STRATEGIC INFORMATIVE ADVERTISING IN A HORIZONTALLY DIFFERENTIATED DUOPOLY

Levent Çelik

CERGE-EI

Charles University
Center for Economic Research and Graduate Education
Academy of Sciences of the Czech Republic
Economics Institute

WORKING PAPER SERIES (ISSN 1211-3298)
Electronic Version

359

Working Paper Series 359
(ISSN 1211-3298)

Strategic Informative Advertising in a Horizontally Differentiated Duopoly

Levent Çelik

CERGE-EI
Prague, September 2008

ISBN 978-80-7343-159-4 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-148-7 (Národohospodářský ústav AV ČR, v.v.i.)

Strategic Informative Advertising in a Horizontally Differentiated Duopoly*

Levent Çelik

CERGE-EI†

September, 2008

Abstract

When firms possess information about their competitors' products, their advertisements may leak extra information. I analyze this within a duopoly television market that lasts for two periods. Each station may advertise its upcoming program by airing a tune-in during the first program. Viewers may alternatively sample a program. I find that each station's equilibrium tune-in decision depends on both upcoming programs - thereby revealing more information than the actual content - when the sampling cost is sufficiently low. Otherwise, tune-in decisions are made independently. It is welfare improving to ban tune-ins in the latter case but not in the former.

Abstrakt

Pokud společnosti vlastní informace o produktech svých konkurentů, jejich inzerce v sobě může nést další informace. Analyzuji tuto hypotézu na duopolním trhu televizních stanic, který trvá dvě periody. Každá stanice může inzerovat svůj nadcházející pořad vysíláním upoutávek během prvního pořadu. Diváci mohou případně zhlédnout ukázku z pořadu. Zjistil jsem, že rovnovážné rozhodnutí každé stanice ve vysílání upoutávek závisí na obou nadcházejících pořadech -- tudíž odhalí více informací než současný obsah -- pokud cena přepínání a prohlížení jiných pořadů je dostatečně nízká. Jinak jsou rozhodnutí o upoutávkách činěny nezávisle. Zakázání upoutávek v prvním případě vede ke zvýšení bohatství, v druhém případě nikoli.

Keywords: Informative Advertising, Tune-ins, Sampling, Information Disclosure, Signaling.
JEL Classification: D83, L13, M37.

* CERGE-EI is a joint workplace of the Center for Economic Research and Graduate Education, Charles University, and the Economics Institute of the Academy of Sciences of the Czech Republic. Address: P.O.Box 882, Politickych veznu 7, 111 21, Prague 1, Czech Republic. Email: celik@cerge-ei.cz.

† I am grateful to Simon Anderson and Maxim Engers for their invaluable help during the progress of this paper. Thanks also go to Bilgehan Karabay, Krešimir Žigić and Lawrence Smith for helpful suggestions. I am responsible for all errors.

1 Introduction

It is common in the literature on informative advertising to assume that consumers are initially unaware of market existence or that search costs are prohibitively high so that consumers never engage in searching.[1] Thus, advertisements (henceforth, ads) inform them about product existence along with several other product characteristics. In particular, consumers do not make any inferences for the products about which they have not been informed through ads. Many differentiated-products markets do not fit these specifications. In several consumer markets, product existence is common knowledge and/or consumers actively search for product information. The television (henceforth, TV) industry is a good example. Although many people may have limited or even no information about program attributes, the existence of TV programs is common knowledge to everyone.[2]

The present paper proposes a two-period model of informative advertising in a TV market with two TV stations when potential viewers are uncertain about their match values with the programs in the latter period. A key element of the model is that the TV stations know how their own as well as their rival's program fits viewers' preferences. It is shown that this information structure leads to an equilibrium in which the decision of a TV station to advertise its own program may strategically depend on its rival's program, thus indirectly revealing information about it as well.

I focus on the provision of tune-ins.[3] Tune-ins constitute an important component of TV advertising. There are several TV programs which generate high audiences, and in turn, high advertising revenues. Nevertheless, TV stations continue to allocate a significant amount of time to tune-ins.[4] Although the main role of tune-ins is to convey program information to imperfectly informed viewers, they are different from most common forms of informative advertising. Most importantly, they do not impose direct costs on TV stations. Rather, TV stations incur opportunity costs for not having allocated the same time slots to commercial ads. Therefore, the net costs of tune-ins depend on the audience size of the program during which they

[1] For examples, see Grossman and Shapiro (1984) and Christou and Vettas (2008).

[2] The lack of information about program attributes may be due to the fact that the programs are newly introduced, or that the costs associated with gaining information are relatively high. Furthermore, individuals have limited memories.

[3] Tune-ins are preview ads for broadcasters' upcoming programs.

[4] For instance, the number of minutes allocated to tune-ins during the Super Bowl in 2000 was 16.5 out of a total of 87 non-program minutes while the price of a 30-second commercial was $2 million.

are aired and of the one which they promote.

TV stations forgo about 20% of their advertising revenues to air tune-ins for their upcoming programs (Anand and Shachar (1998)).[5] This fact, on its own, suggests the importance of the incomplete information structure in the TV market, yet most of the related literature assumes that viewers possess full information about program characteristics. Had viewers already been fully informed about the upcoming programs, there would be no need for tune-ins.

Tune-ins often provide direct information about program characteristics.[6] The level of information they provide is quite high. Based on a detailed panel dataset on viewer choices, Emerson and Shachar (2000) report that about 65% of all viewers continue to watch the same network broadcaster (including the times when a tune-in has not been aired). This observation demonstrates that tune-ins achieve their main goal: raising the audience size of the promoted programs.

In Çelik (2008a), I take a look at the extent to which a single TV station is willing to air tune-ins. The model is developed in a simple Hotelling framework in which there is a continuum of potential viewers distinguished by their ideal programs. This is represented by assigning to each potential viewer a unique location along the unit line. As usual in Hotelling models, a viewer's net utility is lower the further away the actual program is from her ideal program. The TV station airs two consecutive programs. The location of the first program is assumed to be common knowledge. The location of the second program is ex-ante unknown to viewers. However, the viewers know that the TV station is privately informed about its location. Therefore, they rationally expect the TV station to share this information with the first-period audience if it is a profitable strategy to do so. The cost of airing a tune-in is the forgone revenue from a commercial ad during the first program. In this setting, it is shown that there exists a (unique, under mild conditions) perfect Bayesian equilibrium (PBE) in which the TV station airs a tune-in whenever the two programs are similar enough. In the absence of a tune-in, no viewer within the first-period audience keeps watching TV.

In order to extend the analysis above to include a second station, one has to introduce the

[5]Anand and Shachar (1998) report that in 1995, three major network stations in the U.S. devoted 2 of 12 minutes of nonprogramming time to tune-ins. Since advertising revenues represent almost all of the revenues of a network, the share of revenues spent on tune-ins is proxied as 20%.

[6]It is necessary to distinguish between tune-ins for regular programs, such as everyweek sitcoms, and those for special programs, such as movies. The latter are expected to be more effective on ratings in the sense that people may possess little or no information about the timing and attributes of such programs.

possibility of switching from one station to the other. In fact, Çelik (2008b) introduces as an extension to Çelik (2008a) the possibility of switching off after sampling a few minutes of a program. While a PBE similar to the one described above still exists, it is no longer unique. For a low value of the sampling cost, there exists another PBE in which the TV station never airs a tune-in. In this paper, I move one step further by incorporating viewers' switching behavior into the same setup when there are two TV stations. I assume that the amount of time required for learning the actual location of a program is fixed and the same for all programs and individuals. However, this process entails an opportunity cost when a viewer does not continue to watch the program she chose to sample.

The process of costly sampling plays a crucial role for two reasons. First, for an equilibrium that involves the use of tune-ins to exist, sampling cost (or equally switching cost) has to be positive. Had it been zero, viewers could costlessly learn about the programs at both stations and make their decisions without any uncertainty. Therefore, there would be no need for tune-ins. Second, a positive sampling cost may create an incentive for a station to choose not to air a tune-in. This is because the cost of sampling becomes sunk once a viewer chooses to engage in sampling. That is, when there is costly sampling, some individuals may end up watching a program that they would not choose to watch with complete information. By the same token, an individual's final decision may not be the one that maximizes her utility with complete information.

When a TV station is informed about the content of its rival's program, its decision to air a tune-in may transmit information about not only its own program but also its rival's program. Since sampling is costly, a station is relatively more inclined to air a tune-in in order to keep its current viewers tuned in when its rival has a similar program. However, this may signal to the recipients of that tune-in that the program at the other station is likely to be a good match. Similarly, when a station does not advertise its upcoming program, it does not necessarily mean that it is a bad match for that station's viewers. It could rather be the case that it is a better match compared to the program at the other station.

In this paper, I am primarily interested in exploring the nature of strategic behavior described above, and ultimately in finding out if an equilibrium in which viewers' priors are changed at the interim stage exists. I show that such an equilibrium exists although it is not unique. Without any restrictions on viewers' beliefs, there is another equilibrium in which viewers' beliefs about either program are unchanged. Tune-ins exist in all equilibria regardless of the value of the sampling cost. This is in contrast with the finding in a monopoly setting where, for low values of the sampling cost, there exists a PBE in which the TV station never airs a tune-in (Çelik (2008b)).

