacit collusion between firms in this industry.

In this paper, I want to expand the literature by investigating whether there is evidence of alternating advertising between firms. Firstly, I propose an extension of the model by Amelio and Biancini by adding advertising to the model and finding the optimal level of advertising for the collusive equilibrium. Like the work done in that paper, I want to compare the two collusive strategies, alternating monopoly and market sharing, to find conditions when the prior is feasible and preferred. Then, I utilize the Nielson Ad Intel data to conduct the empirical exercise to find colluding firms. Lastly, I will analyze colluders' spending behavior in the ad market compared to competitive firms.

3 Model

The model in this section is built on the framework by Amelio and Biancini (2010). Consider a market with N symmetric firms producing homogeneous goods at constant marginal cost c. To simplify the analysis, assume $N = 2$ and $c = 0$.[2] These two firms play an infinitely repeated game to maximize the discounted future profit, and at each stage, they earn $\pi(p) = (p - c)D(p)$. The monopoly price is $p^M = \arg\max_p \pi(p)$. Suppose there are two possible states of demand, high and low. The low state of demand manifests every period with probability α, and when this happens, there is no demand:

$$D \in \{D^H(p) = D(p), D^L(p) = 0\}, Prob\{D = D^L(p)\} = \alpha \tag{3.1}$$

The two players in the market cannot observe the state of demand that they are in, and the price and sales of their rival. If a firm has positive profit during the collusive periods, it knows that the other firm is still following the collusive strategy. However, when a firm observes zero profit, it does not know whether it just happened to be in the low state of demand or the other firm undercut it.

At each period, firms decide on a level of advertising A. When at least one firm advertises, the firm with a higher level of advertising observes profit $\pi(p) = pD(p)$ if demand is in state high and $\pi(p) = 0$ otherwise. If both firms choose the same A, the firms share the whole demand $D(p)$.[3] Advertising is publicly observable[4]; thus, by choosing to advertise and entering [5] the market, firms are making a move detectable to other cartel members. Thus, during the alternating monopoly periods, firms that decide to enter the market in 'non-assigned' periods will be detected with probability 1. In this case, advertising serves as a coordination device for firms as it helps monitor the other firm when market demand is uncertain.

3.1 The Alternating Monopoly Strategy (AMS)

In the Alternating Monopoly Strategy, firms take turns being the monopoly in the market. For example, consider a cartel of 3 firms A, B, and C. Firm A will enter the market in periods {1, 4, 7, ...}, and firm B will do so in periods {2, 5, 8, ...}, and firm C's periods are {3, 6, 9, ...}.

First, consider the equilibrium in which firms follow the alternating monopoly strategy. Any level of advertising will always bring in the whole demand available in each period. Thus, in this case, firms only need to pay $A = \epsilon$, where ϵ is positive and negligible. This minimal level of advertising is enough to set

[2] The case with more firms will be discussed in the late subsection.

[3] This applies to the case when both firms choose not to advertise, i.e $A = 0$.

[4] If firms can observe advertising before price-setting, then deviation from the collusive strategy will be impossible. In this paper, I assume firms observe advertising after prices have been set.

[5] When firms enter the market, they will produce $q > 0$

the firm apart from its rival, so there is no incentive to spend more. In each period, firms will set the profit-maximizing price p^M and earn profit π^M. The expected profit of each firm in each period will be $(1-\alpha)\pi^M - A \approx (1-\alpha)\pi^M$. Assume that firm 1 starts advertising in the first period and firm 2 starts in the second period. Let δ be the discount factor for both firms, $\delta < 1$. Their net present value under collusion are as follows:

$$v_1 = (1-\alpha)\pi^M + \delta^2 v_1 \tag{3.1.1}$$

$$v_2 = \delta(1-\alpha)\pi^M + \delta^2 v_2 \tag{3.1.2}$$

The discount factor here is δ^2 because firms have to wait for the other player's turn. The incentive to deviate for the two firms differs. If both firms follow the collusive strategy, firm 1 has at least one period of 'guaranteed' monopoly profit. On the other hand, firm 2 is always at risk of being undercut by firm 1, making its incentive constraint higher. Thus, as long as the incentive constraint of firm 2 is satisfied, both firms will follow the Grim trigger strategy. If a firm decides to undercut, they will choose $A = \epsilon + \omega$, where ω is also positive and negligible. The deviating firm will earn the monopoly profit $(1-\alpha)\pi^M$. On the other hand, undercutting in price means sharing the market with the other firm and earning strictly less than the monopoly profit. Thus, firms will choose to undercut in level of advertising instead of price. The two firms will collude until a firm competes in its non-assigned period, firms punish by going back to competition. As any higher level of advertising will attract the whole demand, in equilibrium, both firms will choose $A = pD(p)/2$.[6] Thus, both firms will earn 0 profit during the competition periods. The incentive constraint for firm 2 is:

$$v_2 \geq (1-\alpha)\pi^M \tag{3.1.3}$$

From equations (3.1.2) and (3.1.3):

$$\begin{aligned} v_2 &= \frac{\delta(1-\alpha)\pi^M}{1-\delta^2} \geq (1-\alpha)\pi^M \\ &\implies \frac{\delta}{1-\delta^2} \geq 1 \\ &\implies \delta \geq \frac{\sqrt{5}-1}{2} = \underline{\delta}_{AMS} \end{aligned} \tag{3.1.4}$$

When the discount factor for the two firms is above $\underline{\delta}_{AMS}$, they will follow the alternating monopoly strategy. With the minimum level of discount factor and net present value derived in this section, we can compare this strategy to the traditional market sharing strategy.

[6] Any higher level of advertising will result in negative profit, and any lower level of advertising will allow the rival to capture the whole market

3.2 The Market Sharing Strategy (MSS)

By sharing the market, the two firms choose the same level of advertising. Similar to the alternating monopoly case, firms will follow the Grim trigger strategy until a firm decides to deviate. In equilibrium, firms will set the level of advertising A, where A can be either negligible or even zero.[7] In each period, each firm will earn $\pi^M/2$ if colluding and nothing if competing.

In the market sharing strategy, both firms will always participate in the market and advertise. Thus, advertising cannot help detect deviation like in the case of alternating monopoly. Although the level of advertising may be the same, firms can still undercut by lowering the price to $p = p^M - \epsilon$. Thus, when a firm observes zero profit, it will not know whether it had bad luck or because the other firm deviated. To tackle this problem, both firms will go back to competition with probability β when observing zero profit. Thus, the net present value for each firm is:

$$v = (1-\alpha)\frac{\pi^M}{2} + \delta\{(1-\alpha)v + \alpha[(1-\beta)v + \beta \cdot 0]\} \tag{3.2.1}$$

Even when a firm deviates, the chance of the cheated firm deciding to go back to competition is $\beta < 1$. Thus, the cheating firm can still earn positive profit in the next periods. The incentive constraint is:

$$v \geq (1-\alpha)\pi^M + \delta[(1-\beta)v + \beta \cdot 0] \tag{3.2.2}$$

From equations (3.2.1), by taking first order condition with respect to β, the profit-maximizing β^* is:

$$\begin{aligned} \beta^* &= \frac{1-\delta}{\delta(1-2\alpha)} \leq 1 \\ \implies \delta &\geq \frac{1}{2(1-\alpha)} = \underline{\delta}_{MSS} \end{aligned} \tag{3.2.3}$$

By replacing β^* to equation (3.2.1), we have:

$$\begin{aligned} v &= (1-\alpha)\frac{\pi^M}{2} + \delta(1-\alpha)v + \delta\alpha\left[1 - \frac{1-\delta}{\delta(1-2\alpha)}\right]v \\ \implies v &\left[1 - \delta + \delta\alpha - \delta\alpha + \frac{\alpha(1-\delta)}{1-2\alpha}\right] = (1-\alpha)\frac{\pi^M}{2} \\ \implies v &= \frac{(1-\alpha)(1-2\alpha)}{2(1-\alpha-\delta+\alpha\delta)}\pi^M = \frac{1-2\alpha}{2(1-\delta)}\pi^M \end{aligned} \tag{3.2.4}$$

[7] The 2 firms are indifferent between advertising at a minimal negligible amount or not advertising at all. In either case, the deviating firm can undercut by lowering its price, which is not observable.

By replacing β^* to equation (3.2.2), we have:

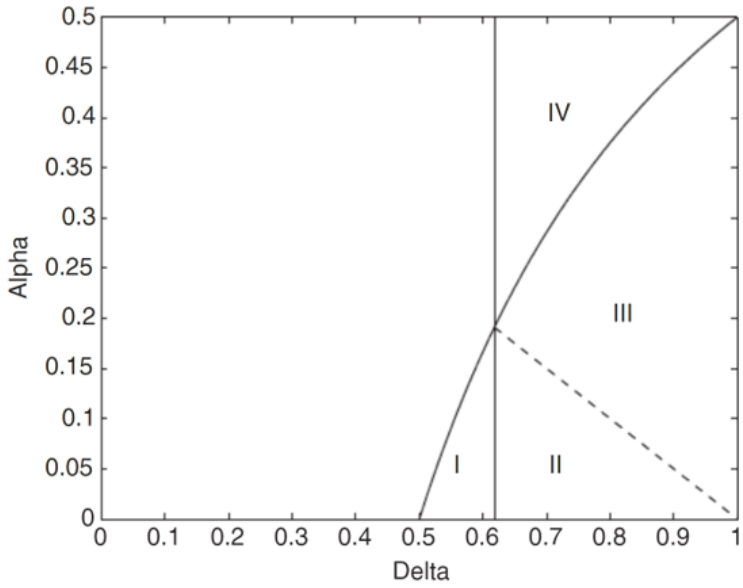
$$\begin{aligned} & v \geq (1-\alpha)\pi^M + \delta\left[1 - \frac{1-\delta}{\delta(1-2\alpha)}\right] v \\ \implies & v\left[1 - \delta + \frac{1-\delta}{1-2\alpha}\right] \geq (1-\alpha)\pi^M \\ \implies & v \geq \frac{(1-\alpha)(1-2\alpha)}{2(1-\alpha-\delta+\alpha\delta)}\pi^M = \frac{1-2\alpha}{2(1-\delta)}\pi^M \end{aligned} \tag{3.2.5}$$

Thus, the incentive constraint is always satisfied when firms are choosing the profit-maximizing β^*. We can compare the two strategies with the minimum discount factor and the net present values to see when alternating monopoly might be preferred to the traditional market sharing strategy.