Signaling has traditionally been investigated within the context of vertically differentiated products. When consumers are uninformed about the actual quality of an experience good, a high-quality seller can credibly signal this information by setting a high price or by spending a non-trivial amount of money on (uninformative) advertising. My findings suggest that signaling is also possible in horizontally differentiated markets. Signaling occurs regardless of whether a station chooses to or not to air a tune-in. In the former case, only information about the other program is signalled. In the latter, information about both programs is signalled. However, a fully separating equilibrium can not be achieved in the current setting; viewers cannot locate the programs with certainty.

For certain program locations, the model can also be interpreted as one with vertical differentiation. To be more specific, when a station's upcoming program is better suited to all of its current viewers than the other station's upcoming program, the two programs are effectively vertically differentiated for those viewers. In such a situation, I find that the former station does not air a tune-in. Although this result is strikingly different from what traditional models of signaling predict, a direct comparison may be misleading since TV programs are not experience goods. Nonetheless, it is interesting to highlight that signaling is possible even in the absence of advertising.

I also analyze the welfare effects of a possible ban on the use of tune-ins. I find that when it is not a credible strategy for a station to behave strategically, it may be welfare improving to ban tune-ins. In such a situation, stations advertise their programs more often. Although viewers enjoy a higher surplus as a result of improved information, social welfare is reduced because the decrease in revenues of the TV stations overweighs the increase in consumer surplus.

The paper is organized as follows. The next section reviews the related literature. In section 3, I introduce the main model and characterize the equilibria. Section 4 argues when it may be welfare improving to ban tune-ins. Finally, section 5 discusses the findings and concludes.

2 Related Literature

Directly informative advertising has been the topic of several previous studies. Butters (1977) was the first to model the informative role of advertising. In his paper, products are homogeneous and advertising conveys information about prices, hence also about the existence of the products indirectly. However, much advertising involves informing consumers about product attributes other than just about prices. Grossman and Shapiro (1984) study an extended model in which consumers are heterogeneous in their preferences and advertising informs them not only about the existence but also about the characteristics of the products. Common to both of these papers is that advertising technology is exogenous and people cannot change their likelihood of receiving an ad.

The current paper has several similarities with the latter of the two papers above; consumers are heterogeneous in their preferences and seek to watch the program yielding the highest (expected) benefit, programs are horizontally differentiated, and advertising provides information about their attributes. I assume that it is free to watch TV, and that the number of total non-program breaks is given exogenously. Therefore, my analysis does not involve price advertising. However, I depart from Grossman and Shapiro (1984) in several ways, mainly in how advertising is modeled. Advertising in this paper is exclusive; only the viewers who watch the first program may receive a tune-in of the second program at that station. It is also strategic in the sense that a station's decision to air or not to air a tune-in conveys information about the programs at both stations.

Confining attention to the literature that focuses on informative advertising in horizontally differentiated oligopoly markets, a related paper is Meurer and Stahl (1994). They analyze the welfare properties of informative advertising in a duopoly market where a fraction of buyers are uninformed about the product characteristics. There are two types of buyers. One type is ideally matched with one firm and the other type is ideally matched with the other firm. As in Butters (1977), Grossman and Shapiro (1984) and many others, a firm chooses its advertising intensity and a random fraction of consumers receive the ad. Advertising informs a buyer of her best match. Firms choose their prices after advertising takes place. They treat product information as a public good, which implies that information about one product provides information about the others as well. They characterize a unique subgame perfect Nash equilibrium in which the level of advertising provided may be more or less than socially optimal. While advertising improves the match between consumers and products, it gives firms a higher market power by increasing brand loyalty.

Within the same strand of literature, another related paper is Anand and Shachar (2006). They use the same setup with that of Meurer and Stahl (1994) with three major differences. First, a firm can only advertise through one or both of two available media channels, and consumer preferences over product attributes are perfectly correlated with their choice of media channel. So, for instance, if consumers of media channel 1 are ideally matched with product 1, then firm 1 can target these consumers by advertising through media channel 1. Second, advertising messages are noisy in the sense that consumers may get the wrong idea from a firm's informative ad. Therefore, firms advertise more than once. Finally, firms do not choose prices, which are therefore suppressed in the analysis. In such a setting, Anand and Shachar (2006) characterize a separating equilibrium in which a firm advertises only to those consumers for whom that product is the ideal one. As long as the ads are not completely noisy – in which case the ads would equally be interpreted right or wrong – there exists a threshold amount of advertising which ascertains a consumer that the advertised product is her best match. Thus, regardless of the content of the ad, each consumer purchases the product that she was advertised to.

There are major differences between my model and those of Meurer and Stahl (1994) and Anand and Shachar (2006). First, in both of these papers, products are experience goods, so consumers do not have the option of obtaining product information by a costly search. In the current paper, I treat TV programs as search goods since program sampling is a common practice in real life. If I rather treated them as experience goods, the unique symmetric equilibrium would involve no strategic behavior by the stations. Therefore, sampling plays a crucial role for the results in this paper. Second, there are only two distinct types of consumers in both papers, one ideally matched with one product and the other with the other product. In Meurer and Stahl (1994), this assumption implies that an informative ad by one firm necessarily informs the recipient about the other firm's product, and therefore plays a critical role for their results. In Anand and Shachar (2006), it is a necessary assumption for perfect separation. In my model, on the other side, there is a continuum of people who may or may not be ideally matched with either program. Therefore, the tune-in decision of a station is a function of the program location of the other station. Third, advertising in my model is purely informative unlike in Anand and Shachar (2006), and reaches a nonrandom group of consumers unlike in Meurer and Stahl (1994). In this sense, I use a different advertising technology in the current paper.

To the best of my knowledge, there are no previous theoretical papers that analyze tune-ins. There are, however, several empirical studies of the effects of tune-ins on viewing choices of individuals. Anand and Shachar (1998) estimate the differential effects of tune-ins on viewing decisions for regular and special shows. They find that a viewer's utility from a regular show is a positive concave function of the number of times she is exposed to its tune-ins. They also find a significant difference between the effectiveness of regular and special tune-ins, with special ones being less effective when there are few tune-ins and more effective when there are many. In Anand and Shachar (2005), the content of tune-ins is modeled as a noisy signal of program attributes. Consumers are a priori uncertain about program attributes and exposure to tune-ins affect their information sets. Consumers have additional sources of information other than tune-ins, such as word-of-mouth and media coverage. Before each period starts, they update their beliefs based on the tune-ins they have been exposed to and the other information they have received, and then choose the program that maximizes their utility. They find that while exposure to advertising improves the matching of viewers and programs, in some cases it decreases a viewer's tendency to watch a program.

There are important differences between the model in this paper and the two papers by Anand and Shachar. I improve upon their models by assuming forward-looking viewers rather than myopic. Therefore, viewers correctly anticipate the tune-in strategy of the TV station. Most importantly, they infer that unadvertised programs are not likely to offer a good match. Anand and Shachar only analyze the viewer behavior thereby ignoring the optimal tune-in choices of TV stations. However, tune-in choices of TV stations depend on the viewing decisions of people. By explicitly modeling the optimal TV station behavior, I offer a more thorough analysis of tune-ins and their effects on people's viewing choices.

The findings in this paper are also (weakly) related to the literature on quality signaling with multiple senders when firms have common knowledge of product qualities. Hertzendorf and Overgaard (2001a) consider a static duopoly in which nature selects one firm as the high-quality producer and the other as the low-quality producer. Both firms observe their qualities before they make their price-advertising decisions. Thus, one firm's price-advertising choice also reveals information about the quality of the other firm's product. Assuming that variable costs are independent of quality, they identify a unique separating equilibrium in which the high-quality producer uses dissipative advertising to signal its quality when the quality difference is sufficiently small. For higher quality differentials, a high price is sufficient to signal quality without any advertising. Similarly, Fluet and Garella (2002) consider a static duopoly model in which each firm is informed about the quality of both products (which may be either high or low). Assuming that variable costs are increasing in quality, they similarly find that a positive level of advertising by a high-quality firm is necessary for separation when the quality difference is sufficiently small.

Bontems and Meunier (2005) also consider a two-sender duopoly model of quality signaling when the products are both vertically and horizontally differentiated. As in Hertzendorf and Overgaard (2001a), nature assigns only one of the firms as the high-quality producer. However, this assignment occurs after firms choose their locations. In contrast with Hertzendorf and Overgaard (2001a) and Fluet and Garella (2002), the authors find that a positive level of advertising is necessary for separation regardless of the degree of vertical differentiation. Firms choose maximal horizontal differentiation when the quality difference is small and minimal horizontal differentiation when it is sufficiently high.

Matthews & Fertig (1990) consider an incumbent-entrant setup where product quality of the entrant is known to the firms only while that of the incumbent is known by everyone in the market. Prices are exogenous and the incumbent may advertise in order to inform consumers about the product quality of the entrant; i.e. it may counteract misleading attempts by a low-quality entrant. In sharp contrast with the existing models of quality signaling, they show that a high-quality entrant can successfully signal its quality by spending an infinitesimal amount on advertising.[7]

[7]For other studies of signaling when there are multiple senders with common information, see Bagwell and Ramey (1991), de Bijl (1997) and Hertzendorf & Overgaard (2001b).

3 The Model

There are two TV stations, station Y and station Z, each airing two programs in two consecutive time periods. The programs are characterized by their locations on the unit interval $[0, 1]$. They are of the same length and have zero production costs. Each station is fully informed about all program locations. There is a discrete number, $A > 1$, of time slots to be allocated to non-program content during each program, where A is taken as exogenous.[8] I will henceforth refer to these as ads. Thus, the game in this paper may be thought of as a subgame of a larger game where the choices of program locations and the amount of non-program minutes are already made.

There is a large number of advertisers that are willing to pay up to $\$p$ per viewer reached for placing a commercial during a program in each period. Each commercial is one time-slot long. Alternatively, each TV station may choose to air a tune-in (or tune-ins) during the first program for the purpose of promoting the next program. Production of a tune-in does not entail any costs. I assume that a tune-in has the same length as a commercial. Each TV station splits the available A ads during the first program between commercials and tune-ins (so, an ad may be in the form of a commercial or a tune-in). Hence, the TV stations incur an opportunity cost for placing tune-ins. I assume that the TV stations cannot lie in a tune-in; i.e. they are legally bound to advertise a preview of the actual program in the tune-in, and that the tune-in is fully informative. Finally, the objective of a TV station is to maximize its total advertising revenue which is generated by payments received from advertisers for placing commercials.

On the other side of the market, there is a continuum of N potential viewers who are uniformly distributed along the unit interval with respect to their ideal programs. To each possible program location on the unit line, there corresponds a viewer for whom that program is the ideal one. A viewer who is located at λ obtains a net utility $u(\lambda, x) = v - |\lambda - x|$ from

[8] While U.S. broadcasters are free to choose the amount of their non-program minutes, advertising ceilings are imposed on broadcasters in most European countries. Therefore, in most cases, especially at prime-time, the amount of non-program minutes that mazimizes a broadcaster's revenue falls below the imposed ceiling. There are also technical reasons for making this assumption. First, if TV stations were allowed to choose the amount of non-program minutes, then people would rationally form priors about it. Second, and most importantly, the amount of non-program minutes in the first period would possibly provide a signal for the location of the second program. Addressing these issues is beyond the scope of this paper, since the main focus is on the role of tune-ins. Doing so is an excellent area for future research.

watching a program located at x.[9,10] Viewers' locations stay the same across the two periods. Not watching TV yields zero benefits.[11]

The locations of the first programs are assumed to be common knowledge. Although people know that each station offers two consecutive program, they do not know where on the unit interval the second programs are located at. Denoting the location of the second program of station Y with y and that of Z with z, I assume that viewers' priors are given by a simple discrete uniform density: $y, z \in \{0, \frac{1}{2}, 1\}$, where each of these three locations is equally likely to be the actual location of either of the two programs from viewers' point of view. Viewers know that the stations know the location of their own as well as their rival's program.

A viewer makes a decision at each time that maximizes her total utility. Viewers have the option of switching to the other station or simply turning the TV off after sampling a few minutes of a program. I assume that the amount of time required to learn the true location of a program is constant and same for both programs and for all viewers. Let k denote this amount of time. The sampling process entails a cost of $c > 0$, which becomes sunk once a viewer chooses to sample a program. I will henceforth refer to it as the "sampling cost". A viewer incurs a sampling cost in one of the following three situations:

(i) Suppose a viewer samples the programs of both stations and ends up watching the one that yields a higher utility. She incurs $-c$ in this case since she will have missed k minutes of the program she ends up watching.

(ii) Suppose a viewer decides to turn her TV off after sampling only one of the programs. Then her net utility is $-c$ since she has missed k minutes of the outside option.

(iii) Suppose a viewer decides to turn her TV off after sampling both programs. Then her net utility is $-2c$ since she has missed $2k$ minutes of the outside option.

In the first period, viewers have full information and therefore they simply watch the program that yields a higher utility for the whole period. They do not switch between the two

[9]The gross utility v can capture how interruptions during a program affect a viewer. Specifically, the effect of an increase (a decrease) in the nuisance cost of a commercial on a viewer's utility can be captured by lowering (raising) the gross utility. Note that, in this formulation, tune-ins also create a nuisance.

[10]Alternatively, v can be interpreted as the quality of a program which enters into everyone's utility in the same way.

[11]A constant, t, can be put in front of $|\lambda - x|$ that measures the disutility associated with one unit of distance from the ideal program location. However, since the value of not watching TV is zero, utility can easily be expressed as $r - |\lambda - x|$, where $r = \frac{v}{t}$.

stations since sampling is costly.[12] However, sampling one or both of the stations may be optimal in the second period. Once viewers' sampling is finalized, audience shares of the stations and, in turn, the revenues are realized.

Under complete information, the utility of watching a program located at x for a viewer located at λ is $u(\lambda, x_1) = v - |\lambda - x|$. This is nonnegative when λ lies within v units of distance around x. If there are two programs to choose between, $x_Y < x_Z$, then the marginal viewer will be the one located at the halfway, i.e. $\frac{x_Y+x_Z}{2}$. She will simply randomize between the two programs. Viewers with locations $\max\{0, x_Y - v\} \leq \lambda < \frac{x_Y+x_Z}{2}$ watch program x_Y while the ones with locations $\frac{x_Y+x_Z}{2} < \lambda \leq \min\{x_Z + v, 1\}$ watch program x_Z.

I maintain the following three assumptions throughout the analysis.

Assumption 1 $\frac{1}{4} + c < v < \frac{1}{2} - c$, *where* $c > 0$.

Assumption 2 $\frac{1}{4} + \frac{1}{2A} < v < \frac{1}{2} - \frac{1}{A}$, *where* $A > 0$.

Assumption 3 *The first programs at stations* Y *and* Z *are located at* $\frac{1}{4}$ *and* $\frac{3}{4}$*, respectively, and this is common knowledge.*

The first two assumptions rule out equilibria in which neither station airs any tune-ins. To be more precise, take Assumption 1. When v is small, sampling becomes relatively too costly and a viewer is less likely to sample the program at the other station. Therefore, a TV station has a lesser incentive to air a tune-in. Similarly, sampling becomes relatively too cheap when v is large, and a viewer is more likely to sample the program at the other station. Once more, a TV station has a lesser incentive to air a tune-in. The second assumption places similar bounds on the value of v relative to the (opportunity) cost of airing a tune-in ($\frac{1}{A}$ is the per-viewer (opportunity) cost of a tune-in).[13] This shall be more clear as the analysis proceeds. By restricting v to lie in the specified interval, Assumption 2 also (indirectly) imposes an upper bound on the value of the sampling cost: $0 < c < \frac{1}{8}$. The third assumption is made in order to

[12]In practice, a viewer may start watching the program that yields a higher utility, then switch to the other station and hope during the sampling period that she will see a tune-in for the upcoming program. Since there is at most one tune-in in equilibrium, the chances of seeing one is quite low. Furthermore, if she does not see a tune-in, this does not necessarily mean that the station did not air one. The same viewer has the option of sampling the other station's upcoming program in the second period and learning its location perfectly. In either case, the viewer incurs the same cost. So, switching in the first period is a dominated strategy.

[13]Note that $\frac{1}{4} + \frac{1}{2A} < \frac{1}{2} - \frac{1}{A}$ implies $A > 6$. This lower bound is quite reasonable since, empirically, we observe a hig number of ads during regular TV programs.

simplify the analysis. Together with Assumption 1 (i.e. $v > \frac{1}{4}$), it simply says that viewers on the lower half of the unit line watch station Y in the first period and the ones on the upper half watch station Z.

The timing of the moves is as follows. First, people make their first-period viewing decisions. Then the first program starts, and the TV stations make their tune-in decisions during the first program. Having watched the first program, people update their beliefs about the second programs depending on whether or not they were exposed to a tune-in. The second programs start and people make their optimal sampling decisions. After each individual completes sampling one or both (or none) of the stations, they make their final second-period viewing choices and the payoffs are realized.

The equilibrium concept used is perfect Bayesian equilibrium (PBE). That is, the TV stations make optimal tune-in decisions taking the location of their rival's program and the rationality of people into account, and people make optimal sampling and viewing decisions after observing the tune-in decision of the station they have watched. In particular, people's inferences (or posterior beliefs) after the first period about the locations of the second programs must be correct, and the TV stations should not have any incentive to deviate.

The advertising revenue of a TV station is the payments received from advertisers. So, in each period, the total revenue of a station is the total number of people watching that station, given by N times the audience share in that period, times per-viewer revenue. If a station airs a tune-in, then its per-viewer revenue is $(A-1)p$. If it does not, then the per-viewer revenue is Ap.

As discussed earlier, TV stations may choose to behave strategically due to their knowledge of the rival station's program. However, regardless of the location of the rival's program, a station clearly never airs a tune-in for a program that none of its current viewers would like to watch. This case arises for station Y when $y = 1$, and for station Z when $z = 0$. Given that a station cannot communicate any information with the viewers of the other station, it does not pay off for either station to air a tune-in for such programs.

Let $q_i(y, z)$ be a binary variable that assumes a value of 1 if station i airs a tune-in when the two programs are located at (y, z), and 0 otherwise. So, if station Y airs a tune-in for $y = 0$ when $z = 0$, then we have $q_Y(0, 0) = 1$. The following lemma is immediate.

Lemma 1 $q_Y(1,z) = 0$ *for all* z*, and* $q_Z(y,0) = 0$ *for all* y*.*

Next, consider a situation in which neither of the stations air a tune-in for their upcoming programs regardless of their locations. Suppose that these strategies constitute a PBE. I will refer to it as the "no tune-in" PBE. At such a PBE, people's priors would be unchanged. This means that all viewers are indifferent between sampling either station in which case I assume that a random half initially sample Y and the remaining ones sample Z (if sampling occurs at all).