3.3 Comparing alternating monopoly and market sharing strategy

To compare the two strategies, we can look at the feasibility range and which strategy brings more expected profit for each firm.

Figure 1: Regions of equilibria (Amelio and Biancini, 2010)



Note: MSS and AMS is the only feasible strategy in region I and IV respectively. In region III, AMS is preferred to MSS, and in region II, MSS is the preferred strategy.

From equations (3.2.3) and (3.2.4), we can derive the area of feasibility for both strategies. MSS is feasible when $\delta \geq \frac{1}{2(1-\alpha)} \leftrightarrow \alpha < \frac{1}{2}$, and AMS is feasible when $\delta \geq \frac{\sqrt{5}-1}{2}$. When $\frac{1}{2(1-\alpha)} \leq \delta \leq \frac{\sqrt{5}-1}{2}$, only MSS is feasible and likewise, when $\frac{1}{2(1-\alpha)} \geq \delta \geq \frac{\sqrt{5}-1}{2}$, only AMS is feasible. When both are feasible, i.e $\delta \geq max\{\frac{1}{2(1-\alpha)}, \frac{\sqrt{5}-1}{2}\}$, the two firms will use expected net present value to choose the preferred strategy.

From the net present value equations above, AMS will bring in more profit when $2\alpha + \delta > 1$.[8] Figure 1 illustrates the feasibility regions. MSS is the only feasible strategy in region I and AMS is the only feasible strategy in region IV. In region III, AMS brings in more profit and thus preferred to MSS. Likewise, in region II, MSS is the preferred strategy.

From Figure 1, the alternating monopoly strategy thrives compared to market sharing under certain conditions. Since firms do not have to care about the demand states for periods they are not participating, alternating monopoly is better when there is more uncertainty in the market. However, since firms need to wait for one period until their active periods, the alternating monopoly strategy is only for firms with higher discount factors. Less patient firms will choose the market sharing strategy when colluding. Nonetheless, if patience is not an issue, then alternating monopoly will always do better as $\delta \to 1$, $2\alpha + \delta > 1 \; \forall \; \alpha > 0$.

3.4 Observable Demand Shock

Market uncertainty was proved to be an important factor that makes alternating monopoly more attractive to colluding firms. In this section, consider the case in which firms know the distribution for α, $F(\alpha)$. Suppose shocks are independent and iid across periods. Let $\mu_\alpha = \int_{\underline{\alpha}}^{\overline{\alpha}} \alpha dF(\alpha)$ be the expected value for α. The expected net present value changes as firms now know the expected value of the probability of a low market state. Thus, the incentive constraint for both firms also changes as follows. For the market sharing strategy,

$$\delta_{MSS}(\mu_\alpha) \geq \frac{1}{2(1-\mu_\alpha)} \tag{1}$$

And for the alternating monopoly strategy,

$$\delta_{AMS}(\mu_\alpha) \geq \frac{\sqrt{(1-\mu_\alpha)^2 + 4(1-\underline{\alpha})^2} - (1-\mu_\alpha)}{2(1-\underline{\alpha})} \tag{2}$$

In this case, the threshold for alternating monopoly is no longer constant, but it depends on the distribution $F(\alpha)$. In an environment where firms haves more information on the market state, alternating monopoly becomes less desirable.

3.5 Game With More Firms

With the intuition from the 2-firm cases, we can expand the model to accommodate N firms. As with any collusive equilibrium, the incentive constraint is expected to increase when more firms are involved. Thus, it will be harder to maintain the collusive equilibrium for both firms. However, we can compare the impact

[8] The region above the dotted line in Figure 1 represents $2\alpha + \delta > 1$

of having more firms on the alternating monopoly and the market sharing strategy. As the discount factor thresholds depend on the number of firms, we denote them as functions of N, i.e., $\delta_{AMS}(N)$ and $\delta_{MSS}(N)$.

For the market sharing strategy, the payoff each period for each player becomes π^M/N. Thus, the expected net present value for each firm becomes

$$v = \frac{1 - N\alpha}{N(1-\delta)}\pi^M \tag{3.5.1}$$

And the incentive constraint becomes

$$\delta_{MSS}(N) \geq \frac{N-1}{N(1-\alpha)} \tag{3.5.2}$$

In the alternating monopoly strategy, the payoff for each period is still the monopoly profit. However, firms need to wait $N-1$ periods until they can be active again. The incentive constraint will also become the constraint of the N^{th} firm that enters the market. The expected net present value for the firm starting at period i becomes

$$v_i = \frac{\delta^{i-1}(1-\alpha)}{1-\delta^N}\pi^M \tag{3.5.3}$$

And the incentive constraint becomes

$$\frac{\delta_{AMS}(N)^{N-1}}{1-\delta_{AMS}(N)^N} \geq 1 \tag{3.5.4}$$

Following the same steps as in Amelio and Biancini (2010) by taking the first order condition of $\delta_{AMS}(N)$ and $\delta_{MSS}(N)$ with respect to N, we have

$$\frac{\partial \delta_{MSS}(N)}{\partial N} > \frac{\partial \delta_{AMS}(N)}{\partial N} > 0 \tag{3.5.5}$$

From this result, the alternating monopoly strategy is more robust to an increase in the number of firms involved as it suffers less from introducing new firms. In the case of N firms, this strategy also remains feasible. Now that we have established the feasibility of this strategy, I want to look for empirical evidence of this phenomenon in different markets.

4 Empirical Analysis

4.1 Data

In this paper, I will attempt to detect tacit collusion in advertising using Nielsen's Ad Intel data set. This data set covers both local and national advertising occurrences[9] from 2010 to 2019, and advertisements are divided into ten categories and 24 sub-categories as presented in Table 1. The focus of this project will be the three categories with the most advertising occurrences: Spot TV, Network TV, and Radio.

Table 1: Categories of advertisements in Nielsen Ad Intel data

Sub-categories	**Categories**	**Sub-categories**	**Categories**
Network TV	Network TV	National Newspaper	Newspaper
Spanish Language Network TV	Network TV	National Sunday Supplement	Newspaper
Cable TV	Network TV	Local Newspaper	Newspaper
Spanish Language Cable TV	Network TV	Local Sunday Supplement	Newspaper
Syndicated TV	Network TV	National Magazine	Magazine
Spot TV	Spot TV	Local Magazine	Magazine
Network Clearance Spot TV	Spot TV	Outdoor	Outdoor
Syndicated Clearance Spot TV	Spot TV	National Internet	Internet
Local/Regional Cable TV	Spot TV	Local Internet	Internet
Network Radio	Radio	National Cinema	Cinema
Spot Radio	Radio	Local Cinema	Cinema
National Digital	Digital	FSI Coupon	FSI Coupon

Note: In this paper, I will only use 3 categories with the most number of ad occurrences: Network TV, Spot TV, and Radio data sets.

Firms in the Nielsen data set can be divided into industries at three levels: sub-category, major-category, and industry. For example, Timberland shoes will be categorized as Shoes & Boots at the sub-category level, Footwear at the major-category level, and Apparel, Footwear, & Accessories at the industry level. In this project, I will use major-category to divide the brands for the collusion detecting procedure. Thus, firms from different sub-categories but the same major-category can still be considered potential colluders. For the example of Timberland, its potential colluders may include firms from different sub-categories such as Sports Footwear (for example, Nike shoes). When detecting collusion, we want to consider homogeneous firms that produce the same goods. Using industry as the divisor would not help us achieve this goal because

[9]The Ad Intel data covers 225 different geographical markets, including national.

it is too broad: we would have firms producing shoes and shoelaces as competitors. On the other hand, using sub-category would ensure that only firms producing the exact same goods would collude; however, we would ignore the competition between firms producing goods that are substitutes for each other, like Timberland and Nike shoes. Thus, major-category is the middle ground that accounts for competition between firms producing different but competing products while also making sure these firms are homogeneous enough.