Lemma 2 *Suppose a "no tune-in" PBE exists. Then all viewers sample at least one of the stations. If the location of the program sampled first is less than* $\frac{1}{4} + \frac{3c}{2}$ *units away from a viewer's own location, then that viewer stops sampling. Otherwise, she samples the program at the other station, too.*

The proof of Lemma 2 (as well as all the remaining proofs) can be found in Appendix A. We can now express the second-period audience shares of stations Y and Z for all possible values of (y,z) under a "no tune-in" PBE. Audience share of a station is to be understood as the fraction of the whole population watching that station.

Lemma 3 *Suppose a "no tune-in" PBE exists. Then, the audience shares of station* Y *and* Z *under all program combinations are given by (the first number in each box is station* Y*'s share and the second one is station* Z*'s share):*

	$\mathbf{z=0}$	$\mathbf{z=\frac{1}{2}}$	$\mathbf{z=1}$
$\mathbf{y=0}$	$\frac{v+c}{2}, \frac{v+c}{2}$	$\frac{1}{4}, v+c+\frac{1}{4}$	$v+c, v+c$
$\mathbf{y=\frac{1}{2}}$	$v+c+\frac{1}{4}, \frac{1}{4}$	$v+c, v+c$	$v+c+\frac{1}{4}, \frac{1}{4}$
$\mathbf{y=1}$	$v+c, v+c$	$\frac{1}{4}, v+c+\frac{1}{4}$	$\frac{v+c}{2}, \frac{v+c}{2}$

Table 1. Audience shares of station Y and Z.

A "no tune-in" PBE exists only if neither station has any incentive to deviate. As it turns out, under Assumptions 1 and 2, there is always a profitable deviation.

Proposition 1 *A "no tune-in" PBE does not exist.*

Corollary 1 *If a symmetric PBE exists, then it must be true that* $q_Y(0,0) = q_Y(\frac{1}{2},\frac{1}{2}) = q_Z(\frac{1}{2},\frac{1}{2}) = q_Z(1,1) = 1$.

Corollary 1 simply follows from the proof of Proposition 1, and its proof is therefore omitted. When $(y,z) = (0,\frac{1}{2})$ or $(\frac{1}{2},0)$, it can be shown that deviating from a "no tune-in" PBE is profitable for station Y if $A\left[(\frac{1}{4}+\frac{c}{2})-\frac{1}{4}\right] \geq \frac{1}{2}$, or equivalently if $Ac \geq 1$. Although this condition is different than what was shown to be necessary for a deviation when $(y,z) \in \{(0,0),(\frac{1}{2},\frac{1}{2})\}$, it is in general more restrictive compared to $\frac{1}{2} - v \geq \frac{1}{A}$. Together with Assumption 1, $Ac \geq 1$ implies $\frac{1}{2} - v \geq \frac{1}{A}$. However, $\frac{1}{2} - v \geq \frac{1}{A}$ does not necessarily imply $Ac \geq 1$. An important thing to note is that viewers' optimal sampling behavior depends on their inferences from the observed tune-in decisions of the TV stations. As will be argued shortly, a strategy in which station Y airs a tune-in only when $(y,z) \in \{(0,0),(\frac{1}{2},\frac{1}{2})\}$ cannot actually be part of a PBE. So, it is not nesessary to assume that $Ac \geq 1$ for this outcome to arise.

To see this, consider an equilibrium in which station Y airs a tune-in only when $(y,z) \in \{(0,0),(\frac{1}{2},\frac{1}{2})\}$, and station Z does so only when $(y,z) \in \{(\frac{1}{2},\frac{1}{2}),(1,1)\}$. For these strategies to constitute a PBE, viewers' inferences from observed tune-in decisions must be correct. Therefore, when station Y advertises $y = 0$, the first-period viewers of Y infer that $z = 0$ as well. This means that each station ends up with an audience size of $\frac{v}{2}$ as each viewer will watch the first station they choose to sample. Both stations are actually worse off compared to the "no tune-in" regime. However, it is in fact optimal for station Y to switch back to the "no tune-in" regime if Z is going to air a tune-in when $(y,z) \in \{(\frac{1}{2},\frac{1}{2}),(1,1)\}$. If a λ-type viewer who is initially indifferent between the two stations continues to stay at Y after not seeing a tune-in, she will infer (incorrectly) that z is either $\frac{1}{2}$ or 1 upon seeing that $y = 0$. If $\lambda > \frac{1}{4} + c$, it is worth checking out station Z, too. But when she discovers that z is also 0, she will one more time be indifferent between the two stations provided that $\lambda \leq v + c$. Similarly, if she starts at Z and sees that $z = 0$, she will infer that y is either $\frac{1}{2}$ or 1, and will switch to Y if $\lambda > \frac{1}{4} + c$. The second-period audience size of station Y is thus $\frac{v+c}{2}$ as opposed to $\frac{v}{2}$, which means that station Y has an incentive to not air a tune-in when $(y,z) = (0,0)$. But viewers anticipate this correctly and it was previously shown that this cannot be an equilibrium either.

One way to get around this problem is airing a tune-in more often. That is, when a TV station airs a tune-in for a particular program location, its viewers should not be able to infer the exact location of the other program. For station Y, the strategy of airing a tune-in for $y = 0$ only when $z = 0, 1$ (similarly, the strategy $q_Y(\frac{1}{2}, z) = 1$ only when $z = \frac{1}{2}, 1$) cannot happen in equilibrium. This is because station Y would also air a tune-in when $(y, z) = (0, \frac{1}{2})$ so as to (incorrectly) signal to its viewers that z is either 0 or 1. So, no first-period viewer of Y would switch to Z, and thus Y would get an audience size of v. If station Y did not air a tune-in – as would be anticipated by viewers in a PBE – all of its current viewers would switch to station Z and would infer that y is either 0 or 1 upon seeing that $z = \frac{1}{2}$. In this case, those viewers with $\lambda < \frac{1}{4} - c$ would switch back to station Y and stay there upon discovering $y = 0$. So, airing a tune-in is profitable when $v - (\frac{1}{4} - c) \geq \frac{1}{2A}$, which is true by Assumption 2. Note that this condition is satisfied even when the sampling cost is infinitesimally small.

This leaves us with two possible strategies. For station Y, these strategies are (i) air a tune-in unless y is 1, (ii) air a tune-in unless y or z is 1. Similarly, airing a tune-in unless $z = 0$ and unless z or $y = 0$ are the only two possible strategies for station Z. In what follows, I will refer to a strategy in which a station's tune-in decision does not depend on the program of the other station as a non-strategic behavior, and to an equilibrium that involves non-strategic behavior as a non-strategic equilibrium. Similarly, a tune-in strategy that depends on the program of the other station will be referred as a strategic behavior, and the corresponding equilibrium as a strategic equilibrium.

3.1 Strategic Equilibrium

Suppose each station behaves strategically. How would viewers behave if this were a PBE? Since the two stations are identical in every aspect except for the locations of the first programs, the viewing behavior of people in the second period will be symmetric with respect to which station they watched in the first period. Therefore, I can focus on finding only the optimal sampling and final viewing decisions of the viewers who chose to watch Y in the first period.

There are three distinct cases to analyze. The first and the second cases are when Y airs a tune-in for $y = 0$ and for $y = \frac{1}{2}$, respectively. In both cases, the viewers of Y infer that $z \in \{0, \frac{1}{2}\}$. So, their prior beliefs are changed and therefore they will base their decisions on their posterior beliefs. In the third case, Y does not air any tune-ins. Now, it could be that Y did not air a tune-in because either $y = 1$ or $z = 1$ (or both). So, there is a total of five possibilities to analyze:

$$(y,z) \in \{(0,1)\,,(\frac{1}{2},1),(1,0)\,,(1,\frac{1}{2}),(1,1)\}.$$

Their posterior beliefs assign a probability of $\frac{1}{5}$ to each one of these possibilities. Now, the optimal behavior is more complicated to figure out. For example, suppose they sample station Y first. If they observe that $y = 0$, then they can perfectly locate z, and therefore there is no need to continue sampling station Z. But when they observe that $y = 1$, they can say nothing about z. Furthermore, one needs to check if sampling at all is optimal for a viewer. All of these are carefully analyzed in the proof of the following lemma.

Lemma 4 *Suppose a strategic PBE exists. Then, the audience shares of station Y and Z under all program combinations are given by:*

	$\mathbf{z=0}$	$\mathbf{z=\frac{1}{2}}$	$\mathbf{z=1}$
$\mathbf{y=0}$	$\frac{1}{4}, v+c-\frac{1}{4}$	$\frac{1}{4}, v+c+\frac{1}{4}$	$v+c, v+c$
$\mathbf{y=\frac{1}{2}}$	$v+c+\frac{1}{4}, \frac{1}{4}$	$v+c, v+c$	$v+c+\frac{1}{4}, \frac{1}{4}$
$\mathbf{y=1}$	$v+c, v+c$	$\frac{1}{4}, v+c+\frac{1}{4}$	$v+c-\frac{1}{4}, \frac{1}{4}$

Table 2. Audience shares of station Y and Z in a strategic PBE**.**

A strategic PBE exists only if neither station has any incentive to deviate. The next proposition establishes when it exists.

Proposition 2 *The following constitutes a symmetric PBE if $v + c + \frac{1}{A} \leq \frac{1}{2}$: Y airs a tune-in unless y or z is 1, Z airs a tune-in unless y or z is 0.*

When $v + c + \frac{1}{A} > \frac{1}{2}$, people have no reason to expect the strategies in Proposition 2 to be played by the TV stations. This condition is satisfied when $v + c$ is large and/or the number of non-program breaks is small. Intuitively, a larger value of v is associated with a higher audience size since more viewers end up watching TV. A higher sampling cost means that if sampling occurs in the absence of a tune-in, a higher fraction of those who sample stay tuned. When the number of non-program breaks is small, the marginal benefit of promoting the upcoming program is lower. So, in all three cases, the incentive for passing up on airing a tune-in is higher.

From viewers' point of view, the ex-ante expected value of station Y's per-viewer profits is the weighted average of the profits in each of the possible nine cases. Per-viewer revenue in the first period is pA times the audience share in the first period (which is $\frac{1}{2}$) in each case. Per-viewer revenue in the second period is the average of the audience shares given in Table 2 for all of the nine cases, multiplied with pA. Since Y is expected to air a tune-in in four of the nine cases, its expected per-viewer (opportunity) cost is $\frac{4p}{9}$ times the audience share in the first period. So, the ex-ante expected per-viewer revenue of station j, $j = Y, Z$, can be expressed as (the superscript S stands for strategic)

$$E[\Pi_j^S] = \left[\frac{A}{2} + \frac{(6\,(v+c)+1)\,A}{9} - \frac{2}{9}\right] p.$$

3.2 Non-strategic Equilibrium

What happens when $v + c + \frac{1}{A} > \frac{1}{2}$? Based on the analysis so far, one possibility is when each station airs an additional tune-in relative to the PBE in Proposition 2. For station Y, this is when $q_Y\,(0, z) = 1$ for all z and $q_Y(\frac{1}{2}, z) = 1$ unless $z = 1$, or $q_Y(\frac{1}{2}, z) = 1$ for all z and $q_Y\,(0, z) = 1$ unless $z = 1$ (symmetric for Z). These are summarized in Table 3 below (for station Y only).

Hypothetical Strategy 1

	$\mathbf{z=0}$	$\mathbf{z=\frac{1}{2}}$	$\mathbf{z=1}$
$\mathbf{y=0}$	1	1	1
$\mathbf{y=\frac{1}{2}}$	1	1	0
$\mathbf{y=1}$	0	0	0

Hypothetical Strategy 2

	$\mathbf{z=0}$	$\mathbf{z=\frac{1}{2}}$	$\mathbf{z=1}$
$\mathbf{y=0}$	1	1	0
$\mathbf{y=\frac{1}{2}}$	1	1	1
$\mathbf{y=1}$	0	0	0

Table 3. Value of $q_Y(y, z)$ in two hypothetical strategies.

When Y does not air a tune-in, all of its viewers switch to Z since it is highly likely that $y = 1$. If z turns out 0 or $\frac{1}{2}$, then they are certain that $y = 1$, and none of them come back to Y. When it turns out that $z = 1$, however, viewers will get confused. Station Y might have played the first or the second strategy. If it played the first strategy, y could be $\frac{1}{2}$ or 1 with equal chances. If it played the second one, on the other hand, y is 0 or 1. Without any further information, viewers just assume that the two strategies are equally likely to be played, and therefore their inference will be $\Pr\,(y = 0) = \Pr(y = \frac{1}{2}) = \frac{1}{4}$, $\Pr\,(y = 1) = \frac{1}{2}$. But sampling Y would be optimal for all $\lambda \in [0, \frac{1}{2}]$ with these posteriors. This means that station Y could have done better by deviating and reverting back to the strategy in Proposition 2. Since viewers anticipate this beforehand, we cannot have either of these strategies being played in a symmetric PBE.

A second, and the only other, possibility when $v+c+\frac{1}{A} > \frac{1}{2}$ is the non-strategic equilibrium in which the TV stations air a tune-in unless their second program is located at the farther end of the unit line compared to their first-period program. In this case, the priors of viewers who watch Y in the first period about z are unchanged regardless of the tune-in decision of Y.

Lemma 5 *Suppose a non-strategic PBE exists. Then, the audience shares of station Y and Z under all program combinations are given by:*

	$\mathbf{z=0}$	$\mathbf{z=\frac{1}{2}}$	$\mathbf{z=1}$
$\mathbf{y=0}$	$\frac{1}{4}+\frac{1}{4}$	$\frac{1}{4}+\frac{1}{4}$	v
$\mathbf{y=\frac{1}{2}}$	$v+\frac{1}{4}+\frac{3c}{2}$	$v+c$	$v+\frac{1}{4}-\frac{1}{4}$
$\mathbf{y=1}$	$v+c$	$\frac{1}{4}-\frac{1}{4}$	$v-\frac{1}{4}+\frac{1}{4}$

Table 4. Audience shares of station Y and Z in a non-strategic PBE**.**

Note that deviation is not possible in this case, since none of Y's current viewers would keep watching or would come back later when $q_Y = 0$. So, the unique symmetric PBE when $v + c + \frac{1}{A} > \frac{1}{2}$ is the one in which the two stations play non-strategically.

Proposition 3 *When $v + c + \frac{1}{A} > \frac{1}{2}$, the unique symmetric PBE is the one in which Y airs a tune-in unless $y = 1$, and Z airs a tune-in unless $z = 0$.*

Arguing along the same lines as before, the ex-ante expected per-viewer revenue of station j, $j = Y, Z$, can be expressed as (the superscript NS stands for non-strategic)

$$E[\Pi_j^{NS}] = \left[\frac{A}{2} + \frac{(6v + 4c + 1)\,A}{9} - \frac{1}{3}\right] p.$$

Simple comparison yields that $E[\Pi_j^S]$ is always greater than $E\left[\Pi_j^{NS}\right]$. Even though it is on average more profitable to behave strategically, the existence of profitable deviations induces the TV stations to behave non-strategically. When $v + \frac{1}{A} > \frac{1}{2}$, even an infinitesimally small value of the sampling cost gives rise to the non-strategic equilibrium.

When $v+c+\frac{1}{A} \leq \frac{1}{2}$, both equilibria can be supported as PBEs. However, as long as viewers rationally expect the TV stations to play the less costly strategies, the non-strategic equilibrium can be ruled out. To be more precise, provided that $v+c+\frac{1}{A} \leq \frac{1}{2}$, it is always optimal to play strategically for the TV stations when the viewers expect them to do so. However, if the viewers are pessimistic in the sense that they only expect the worse when they do not see a tune-in, the unique PBE is the non-strategic one.

4 Social Value of Tune-ins

In this section, I analyze the effects of a possible ban on the use of tune-ins. I compare the expected social welfare under a "no tune-in" regime with that of no restrictions. In Appendix B, I find the expected utility of a random viewer in all of the possible three situations: the strategic equilibrium (S), the non-strategic equilibrium (NS), and a "no tune-in" equilibrium (NT).

In a regime of no tune-ins, ex-ante expected per-viewer revenue of a station in the second period is just the average of the audience shares given in Table 1, multiplied with the number of commercials and the per-viewer price. The stations are symmetrical in every manner, so the total ex-ante expected per-viewer revenue of station j, $j = Y, Z$, is given by

$$E[\Pi_j^{NT}] = A\left[\frac{1}{2} + \frac{6(v+c)+1}{9}\right]p.$$

Let W denote the social welfare which is defined as the summation of the total revenue of the two stations and viewer well-being. The change in expected social welfare when the non-strategic PBE arises is expressed as

$$\begin{aligned} E\left[W^{NS} - W^{NT}\right] &= N\left[E_\lambda\left[U_\lambda^{NS} - U_\lambda^{NT}\right] + 2E[\Pi_j^{NS} - \Pi_j^{NT}]\right] \\ &= N\left[(\frac{15}{2} - c - 6v)\frac{c}{9} - 2(\frac{p}{3} + \frac{2cA}{9})\right] \\ &= N\left[(\frac{15}{2} - c - 6v - 4A)\frac{c}{9} - \frac{2p}{3}\right]. \end{aligned}$$

In the notation above, $E_\lambda[U_\lambda^{NS}]$ refers to the expected utility of a viewer located at λ in the non-strategic PBE where expectation is taken over λ. So, it is the expected utility of a random viewer in the non-strategic PBE. As mentioned before, please refer to Appendix B to see how $E_\lambda[U_\lambda^{NS}]$, $E_\lambda[U_\lambda^{NT}]$ and $E_\lambda[U_\lambda^{S}]$ are calculated.

Note that $(\frac{15}{2} - c - 6v - 4A) < 0$ by Assumption 1 (even a much smaller value of A would imply the same result). So, $E\left[W^{NS} - W^{NT}\right] < 0$ for all parameter values. This means that it is welfare improving to ban the use of tune-ins when $v + c + \frac{1}{A} > \frac{1}{2}$, since non-strategic equilibrium is the unique symmetric PBE for these parameter values. Although viewers are obviously better off when there are tune-ins, it may be the case that lost revenues are too high, and therefore it is better to ban tune-ins. The primary reason for why the stations lose that much revenue is that fewer people watch TV when there are more tune-ins in general. In the absence of a ban, the "no tune-in" regime is not sustainable as an equilibrium because of unilateral deviations.