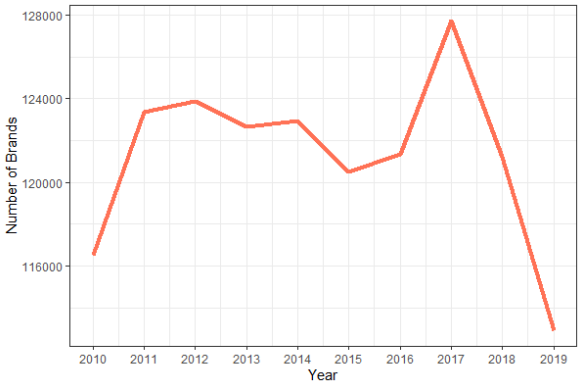
The four variables of interest in this project are Brand, Industry, Market, Ad code, and Ad date. Brand is the name of the brand that bought the commercial, and different brands may be owned by the same parent company. As mentioned above, Industry is the industry each brand is in at the major-category level. Market is the geographical market where an ad was bought. In the case of NetworkTV, all ads are shown nationally, so the market will be the channel an ad was on instead. Ad code is the unique identifier assigned to each commercial bought, and Ad date is the date when each ad occurrence was observed. As each ad may last for more than one day, we can observe multiple ad dates for the same ad code.

4.1.1 Spot TV

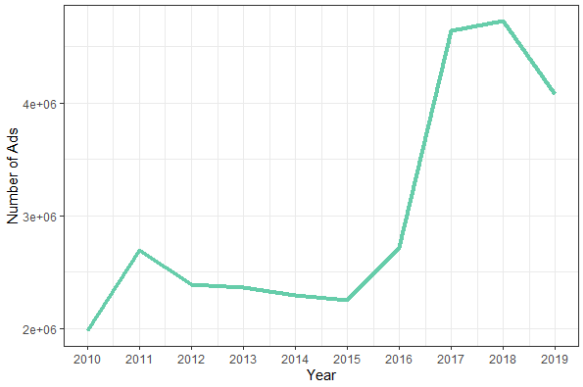
Spot TV advertising refers to the short 30 or 60-second commercial placements on television. When purchasing an ad placement, firms can choose the time slot[10] and also how long each ad lasts (such as for a month or a week) subjective to its budget. Then, the station where the commercial was bought will air the commercials at the times specified in the contract. The number of brands purchasing spot TV ads each year is shown in Figure 2a, and the number of spot TV ads bought each year is shown in Figure 2b.

Figure 2: Number of brands and ads in the Spot TV data set

(a) Number of brands



(b) Number of ads



The number of brands purchasing spot TV ads had an increase in 2017; however, it dropped sharply afterward to a level even below 2010. The number of ads also decreased after 2017 but not as sharply. This

[10] Usually, firms will try to choose a time slot that can help reach the intended audience. For example, a beer firm will not want to have a slot during children's programs.

may happen because most firms that dropped out of the spot TV market are smaller firms, which only purchases very few ads each year. Table 2 include the summary statistics for the number of ads each brand purchased. Although the maximum number of ads a brand bought is 253,502, most firms bought less than ten ads each year. Thus, the total number of ads each year will not decrease by much as long as the outlier firms still remain in the market. The decline in spot TV popularity may be due to its high cost and the rise of digital advertising. From the Nielsen data set, the average cost of a spot TV ad was $235 per occurrence in 2017, while the average cost of a digital ad in 2017 was $99 per occurrence.

I am only interested in brands that purchased more than one commercial in this project because firms can only be considered advertising alternately otherwise. Figure 3a is the histogram for the number of ads per brand after removing 1-ad firms.

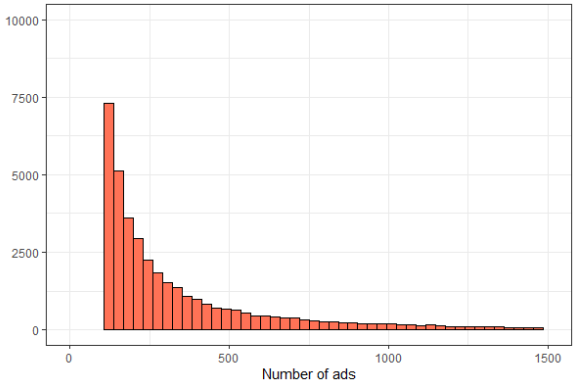
Table 2: Summary statistics for number of ads per brand and ad period length

	Observations	SD	Mean	Min	Q1	Median	Q3	Max
Ad per brand	1,213,026	484.2576	24.84482	1	1	3	9	253502
Ad duration (day)	30,137,414	56.165	34.08556	1	4	12	38	371

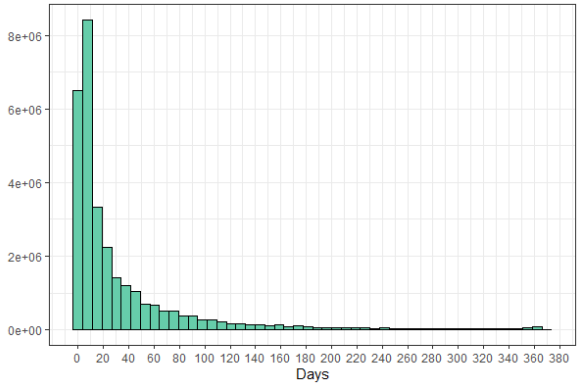
Another variable of interest is the duration each ad lasts for. In the collusion detecting procedure, this variable plays a crucial role in determining whether firms have any ads in the same time period. Table 2 includes the summary statistics for the ad duration we observed from 2010 to 2019. Similar to the number of ads per brand, extreme outliers last for even more than a year; however, most ads last around a month or less. Figure 3b is the histogram for ad duration.

Figure 3: Histogram for number of ads per brand and ad period length for Spot TV

(a) Ad per brand histogram



(b) Ad duration histogram



4.1.2 Network TV

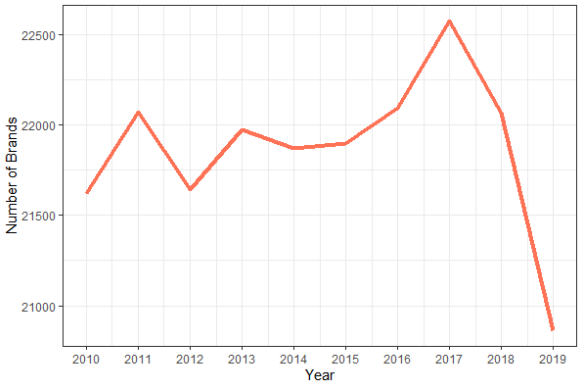
Similar to spot TV, network TV ads are also commercials seen on television; however, they are aired on traditional channels [11] such as ABC or CBS. From Figure 4a, We also observe a steep drop in the number of firms purchasing network TV ads from 2017. The total number of network TV ads also shares the same trend as the number of spot TV ads: it decreased following the drop in the number of advertisers in 2017 but not by much. From the summary statistics in Table 3, most network TV advertisers also purchased very few commercials per year. Thus, the small decrease in the total number of ads relative to the drop in the number of advertisers may also be because most firms that dropped out of the TV ad market are smaller firms with very few ad purchases. Figure 5a is the histogram for ads per bidder of network TV after removing brands that only advertise once.

Table 3: Summary statistics for number of ads per brand and ad period length for Network TV

	Observations	SD	Mean	Min	Q1	Median	Q3	Max
Ad per brand	218,678	112.1631	30.56259	1	1	4	15	6561
Ad duration (day)	6,683,367	51.61195	27.39403	1	4	6	28	366

Figure 4: Number of brands and ads in the Network TV data set

(a) Number of brands



(b) Number of ads

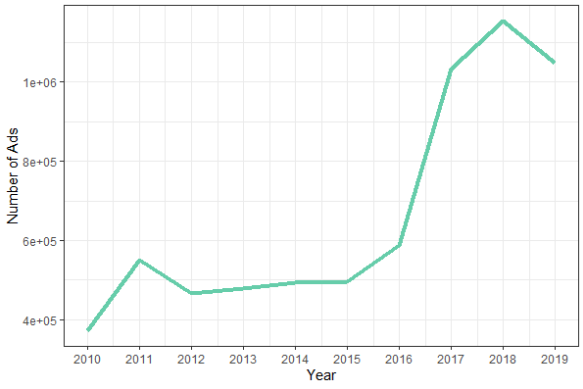
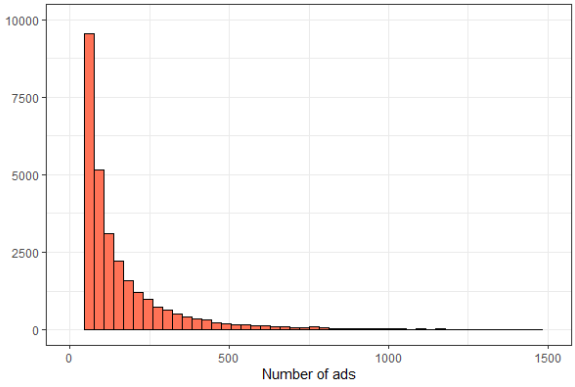


Figure 5b is the histogram for network TV commercials duration. Most ads on this platform do not last very long, and the duration distribution is even more left-heavy than spot TV ads'. In 2017, the average cost of a network TV ad occurrence was $2,040, which was ten times higher than spot TV. Thus, as the popularity of spot TV falls, network TV also follows as these two platforms are very similar, and network TV ads are even more expensive.

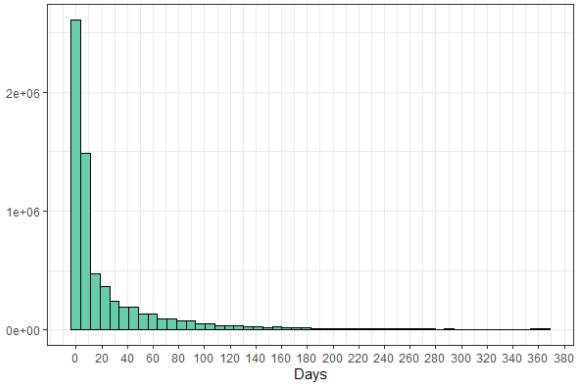
[11] These channels are free of charge; however, viewers can only watch their programs at scheduled times.