The same result does not carry over to the strategic equilibrium. The reason is that the expected audience size in the strategic equilibrium is equal to that in the "no tune-in" regime. Recalling that $E[\Pi_j^S] = \left[\frac{A}{2} + \frac{(6(v+c)+1)A}{9} - \frac{2}{9}\right] p$, the change in expected social welfare when the strategic PBE is the outcome is

$$\begin{aligned} E\left[W^S - W^{NT}\right] &= N\left[E_\lambda\left[U_\lambda^S - U_\lambda^{NT}\right] + 2E[\Pi_j^S - \Pi_j^{NT}]\right] \\ &= N\left(\frac{c}{3} - \frac{4p}{9}\right). \end{aligned}$$

which is negative when $p > \frac{3c}{4}$. These findings are summarized in the next proposition.

Proposition 4 *If the outcome is the strategic PBE, it is welfare improving to ban tune-ins only when $p > \frac{3c}{4}$. If it is the non-strategic PBE, on the other hand, it is always welfare improving to ban tune-ins.*

It immediately follows from Proposition 4 that it may be welfare improving if the two stations collude and maximize total ad revenues. By Lemma 2, it is optimal to air no tune-ins in such a case since all viewers get engaged in sampling without any tune-ins. Thus, as long as the conditions of Proposition 4 hold, collusion is better for the society as a whole. This is formally stated in the next proposition.

Proposition 5 *Collusion between the two stations improves welfare when $p > \frac{3c}{4}$.*

Tune-ins clearly benefit viewers. Without tune-ins, viewers would engage in too much sampling and some would end up watching TV although it yields a negative utility. If viewers had complete information about program attributes, TV stations would serve a smaller audience size. However, information is incomplete and it is not feasible to inform everyone about TV programs. In a non-strategic equilibrium, TV stations are forced by market conditions to air too many tune-ins. This is due to two factors. First, an equilibrium with no tune-ins is not feasible because of the oligopoly structure; without tune-ins, more people would switch away. Second, strategic equilibrium is not credible when c and/or $\frac{1}{A}$ is large. Had viewers believed that the strategic equilibrium would arise, neither station would air any tune-ins at all. When c is large, a station can still capture an audience size that is high enough to make it worthwhile to deviate. When A is small, second-period revenue is not that large anyway, so deviation is again profitable. But, viewers are rational and they perfectly anticipate these incentives beforehand. As a result, the stations are forced to air a higher number of tune-ins. The higher the number of tune-ins, the better choices people make, which implies a smaller audience size in the second period. So, the stations are double jeopardized when the strategic equilibrium cannot be attained; a higher number of tune-ins and fewer viewers on average. The revenue they lose in such a situation is larger than the increase in the well-being of viewers. Therefore, banning tune-ins is welfare enhancing.

The former one of the two factors above is also present in the strategic equilibrium. However, since c or $\frac{1}{A}$ is small enough, strategic equilibrium is credible. Therefore, the second factor does not arise. When the strategic equilibrium is attainable, stations do not end up airing too many tune-ins. Consumer surplus is now lower since viewers more often get stuck watching a program that is a bad match. When the per-viewer commercial price is low relative to the sampling cost, the decrease in the well-being of viewers is smaller than the increase in the revenue of the TV stations due to fewer tune-ins, and therefore no intervention is necessary.[14]

5 Discussion and Conclusion

In this paper, I have introduced a framework in which the advertising decision of a firm (indirectly) provides information to people about the attributes of the product of the other firm in a horizontally differentiated duopoly market. I have chosen the TV industry for this analysis

[14] 88.5 million U.S. viewers watched the 2000 Super Bowl. The average price for a 30-second commercial was $2.1 million. So, the per-viewer price was approximately 2.4 cents. Although it is impossible to make an ordinal comparison of the per-viewer price and the sampling cost, common sense suggests that an average viewer loses more following an unsuccessful sampling.

for several reasons. Most importantly, network stations do not price their programs, tune-ins are directly informative ads, they are special to the TV industry and they are exclusive (in the sense that a TV station cannot advertise to other stations' audiences).

I have analyzed the provision of tune-ins in a two-period model of TV broadcasting where programs are provided by two TV stations and are only horizontally differentiated. For simplicity, I assumed that the first programs at each TV station are known to viewers beforehand, and that the market is completely covered in the first period. The locations of the second programs are ex-ante unknown to people, although they know that the TV stations have this information. Therefore, viewers know that the tune-in decision of the TV station they watch in the first period may provide them with information about the location of the other station's program. In this context, I have characterized the symmetric perfect Bayesian equilibria in which tune-in decisions of the stations and the following inferences of viewers are in accordance.

The main aim of the analysis is to characterize the nature of strategic behavior when TV stations are privately informed about both programs. Therefore, I have restricted the parameter values so as to ensure that an equilibrium in which no tune-ins are aired does not exist. These restrictions simply require that the number of advertisements during a program is not very small, and that the value of the sampling cost is small relative to the gross utility people derive when they watch their ideal programs. The latter one implies that viewers always choose to sample a station if their priors for the program at that station are unchanged. However, it is also implied that the gross utility is not very large so that all of the viewers do not end up watching the second program until the end. I believe that these assumptions are in line with empirical regularities and do not impose restrictions on the findings.

Existence of two symmetric PBEs has been shown. In the first one – referred to as the strategic PBE in the text – each station's tune-in decision depends on the location of its own as well as the location of its rival's program. A station chooses not to air a tune-in whenever at least one of the programs is such that no first-period viewer of that station would watch it. Not airing a tune-in when a station's own program is not appealing to its first-period viewers is optimal because a tune-in would not bring in any viewers. Similarly, it is not optimal to air a tune-in when a station knows that its first-period viewers will not like the program at the other station, and therefore anyone who may initially switch to the other station will come back.

The second possible PBE – referred to as the non-strategic PBE in the text – is the one in which each station's tune-in decision only depends on the location of its own program. A station chooses not to air a tune-in only when its program is such that none of its first-period viewers would watch it. This PBE is shown to exist as long as Assumption 1 is satisfied, and it is unique when either the sampling cost is relatively high or the TV stations have a small number of ads (or both). In the opposite case, both equilibria are valid. It is at first ambiguous as to which one of these equilibria would be selected. If viewers are extremely pessimistic, they would expect the worst scenario upon not seeing a tune-in. This belief structure would eliminate the strategic PBE. However, there is no reason for viewers to be pessimistic in the current model. Since they perfectly know the incentives of the TV stations, they would most likely anticipate that the TV stations would choose the strategies resulting in higher revenues. From their point of view, the expected revenues are higher in the strategic PBE since the stations air fewer tune-ins on average compared to the non-strategic PBE. So, there is not much reason to believe that the stations would behave non-strategically. If, however, viewers were exogenously assumed to be pessimistic, we would have had the non-strategic PBE as the unique PBE.

In the strategic PBE, viewers update their priors about the location of the other station's program upon observing the tune-in decision of the station they have watched in the first period. So, the tune-in decision of the station they have watched in the first period serves as a signal for the program of the other station. There does not exist a fully separating equilibrium in which viewers are able to locate the other station's program with certainty only based on the tune-in decision of a TV station. If a station does not air a tune-in, it is inferred by that station's first-period audience that the upcoming program is probably not a good match for them. This deters them away from staying tuned to the same station. However, they also infer that it could actually be the other station's program that is a bad match. In the strategic PBE, this additional inference exactly offsets the deterrence effect. As a result, viewers are indifferent between choosing either one of the two stations to start watching. After learning the location of the program they choose to sample first, they update their beliefs about the other program and then make their final decisions. At some instances, perfect revelation may occur after sampling one of the stations. Suppose a viewer watches station Y in the first period and station Y does not air a tune-in for its upcoming program. If this viewer continues to watch station Y and discovers after sampling that the program at Y is appealing to her, then she perfectly infers the location of the program at the other station. Had the TV stations behaved non-strategically, this inference would be impossible to reach.

The stations are better off on average in the strategic PBE compared to the non-strategic one. The same is not true for the viewers; sampling occurs more frequently in the strategic PBE since TV stations air fewer tune-ins. From a welfare perspective, it may be desirable to ban tune-ins. In the non-strategic PBE, total revenue of the stations is significantly reduced compared to the strategic PBE and this reduction overweighs the increase in the aggregate viewer surplus. So, it is always desirable to ban tune-ins in the non-strategic PBE. In the strategic PBE, it is desirable only if the value of the sampling cost is sufficiently low. A direct implication is that whenever banning tune-ins is desirable, collusion between the two stations is desirable, too. This follows from the fact that a monopolist would not air any tune-ins in this market.

Real life is clearly not as simple. It is almost impossible to represent TV programs in a unidimensional space. It is also not likely that viewers' preferences stay the same over time, and that viewers have nonrandom utilities. Nevertheless, this paper raises a question that has not been touched on before, and constitutes a starting point for a more thorough analysis of signaling by advertising in horizontally differentiated markets and of (indirect) signaling by advertising when firms have common knowledge of the attributes of all the products in a market.