Figure 5: Histogram for number of ads per brand and ad period length

(a) Ad per brand histogram



(b) Ad duration histogram



4.1.3 Radio

Radio advertising refers to the commercials played by radio stations. There are many forms of radio advertising, such as live reads, in which the person behind the radio will read commercials on air, or radio sponsorship, in which the station will mention the brand that sponsors a specific program. As radio commercials are audio-only and they are also very short, the production cost for each ad must be much lower than the TV ads above. The average price of a radio ad occurrence was $104, which is much cheaper than TV ads and about the same as digital ads. Nonetheless, radio ads have some major weaknesses. Firstly, radio is becoming less popular since people can just listen to any song or podcast directly from their phones. There are peak times of the day, such as rush hours, when people tune in to know about the traffic; however, these time slots are very limited. Secondly, although radio ads being audio-only helps cut down the production costs, they lack the visual appeal that is usually used to capture the audience. Thus, although this platform is cheaper to advertise on, the number of brands participating is becoming lower. Figure 6a shows the number of brands in the radio ad market each year.

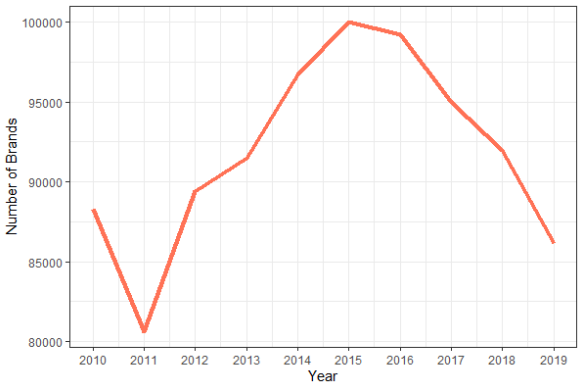
The number of brands purchasing radio increased significantly from 2011 to 2015, but the total number of ads did not have the same growth. From 2016, this platform lost popularity with advertisers, and the number of ads in 2019 is the lowest among the years the Nielsen data set covers. Nonetheless, radio ads still remain one of the most prevalent platforms.

Table 4: Summary statistics for number of ads per brand and ad period length for Radio

	Observations	SD	Mean	Min	Q1	Median	Q3	Max
Ad per brand	918,713	1.413449	1.258428	1	1	1	1	294
Ad duration (day)	1,156,134	121.6258	104.5797	1	8	43	190	365

Figure 6: Number of brands and ads in the Radio data set

(a) Number of brands



(b) Number of ads

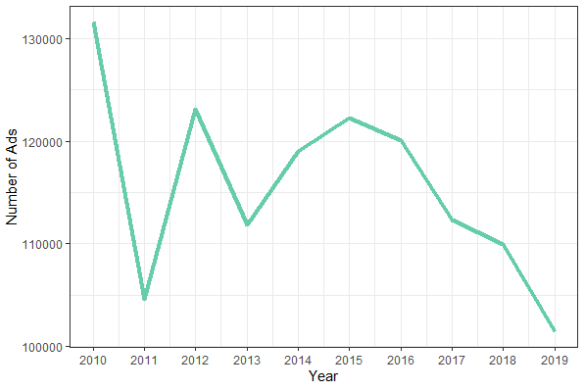
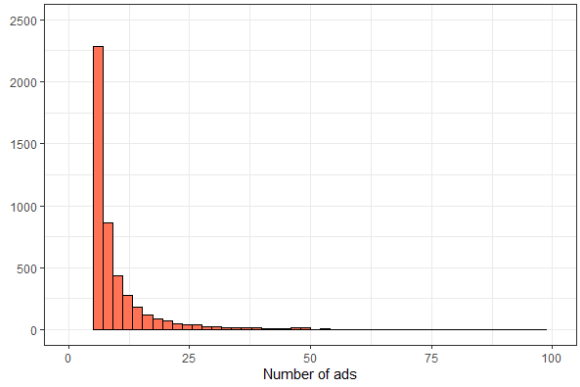


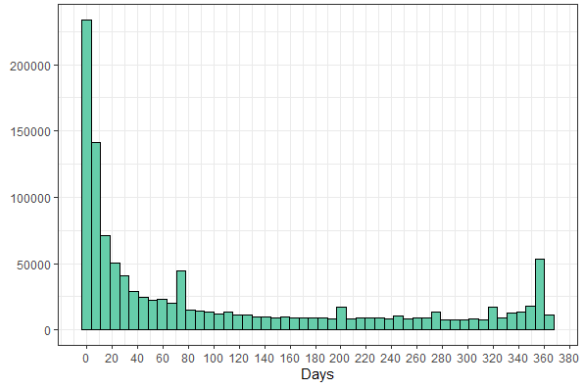
Table 4 is the summary statistics for the number of ads each brand bought and the length of each ad. Although radio ads are much cheaper than TV ads, advertisers buy significantly less compared to TV ads. Thus, the downsides of radio advertising seem to overweight its low cost to firms. Nonetheless, firms attracted to radio ads have much more extended ad periods, as shown in Figure 7b.

Figure 7: Histogram for number of ads per brand and ad period length

(a) Ad per brand histogram



(b) Ad duration histogram



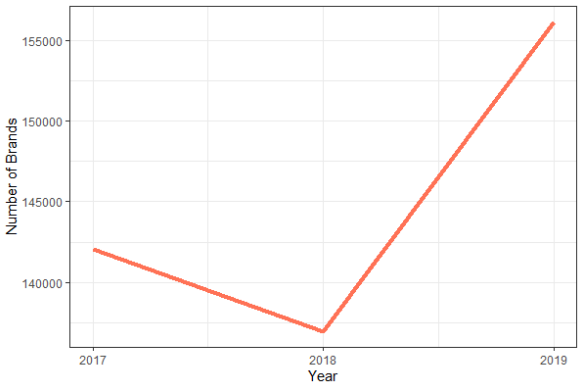
4.1.4 Digital

Digital ads are becoming one of the most dominant advertising platforms. The types of digital ads are incredibly diverse, from sponsored search results to pop-up ad that appears in many websites. On this platform, advertisers may apply technologies such as machine learning to learn more about consumers' backgrounds, spending, and interests, which helps identify who is more likely to purchase their products. As a result, digital advertising is more targeted and efficient than traditional channels. The Nielsen data set

only covers three years of digital ads, from 2017 to 2019; nonetheless, in these three years, the number of brands and ads on this platform has far surpassed network TV and radio. Figure 8 shows the total number of brands and ads in the digital ad market each year. Contrary to the hypothesis above that firms started moving from traditional platforms to digital from 2017, the number of digital ads buyers also decreased, though not nearly as much as in the previous cases. Nonetheless, from 2018 to 2019, digital advertising was the only platform that continued to grow.

Figure 8: Number of brands and ads in the Digital data set

(a) Number of brands



(b) Number of ads

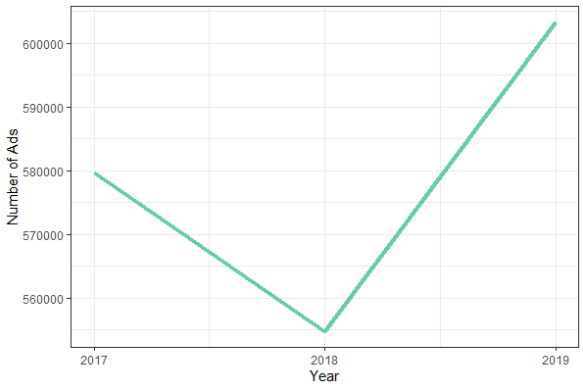


Table 5: Summary statistics for number of ads per brand and ad period length for Digital

	Observations	SD	Mean	Min	Q1	Median	Q3	Max
Ad per brand	435,151	21.8656	3.993345	1	1	1	3	5040
Ad duration (day)	1,737,708	100.5109	89.81252	1	16	47	129	365

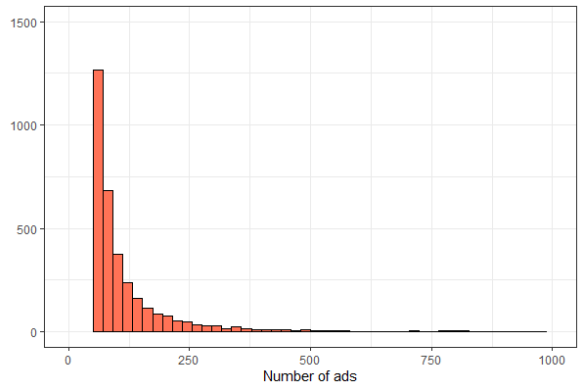
Table 5 is the summary statistics for the number of ads each brand bought and the length of each ad. Similar to all the platforms above, each firm purchased very few ads; in fact, 95% of advertisers purchased less than 12 ads per year, and more than 50% purchased only one. Surprisingly, the low cost of digital ads did not incentivize firms to buy more ads; however, as seen in the histogram in Figure 7b, firms instead chose to buy ads that lasted much longer. Unlike the traditional channels, digital ads have a very different cost structure, which favors ad length over ad quantity. Instead of paying for every ad occurrence, digital advertisers are charged using different metrics such as click-through rate,[12] conversion rate,[13] or cost per click. Thus, firms can choose to leave ads on for an extended period and pay whenever their ads successfully attract more customers. This crucial advantage may also explain why digital ads are becoming more and

[12]This is the rate advertiser pays whenever someone clicks on the ad to learn more about their products.