Appendix A

Proof of Lemma 2 It suffices to analyze the behavior of viewers with locations $\lambda \in \left[0, \frac{1}{4}\right]$. The remaining possibilities are simply symmetrical. Suppose a λ-type viewer chooses to sample one of the programs. If λ is such that $0 \leq \lambda \leq \frac{1}{2} - v - c$, then this viewer knows that she would only watch a program located at 0. If the program that she first samples is not at 0, should she also sample the program at the other station? Unless the other program happens to be located at 0, she would turn her TV off, and her net utility would be $-2c$ since she would have sampled both programs and ended up taking the outside option. So, the expected utility of sampling the other station is $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c)$. On the other hand, if she switches off without sampling the other station, she would enjoy a utility of $-c$. Hence, she should engage in a second sampling if $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c) \geq -c$, or equivalently if $v - \lambda \geq 2c$. The left-hand side is decreasing in λ, so if this inequality is satisfied at $\lambda = \frac{1}{2} - v - c$, it has to be true for all $\lambda \leq \frac{1}{2} - v - c$. Evaluating at $\lambda = \frac{1}{2} - v - c$, we get $2v - c \geq \frac{1}{2}$ which is always true by Assumption 1.

We also need to check if engaging in sampling is optimal at all for this person. Expected utility of doing so is $\frac{1}{3}(v - \lambda) + \frac{2}{3}\left[\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c)\right]$, where the second term is due to the fact that it is also optimal to sample the other station when the first program sampled is not at 0. If this is nonnegative, then it is optimal to engage in sampling for viewers with locations $\lambda \leq \frac{1}{2} - v - c$. Rearranging, expected utility becomes $\frac{5}{9}[v - \lambda - 2c]$, which is nonnegative if $v - \lambda \geq 2c$. This is the same condition as in the previous paragraph, and therefore expected utility is nonnegative.

Now, take a viewer with location $\lambda \in \left[\frac{1}{2} - v - c, \frac{1}{4}\right]$ and suppose that this viewer samples station Y. She stays at Y if y is located at 0. If it turns out that $y = \frac{1}{2}$, she may also want to check out station Z in the hope of finding out $z = 0$. But there is also the chance that z is $\frac{1}{2}$ or 1. If $z = 1$, she would switch back to station Y. If, on the other hand, $z = \frac{1}{2}$, she would be indifferent between the two stations. So, the expected utility of switching to station Z when $y = \frac{1}{2}$ is $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(v - c - \frac{1}{2} + \lambda)$. If this expression is greater than the utility of staying at Y, $v - (\frac{1}{2} - \lambda)$, she should switch to and sample the program at station Z. This is satisfied when $\lambda < \frac{1}{4} - \frac{3c}{2}$. So, when $y = \frac{1}{2}$, it is optimal to also sample Z for the viewers with locations $\frac{1}{2} - v - c \leq \lambda < \frac{1}{4} - \frac{3c}{2}$. Finally, suppose it turns out that $y = 1$. The expected utility of switching to Z is $\frac{1}{3}(v-c-\lambda)+\frac{1}{3}(v-c-\frac{1}{2}+\lambda)+\frac{1}{3}(-2c)$ which equals $\frac{1}{3}(2v-4c-\frac{1}{2})$. This is greater than $-c$ when $2v-c>\frac{1}{2}$, which is again true by Assumption 1. ■

Proof of Lemma 3 Suppose, for instance, that $(y,z)=(0,\frac{1}{2})$. A random half of the viewers sample station Y first. Among these viewers, those with $\lambda\leq\frac{1}{4}+\frac{3c}{2}$ stay at Y while the rest switch to Z. Since $z=\frac{1}{2}$, those with $\lambda>\frac{1}{2}+v+c$ turn their TVs off. From among the other half who chose to sample Z first, the ones with $\lambda\in\left[\frac{1}{4}-\frac{3c}{2},\frac{3}{4}+\frac{3c}{2}\right]$ stay at Z while the others switch to Y. Those with $\lambda<\frac{1}{4}-\frac{3c}{2}$ stay at Y. The same is not true for $\lambda>\frac{3}{4}+\frac{3c}{2}$. The program $y=0$ is not favorable for them, so those with locations $\lambda\in\left[\frac{3}{4}+\frac{3c}{2},\frac{1}{2}+v+c\right]$ switch back to station Z while the rest switch off. So, all together, we get an audience share of $\frac{1}{2}(\frac{1}{4}+\frac{3c}{2})+\frac{1}{2}(\frac{1}{4}-\frac{3c}{2})=\frac{1}{4}$ for station Y. Similarly, it is $\frac{1}{2}(\frac{1}{2}+v+c-(\frac{1}{4}+\frac{3c}{2}))+\frac{1}{2}(\frac{1}{2}+v+c-(\frac{1}{4}-\frac{3c}{2}))=v+c$ for station Z. Arguing along similar lines, we get Table 1 in Lemma 3. ■

Proof of Proposition 1 Suppose Y aired a tune-in when $(y,z)=(0,0)$. For the indifferent viewer from the first-period audience of station Y, the expected utility of switching to Z is $\frac{1}{3}(v-\lambda)+\frac{1}{3}(v-\frac{1}{2}+\lambda)+\frac{1}{3}(v-c-\lambda)$, where the first term is the utility she would enjoy at Z when $z=0$, the second term is the utility she would enjoy at Z when $z=\frac{1}{2}$, and the third term is the utility she would enjoy at Y when $z=1$. This expression equals the utility of staying at Y, $v-\lambda$, for the viewer located at $\frac{1}{4}+\frac{c}{2}$, so the viewers with $\lambda\leq\frac{1}{4}+\frac{c}{2}$ do not switch to Z. Since this is a unilateral deviation, the behavior of the first-period viewers of station Z remains the same. The ones who switch to Z do not come back to Y since they would incur the sampling cost. So, station Y would gain an extra audience of $(\frac{1}{4}+\frac{c}{2})-\frac{v+c}{2}=\frac{1-2v}{4}$ by airing a tune-in, and thus its second-period advertising revenue would go up by $ANp\frac{1-2v}{4}$. The cost of airing a tune-in is the revenue forgone in the first period from a single commercial, which is $Np\frac{1}{2}$. Thus, it is profitable to deviate as long as $\frac{1}{2}-v\geq\frac{1}{A}$.

Suppose the program locations are $(y,z)=(\frac{1}{2},\frac{1}{2})$. If neither station airs a tune-in, they each receive an expected audience size of $v+c$ in the second period. From the previous analysis, if station Y airs a tune-in, viewers with locations $\lambda\in\left[\frac{1}{4}-\frac{c}{2},\frac{1}{2}\right]$ continue to stay with Y while the others, $\lambda<\frac{1}{4}-\frac{c}{2}$, switch to Z. The ones who switch to Z will stay there once they discover that $z=\frac{1}{2}$, since switching back to Y means missing the first few minutes of the program at Y. When this is a unilateral deviation by Y, behavior of the first-period viewers of Z does not change. A random half of them still switch to Y right after the first period ends. Among these viewers, the ones with locations $\lambda \in \left[\frac{1}{2}, \frac{3}{4} + \frac{3c}{2}\right]$ stay at Y. The others go back to Z to check out the program there. Once they discover that $z = \frac{1}{2}$, those with locations at most $v + c$ apart from $\frac{1}{2}$ choose one of the stations at random as their final destination. Similarly, among those who stayed at Z at first, $\lambda \in \left[\frac{3}{4} + \frac{3c}{2}, 1\right]$ also sample Y and a random half of $\lambda \in \left[\frac{3}{4} + \frac{3c}{2}, \frac{1}{2} + v + c\right]$ stay at Y. Hence, station Y collects a total audience size of $\left(\frac{1}{4} + \frac{c}{2}\right) + \frac{1}{2}(v + c)$ as opposed to $v + c$. Since this is a symmetric game, station Z will have the same incentives. When both stations air a tune-in, they each get an audience of $v + c$, the same as before but with different composition. Thus, we get the following audience sizes when $(y, z) = (\frac{1}{2}, \frac{1}{2})$:

	$\mathbf{q}_Z = \mathbf{0}$	$\mathbf{q}_Z = \mathbf{1}$
$\mathbf{q}_Y = \mathbf{0}$	$(v + c, v + c)$	$(\frac{3v}{2} - \frac{1}{4} + c, \frac{v}{2} + \frac{1}{4} + c)$
$\mathbf{q}_Y = \mathbf{1}$	$(\frac{v}{2} + \frac{1}{4} + c, \frac{3v}{2} - \frac{1}{4} + c)$	$(v + c, v + c)$

The unique Nash equilibrium in this game is $(q_Y, q_Z) = (1, 1)$ provided that $\frac{1}{2} - v \geq \frac{1}{A}$. This is true by Assumption 1 and thus the stations face a Prisoners' Dilemma situation. That is why a "no tune-in" regime cannot be maintained in an equilibrium. ■

Proof of Lemma 4 In a strategic PBE, there are three distinct cases to analyze:

Case (1): *Y airs a tune-in for $y = 0$.*

In this case, the viewers of Y infer that $z \in \{0, \frac{1}{2}\}$. Those with locations closer to $\frac{1}{2}$ will have a tendency to switch to Z. Whatever the location of z turns out, none of these people would come back to Y. So, the solution is simple; $\lambda \leq \frac{1}{4}$ stay with Y, the others switch to Z. Those who switch to Z will have the sampling cost sunk, and therefore $\frac{1}{4} < \lambda \leq v + c$ will stay with Z when $z = 0$. The others just switch off in this case. If z turns out $\frac{1}{2}$, then all of them stay with Z.