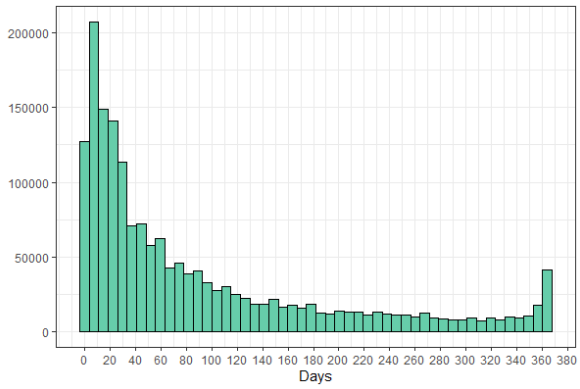
[13]This is the rate charged to advertisers whenever there is a purchase, or a desired action from customers, that was initiated by clicking their ads.

Figure 9: Histogram for number of ads per brand and ad period length

(a) Ad per brand histogram



(b) Ad duration histogram



more prevalent.

Although digital ad is one of the most important advertising platforms, it will not be used in this paper for two reasons. Firstly, the occurrence for digital is not controlled by the advertiser. For example, firms may purchase a Google search result [14] from April 1 to May 30; however, since no one searched for the sponsored keyword until April 15, the start date of that ad in our data set will be April 15 instead of April 1. This false information will definitely lead to inaccurate results. Secondly, I am interested in firm spending on ads since the theoretical model predicts that colluders will only spend a minimal amount. Since digital ad price may also depend on metrics such as click-through rate, the advertisers cannot have complete control over how much they would pay for each ad, which may make the analysis unreliable.

4.2 Collusion Detecting Procedure

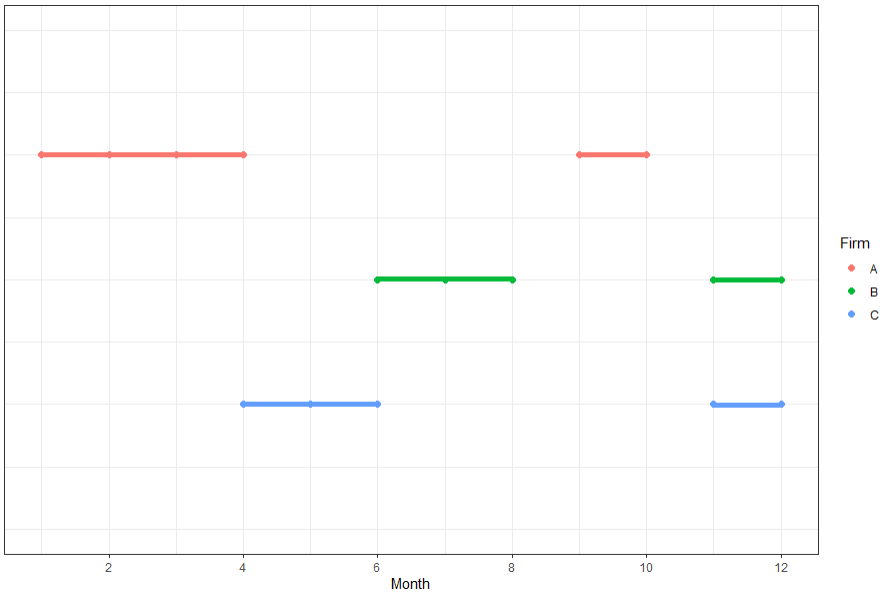
I only consider firms from the same industry and market as potential colluders because firms would have a very weak incentive to collude otherwise. Firms from different markets would have difficulty observing each other's ad occurrences, which makes the monitoring problem harder. I also consider only firms that advertise more than once because they would not be able to advertise alternately with any other firms if they only advertise once.

Firstly, I divide the firms into different industries using the procedure mentioned in the data section. Then, I divide the firms from the same industry into different markets. Firms from different industries or markets are assumed not to collude. If firms from the same industry share multiple markets, then they must be found colluding in all of those markets to be considered a colluding group. Using the unique ad code

[14] When someone searches for the keyboard the firm bought, its ad will pop up. The position of the ad among others will depend on how much the firm paid.

assigned to each ad, I group all ad occurrences with the same ad code into a single ad. The first and last day of that ad is the first and last occurrence observed with its ad code. These dates are used to create an ad range for each ad. For example, an ad that was shown on May 1, May 2, and May 5 by firm X will have a range from May 1 to May 5. If there is another firm Y that advertised on May 3, this new firm's ad still counts as being in X's ad range, and this pair will be considered not colluding. Figure 10 is another example with three firms A, B, and C. A and B may be considered colluding since none of their ad ranges overlap, and C will not be considered colluding with any other firm since its ad ranges overlap with both A and B. Next, I track each ad to the firm that purchased it and which market the ad was presented. Finally, for each market, I have firms of the same industry and all their ads with their ad ranges. Then, I remove all the brands that advertised only once and all the markets with only one firm.

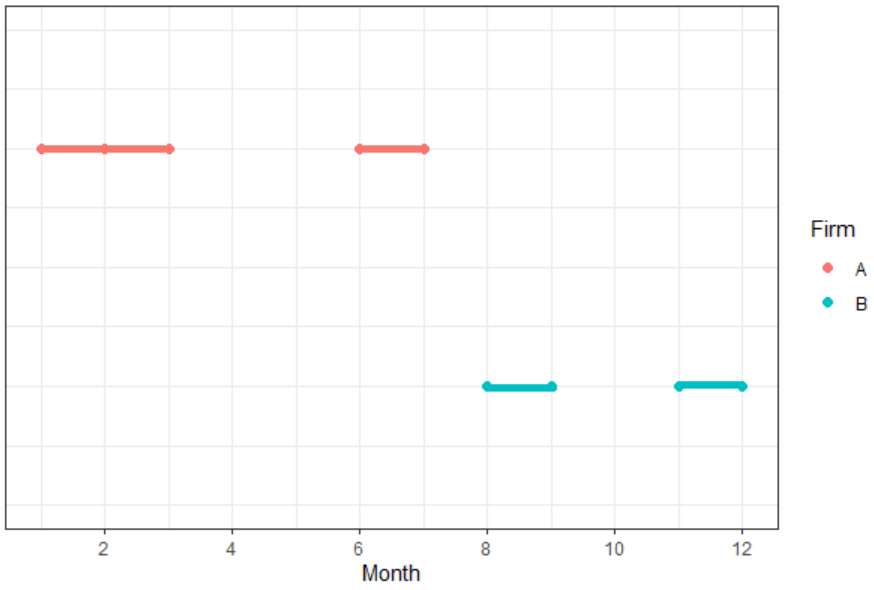
Figure 10: Example with 3 advertising firms



Having no overlap in ad ranges is not sufficient to conclude that firms are colluding. I imposed two other restrictions. Firstly, firms cannot be considered colluding if there are no alternating ad orders from them. For example, in Figure 11, firms A and B had no ad ranges that overlap; however, all of B's ads are after all of A's ads, so there is no alternating ad order. For a firm to be considered colluding with A, there must be at least an ad between March and June. Similarly, at least one of A's ad ranges must be between the other's firm's ad ranges. This restriction not only helps ensure the alternating order of advertising this paper is interested in but also avoide cases where a firm started advertising later than others, causing all their ad ranges to have no overlap.

The second restriction is that, given the number of ads two firms bought, the chance that none of their

Figure 11: Example with 3 advertising firms



ads has any overlap with each other must be unlikely enough. As seen in the data description, a large portion of ads last for only one day, and most firms bought very few ads. Thus, the chance of two firms having their ads not overlapping is very high. Even if their ads are in alternating order and satisfy the first restriction, we still cannot suspect them of colluding because it may happen just by chance. To find the probability that two firms A and B having no overlapping ads, I use Equation 4.2.1, in which n is the non-overlapping period, a is the number of days firm A advertised, and b is the number of days firm B advertised. If the probability p is smaller than 1%, then I conclude that the two firms A and B are colluding.

$$p = \frac{\binom{n}{a}\binom{n-a}{b}}{\binom{n}{a}\binom{n}{b}} \tag{4.2.1}$$

The non-overlapping period n is found as follows. The start of the period is the first day either firm A or B started advertising, and the end is the last day either of them last advertised. Then, the length of the period n is the number of days between the start and the end. Equation 4.2.1 helps ensure that (i) if firms have no overlap in a long period of time, then they must buy a lot of ads during that period to be considered colluders, and (ii) if firms bought only a few ads, then the time period that those ads are in must be short enough. For example, if firm A bought 2 ads and firm B bought 3 ads, then the chance that they have no overlap if the ads are scattered throughout the year is very high. For those firms to be considered colluders, then the colluding periods must be much shorter, or they would have to buy a lot more ads to fill the year.

After finding pairs of firms that may be colluding, I proceed to find bigger potential groups of colluders. For the case of triplets, if three firms (A, B, C) are colluding, then it must also mean that each pair from

the triplet are colluding. Thus, we must be able to find the three pairs (A, B), (A, C), and (B, C) colluding from the procedure above. The same goes for bigger groups: for (A, B, C, D) to be colluding, we must also observe (A, B), (A, C), (A, D), (B, C), (B, D), (C, D) colluding.

After following the procedure in this Section, Section 5 discusses the results found from the three advertising platforms.

5 Results

5.1 Spot TV

In the Spot TV data sets, a total of 34,953 potential colluding firms from 80 different industries were found. Among them, 778 groups were active for two years, 69 groups were active for three years, 13 groups were active for four years, 6 groups were active for five years, and the rest were active for one year or less. There are two reasons behind this extremely large number of groups found. Firstly, the data set is very big with more than 1.2 million firms. From these, we can form $7.4 \cdot 10^{11}$ pairs, and $3 \cdot 10^{17}$ triplets, so the 34,953 groups found represent only about $1.17 * 10^{-11}\%$ of all groups formed. Secondly, the large number of colluders found is due to the main weakness of the detecting procedure. The second restriction above helps reducing the number of 'false suspects' significantly; however, it is still not enough since this approach is only based on probabilities. There should be more filters, such as the collusive markers proposed by Harrington (2007).

Figure 12 is the plot for the number of colluding groups and the number of firms for each market.[15] Some may think that firms have more incentive to collude when there is more competition; however, from the graph, we cannot observe any trend or correlation between the two variables. Thus, the number of colluding groups does not seem to depend on the level of competition in the market. Most markets only have less than ten groups, no matter how many other brands are also in there.

Figure 12: Number of colluding groups vs Number of brands in the Market for Spot TV

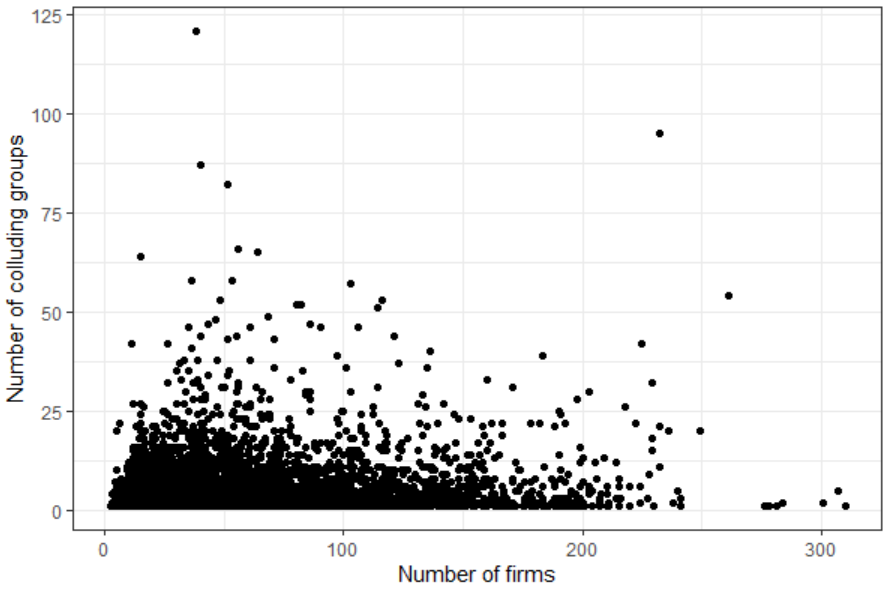


Figure 13 is the cumulative distribution function (CDF) for the number of ads bought by competitive and

[15] This is only for the markets in which at least one colluding group was found.

Figure 13: Number of ads bought by competitive firms vs colluding firms for Spot TV

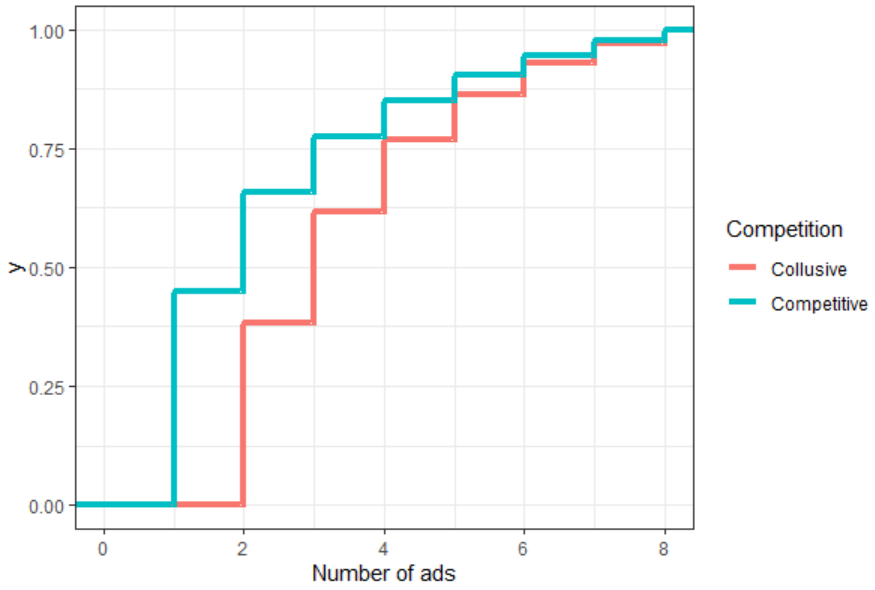
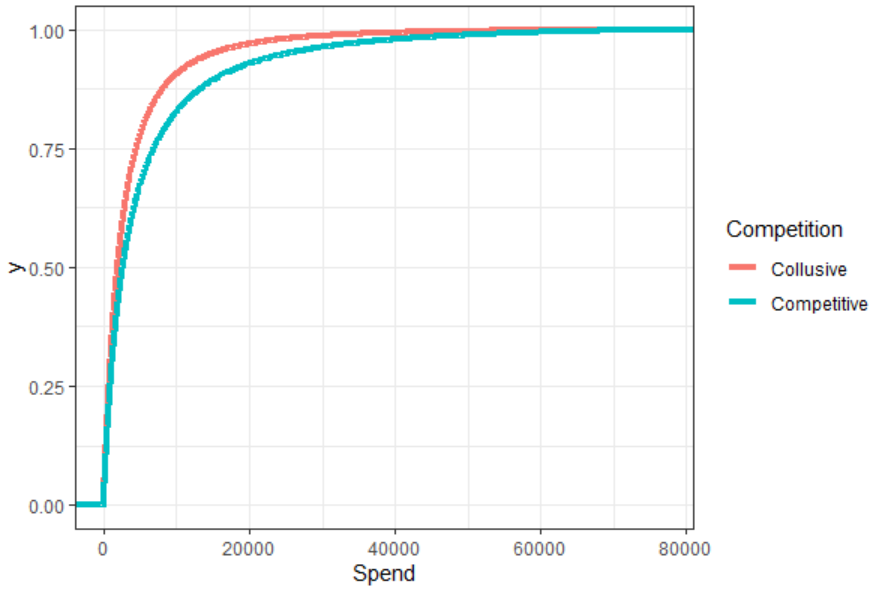


Figure 14: Amount spent on each ad by competitive firms vs colluding firms for Spot TV



collusive firms. In the collusion detecting procedure, I enforce the restriction that firms must have bought at least two ads to be considered colluding. Because of this restriction, the distribution for the number of ads bought per brand for competitive and collusive firms will always be different. Thus, we cannot directly compare the CDF of these two types. Figure 14 is the CDF for spending per ad occurrence for competitive and collusive firms. The graph shows that the CDF for collusive firms is slightly above competitive firms'. This means that given a random amount of money s, the probability that a collusive firm paid less than s is higher than the probability that a competitive firm did. In other words, collusive firms paid less per ad. Nonetheless, we cannot conclude that colluders pay less just from looking at the graph.

One method to test whether the spending distribution for collusive firms stochastically dominates [16] competitive firms' is the Kolomgorov-Smirnov (KS) test. This test helps answering whether the two sets of spending observations from our sample come from the same distribution or not. In this paper, I will use the one-sided KS test with hypotheses

$$H_0 : \forall s \in [\underline{s}, \overline{s}], F_{colluding}(s) = F_{competitive}(s);$$
$$H_a : \forall s \in [\underline{s}, \overline{s}], F_{colluding}(s) \geq F_{competitive}(s),$$

where $\underline{s}$ and $\overline{s}$ is the smallest and largest amount a firm spent on an ad in our data, $F_{colluding}(s)$ and $F_{competitive}$ is the CDF for colluding and competitive firms respectively. The test statistic is

$$D = \sup_{s \in [\underline{s}, \overline{s}]} |F_{competitive}(s) - F_{colluding}(s)|,$$

which measures the maximum difference between the two CDFs. If this difference is large enough, we can conclude that one distribution is stochastically dominant compared to the other.[17] Applying this test on our data returns a test-statistic $D = 0.11313$, and the resulting $p - value \approx 0$. Thus, we can reject the null hypothesis in favor of stochastic dominance. This result also confirms the hypothesis from the theoretical model that colluding firms will spend less on each ad since they do not face as much competition.

5.2 Network TV

In the Network TV data sets, a total of 3,594 potential colluding groups from 61 different industries were found. Among them, most groups' collusion period only lasts for one year. There are 59 groups that were active for two years and 4 groups that were active for three years. The number of groups found is much lower on this platform compared to SpotTV; however, this does not mean that colluding is necessarily harder, or

[16] This means the CDF line for collusive firms is always above the CDF line for competitive firms

[17] In this case, if the test stattistic is large enough, we can say that the colluding CDF has stochastic dominance.

firms have less incentive to collude. The number of advertisers using spot TV ads is about six times as many as those who used network TV, so naturally, we can find anti-competitive firms easier there. Figure 15 is the graph for the number of colluders in a market against the number of firms that were present in that market. Again, no trend could be found in the graph, which means the level of competition does not seem to have a strong effect on the incentive to form a colluding group.

Figure 15: Number of colluding groups vs Number of brands in the Market for Network TV

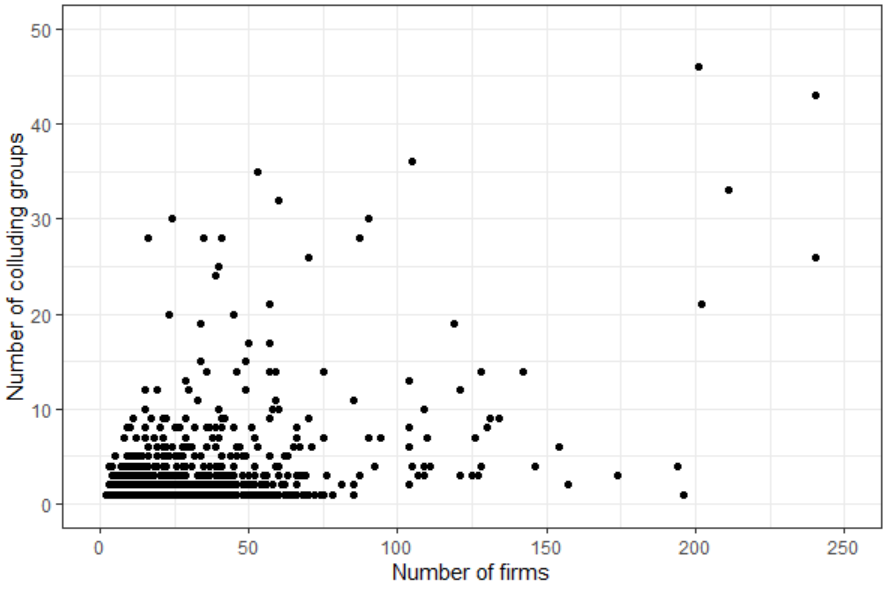


Figure 16: Number of ads bought by competitive firms vs colluding firms for Network TV

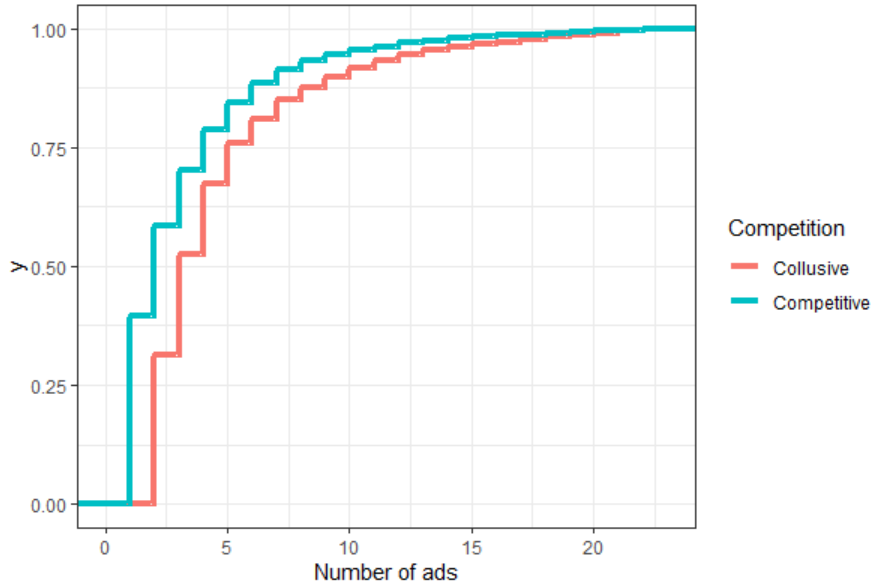
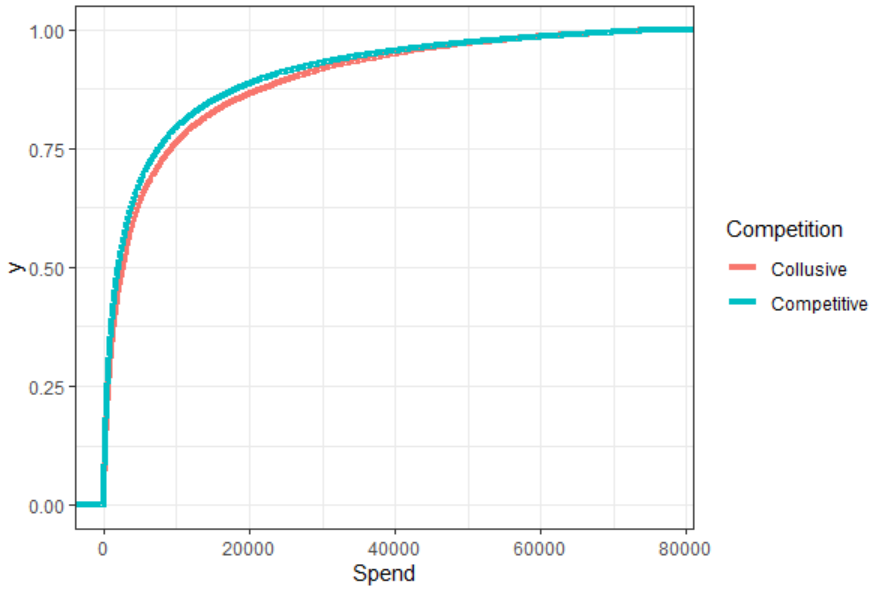


Figure 16 is the CDF for the number of ads bought by competitive and collusive firms. Similar to the

Figure 17: Amount spent on each ad by competitive firms vs colluding firms for Network TV



case of Spot TV, we cannot directly compare the two CDFs because of our restriction. Figure 17 is the CDF for the amount spent on each ad occurrence by competitive and collusive firms. Both CDFs look very similar; however, the competitive CDF seems slightly above the collusive CDF. Applying the KS test above with the alternative hypothesis being competitive CDF is higher, we obtain a test statistic of 0.042332 with $p - value \approx 0$. Thus, we can reject the null hypothesis of similar distribution in favor of competitive CDF's stochastic dominance. This result means that competitive firms are paying more on network TV. Nonetheless, the difference between the two types' spending seems very small according to the graph.

5.3 Radio

From the Radio data set, a total of 12,525 potential colluding groups from 54 different industries were found. Among them, 50 groups were active for two years, one group was active for three years, and the rest for only one year or less. Compared to SpotTV, the rate of groups from NetworkTV and Radio having a long life span is much lower. Figure 18 is the plot for the number of colluders against the number of firms in the market. The same story from the cases above is also presented here: there does not seem to be any trend, and the number of colluding groups remains low regardless of the level of competition.

Figure 19 is the CDF for the number of ads bought by competitive and collusive firms, and Figure 20 is the CDF for the amount spent on each ad occurrence by competitive and collusive firms. Opposed to the previous case, the CDF for collusive firm spending seems to be above the competitive CDF. The KS test, in which the alternative hypothesis is collusive CDF being stochastically dominant, returns a test

Figure 18: Number of colluding groups vs Number of brands in the Market for Radio

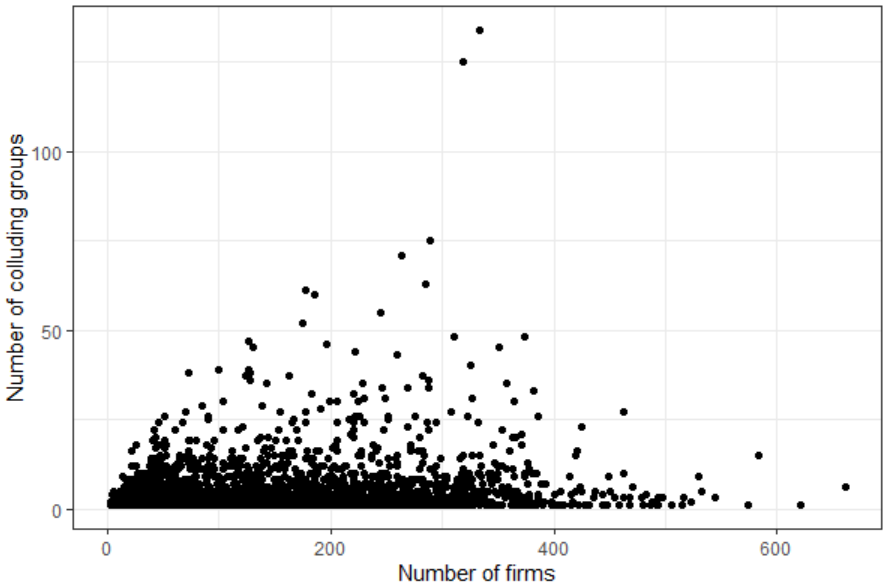


Figure 19: Number of ads bought by competitive firms vs colluding firms for Radio

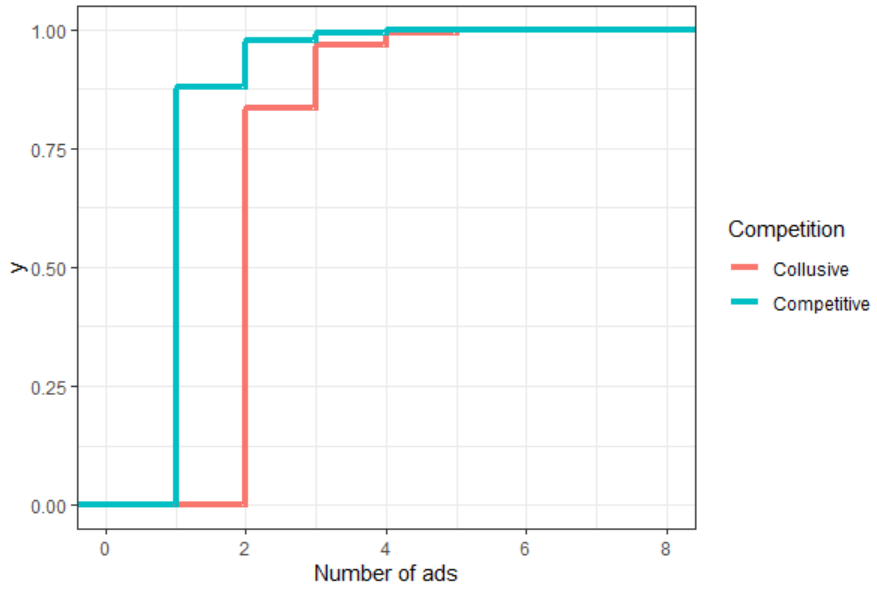
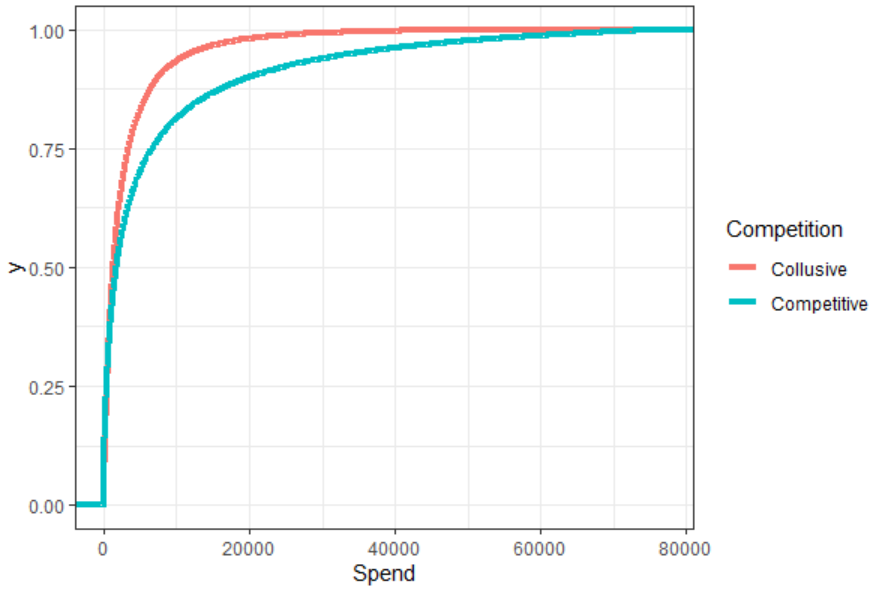


Figure 20: Amount spent on each ad by competitive firms vs colluding firms for Radio



statistic of 0.16829 and $p - value \approx 0$. Thus, we reject the null hypothesis in favor of collusive CDF's stochastic dominance. Colluders are thus paying less, and the difference between the two CDFs are much more significant than in the case of SpotTV according to the graphs.

5.4 Discussion

This section discusses some of the findings and remaining questions.

Which industry do the colluders belong to? Table 6 include the industries in which we observe the most number of colluding groups every year from 2010 to 2019 and in all three platforms used in this paper. Among them, the Business & Consumer Services and Entertainment & Amusements are the most common industries among colluders. For each major category of these industries, we observe evidence of potential collusion in more than 100 markets every single year.

Which type of market has more colluding groups? There is no clear trend whether bigger or smaller cities/channels have more groups. Among the markets with the most collusion cases found, there are many big cities such as Houston TX, which ranked 8^{th} by Nielsen DMA ranking, [18] and smaller cities such as Youngstown OH or Eugene OR, which are outside of the top 100.

How common is multi-market collusion? Nearly all of the cases found were from a single market. In fact, most of the colluding firms seem to be local firms that advertised only in a single market.

What is the most common number of group members? There were groups of 3 firms found;

[18] In 2017, Nielsen released a ranking for geographical markets based on the population of TV homes. The ranking list can be found *here*.

however, they are extremely rare. I did not find any group larger than three from the data set. Nearly all groups consist of only two members.

The theoretical model found that firms are more likely to adopt the alternating advertising strategy when they have a higher discount factor and market demands have high uncertainty. Was evidence of these conditions found from the colluders? Unfortunately, I do not have the data to estimate the demand for the colluding firms. One potential data source is the Retail Scanner data from Nielsen; however, they only have data on products bought in retail chains. As seen in Table 6, the majority of colluders come from industries that do not offer any product in retail stores. For the discount factor, I could not find any literature that studies this variable for the industries we have. Thus, I also cannot conclude whether colluding firms have a higher discount factor.

Can this paper serve as proof of collusion? The evidence found in this paper should not be interpreted as sufficient proof of collusion. Although I tried to impose several conditions to avoid having competitive firms marked as collusive, this procedure still has many flaws. I am only using the probability of observing two firms having no overlap ad period, which is likely to be insufficient. Harrington (2007) proposed collusive markers that may help identify colluders such as firms' prices are strongly positively correlated; however, since I only have the data for firms' choice of advertising, checking these markers is not possible.

Table 6: Industries with most groups

Major Category	Industry
Ready-to-wear	APPAREL,FOOTWEAR, & ACCESSORIES
Engineering & Professional Services	BUSINESS & CONSUMER SVCS
Schools & Camps	BUSINESS & CONSUMER SVCS
Communications & Public Utilities	BUSINESS & CONSUMER SVCS
Financial	BUSINESS & CONSUMER SVCS
Government Advertising	BUSINESS & CONSUMER SVCS
Organization Advertising	BUSINESS & CONSUMER SVCS
Real Estate, Real Estate Brokers & Developers	INSURANCE & REAL ESTATE
Books	PUBLISHING & MEDIA
Magazines, Newspapers, Newsletters & Misc Media	PUBLISHING & MEDIA
Radio Stations	PUBLISHING & MEDIA
Television & Cable Television Stations	PUBLISHING & MEDIA
Medicines & Proprietary Remedies	DRUGS & REMEDIES
Meats, Poultry & Fish	FOODS & FOOD PRODUCTS
Optical Goods,Navigational & Other Prec. Instruments	JEWELRY, OPTICAL GDS. & CAMERAS
Amusements, Events & Miscellaneous Entertainment	ENTERTAINMENT & AMUSEMENTS
Restaurants, Hotel Dining & Night Clubs	ENTERTAINMENT & AMUSEMENTS
Sporting Goods	SPORTING GOODS, TOYS, & GAMES
Games, Toys, & Hobbycraft	SPORTING GOODS, TOYS, & GAMES
Retail Stores	RETAIL
Miscellaneous Products/Services	MISC NOT ELSEWHERE CLASSIFIED
Pre-recorded Records & Tapes	ELEC. ENTERTNMT. EQUIP. & SUPPL.
Building equipment, Fixtures & Systems	BLDG. MAT. EQUIP. & FIXTURES
Automotive Accessories	AUTO.,AUTO.ACCESS & EQUIP
Gas, Oil (Transportation) & Dealer Services	GASOLINE, LUBRICANTS & FUELS
Passenger Travel	TRAVEL,HOTELS & RESORTS
Travel services & Tours	TRAVEL,HOTELS & RESORTS
Hotels & Resorts	TRAVEL,HOTELS & RESORTS
Garden Pest Controls	HORTICULTURE & FARMING
Farming & Livestock	HORTICULTURE & FARMING

6 Conclusion

In this paper, I proposed a theoretical model that shows how firms may have an incentive to follow the alternating monopoly strategy. This strategy is also compared to traditional market sharing. From the analysis, alternating monopoly is preferred to market sharing when there is more uncertainty in the market and when firms are more patient. Furthermore, my contribution is applying advertising to the model as the mean for firms to monitor compliance with the collusive strategy. As advertising only serves as a signal of market entry, firms are predicted to choose only a minimal level of advertising.

There are several weaknesses of the model. Firstly, there are only two states of demand, with low state bringing in zero profit for all firms. This is a very extreme simplification, and more demand states should be considered. Secondly, the model does not consider firms' probability of being detected. When firms account for the expected fines in the profit-maximizing problem, the incentive to follow alternating monopoly will significantly decrease if the authority uses a penalty regime that bases on the number of collusive periods.

For the empirical analysis, I propose a method to detect alternating monopoly from the Nielsen Ad Intel data. By applying this procedure to the data set on spot TV, network TV, and radio ads, about 50,000 potential groups of colluders were found. By comparing the spending between the two types, I found that collusive firms did spend more than competitive firms on the spot TV and radio advertising platform. In network TV ads, competitive firms are found to spend slightly more.

Currently, the collusion detecting procedure is suffering a major weakness: it only relies on probability to conclude whether firms are colluding or not. Furthermore, I also do not have enough data and information to conclude whether colluding firms are in a market with demand uncertainty and whether they have a high discount factor. These limitations hopefully can be worked on in future research.

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