Case (2): *Y airs a tune-in for $y = \frac{1}{2}$.*

In this case, the viewers of Y infer that $z \in \{0, \frac{1}{2}\}$. Those with locations closer to 0 will have a tendency to switch to Z. Similar with case (1), $\lambda \geq \frac{1}{4}$ stay with Y, the others switch to Z. Those who switch to Z will have the sampling cost sunk, and therefore $\frac{1}{2} - (v + c) < \lambda \leq \frac{1}{2}$ will stay with Z when $z = \frac{1}{2}$. If z turns out 0, then all of them stay with Z.

Case (3): Y *does not air a tune-in.*

The inference of viewers in this case is that Y did not air a tune-in because either $y = 1$ or $z = 1$ (or both). There are five possibilities:

$$(y, z) \in \{(0, 1), (\frac{1}{2}, 1), (1, 0), (1, \frac{1}{2}), (1, 1)\}.$$

So the posterior probability that $y = 0$ is same with the probability that $z = 0$, which is $\frac{1}{5}$. Similarly, $\Pr(y = \frac{1}{2}) = \Pr(z = \frac{1}{2}) = \frac{1}{5}$, and $\Pr(y = 1) = \Pr(z = 1) = \frac{3}{5}$. This means that viewers are indifferent between the two stations, and a random half will choose Z first. For those who stayed with Y, the actual location of y will determine their further behavior.

If $y = 0$, they infer that $z = 1$. So viewers with locations less than $v + c$ stay with Y, and the rest switch off. Note that for $v < \lambda \leq v + c$ switching off yields a disutility of c, so it is better to stay tuned.

If $y = \frac{1}{2}$, they infer that $z = 1$. So viewers with locations $\frac{1}{2} - (v + c) \leq \lambda \leq \frac{1}{2}$ stay with Y, and the rest switch off.

If $y = 1$, they infer that $z \in \{0, \frac{1}{2}, 1\}$, each with equal probability. If the viewers with locations $0 \leq \lambda < \frac{1}{2} - (v + c)$ choose to sample the program at station Z, they will only stay there when $z = 0$. So, the expected utility of sampling Z for a generic λ-viewer from this interval, denoted by $E\left[U_Z^\lambda\right]$, given that station Y did not air a tune-in (i.e. given that $q_Y^{-1}(0) = (1, z)$) is

$$E\left[U_Z^\lambda \mid q_Y^{-1}(0) = (1, z)\right] = \frac{1}{3}(v - c - \lambda) - \frac{2}{3}(2c).$$

Note that the highest utility a viewer may get in this case is $v - c$, since she started sampling with station Y and incurred the sampling cost. Viewers would stay tuned if the expected utility of sampling Z is not less than $-c$. Otherwise they turn their TVs off right after the first program ends. For $\lambda = \frac{1}{2} - (v + c)$, the expected utility of sampling is $\frac{1}{3}(2v - \frac{1}{2}) - \frac{2}{3}(2c)$. This is at least as great as $-c$ if $2v - \frac{1}{2} \geq c$, which is true by Assumption 1. Since $E\left[U_Z^\lambda \mid q_Y^{-1}(0) = (1, z)\right]$ is decreasing in λ, all of these viewers would choose to sample Z.

Viewers with locations $\frac{1}{2} - (v + c) < \lambda \leq \frac{1}{4}$ would stay with Z unless $z = 1$. So, their expected utility is

$$\begin{aligned} E\left[U_Z^\lambda \mid q_Y^{-1}(0) = (1, z)\right] &= \frac{1}{3}\left[(v - c - \lambda) + (v - c - (\frac{1}{2} - \lambda)) - (2c)\right] \\ &= \frac{1}{3}(2v - 4c - \frac{1}{2}). \end{aligned}$$

This expression is greater than or equal to $-c$ when $2v - \frac{1}{2} \geq c$, which is the same condition as before. Hence, it is satisfied for all $\lambda \in [\frac{1}{4}, \frac{1}{2}]$. The choices of viewers with locations on $[\frac{1}{4}, \frac{1}{2}]$ are just symmetric with those on $[0, \frac{1}{4}]$, so they all sample Z as well. If the program turns out to be located at 0 or $\frac{1}{2}$, station Z gets an audience size of $N(v+c)$. If $z = 1$, everyone switches off.

For those of $0 \leq \lambda \leq \frac{1}{2}$ who switched to Z initially, the subsequent choices are similar. Now, I need to check if sampling one of the stations is desirable at all, conditional on not seeing a tune-in. For $0 \leq \lambda < \frac{1}{2} - (v+c)$, the expected utility of starting sampling with station Y is

$$E\left[U_Z^\lambda \mid q_Y = 0\right] = \frac{1}{5}(v - \lambda) + \frac{1}{5}(-c) + \frac{3}{5} E\left[U_Z^\lambda \mid q_Y^{-1}(0) = (1, z)\right].$$

Similarly, for $\frac{1}{2} - (v+c) \leq \lambda < \frac{1}{4}$, it is

$$E\left[U_Z^\lambda \mid q_Y = 0\right] = \frac{1}{5}(v - \lambda) + \frac{1}{5}(v - \frac{1}{2} + \lambda) + \frac{3}{5} E\left[U_Z^\lambda \mid q_Y^{-1}(0) = (1, z)\right].$$

We need this value to be nonnegative for a viewer to sample Y. For $0 \leq \lambda < \frac{1}{2} - (v+c)$, $E\left[U_Z^\lambda \mid q_Y = 0\right] = \frac{2}{5}(v - c - \lambda) - \frac{2}{5}(2c)$. This is negative if λ is greater than $3c - v$. If $\frac{1}{2} - (v+c)$ is less than (or equal to) $3c - v$, then all of these people engage in sampling. $\frac{1}{2} - (v+c) \leq 3c - v$ if $c \geq \frac{1}{8}$. By Assumption 1, we must have $\frac{1}{4} + c < \frac{1}{2} - c$, which implies $c < \frac{1}{8}$. By monotonicity of $E\left[U_Z^\lambda \mid q_Y = 0\right]$ (increasing up to $\lambda = \frac{1}{4}$, and decreasing thereafter), we can conclude that sampling is desirable conditional on $q_Y = 0$.

Everything is symmetrical for station Z. So, the audience shares in Table 2 are straightforward to calculate. ■

Proof of Proposition 2 Suppose $(y, z) = (0, 0)$. If station Y deviates and does not air a tune-in, then a random half of its viewers stay with it while the other half switch. Those who stayed would think that $z = 1$ upon seeing that $y = 0$, and the ones with locations less than $v + c$ would continue staying. Those who initially switched to Z would think that $y = 1$ upon seeing $z = 0$, and therefore none of them would switch back to Y. So, station Y would end up with an audience share of $\frac{v+c}{2}$. It is profitable to deviate if

$$A\left(\frac{1}{4} - \frac{v+c}{2}\right) < \frac{1}{2},$$

where the left hand side is the marginal per-viewer revenue of a tune-in and the right hand side is the per-viewer cost of a tune-in. So, Y would not deviate if $v + c + \frac{1}{A} \leq \frac{1}{2}$. The same is true for $(y,z) = (0,\frac{1}{2}),(\frac{1}{2},0)$ and $(\frac{1}{2},\frac{1}{2})$. Note that deviation is not profitable when $y = 1$ since station Y can only communicate with its own viewers, and none of them would watch a program located at 1. It remains to analyze if it is profitable for Y to deviate when $(y,z) = (0,1)$ or $(\frac{1}{2},1)$. In both cases, station Y is already getting the highest possible audience share from its first period without a tune-in. So, airing a tune-in cannot increase Y's audience size. Therefore, deviation is not profitable in these two cases, either. ■

Proof of Lemma 5 In a non-strategic PBE, there are three distinct cases to analyze:

Case (1): *Y airs a tune-in for $y = 0$.*

Since there is also the chance that $z = 1$, only the viewers with $\lambda > \frac{1}{4} + \frac{c}{2}$ sample Z. If z turns out to be located at 1, the ones with $\lambda \leq v$ come back to Y. If $z = 0$ or $\frac{1}{2}$, none of them come back.

Case (2): *Y airs a tune-in for $y = \frac{1}{2}$.*

This case is symmetric with Case (1).

Case (3): *Y does not air a tune-in.*

In this case, it is inferred that $y = 1$, and therefore none of the current viewers of Y will watch it.

Everything is symmetrical for station Z. So, the audience shares in Table 4 are straightforward to calculate. ■

Proof of Proposition 3 Proof is obvious since deviation is not possible in a non-strategic PBE. Furthermore, this is the only possible form (left) for a non-strategic PBE, so it must be unique if it exists. ■

Proof of Proposition 4 The calculations are in the text preceding Proposition 4. ■

Proof of Proposition 5 Proof is obvious by the argument in the paragraph preceding Proposition 5 in the text. ■

Appendix B

Here, I find the utility of a random viewer under three specifications; the strategic PBE (S), the non-strategic PBE (NS), and the "no tune-in" regime (NT). I assume that the viewer located at $\frac{1}{2}$ watches station Y in the first period, and that whenever a viewer is indifferent between staying at a station or sampling the other one (or switching off), she chooses to stay (these assumptions do not change the results since there is a continuum of viewers). The findings in this appendix help me calculate the social welfare in Section 3. In each one of the nine possible program locations, average viewer derives a different level of utility since the TV stations, and in turn the viewers, behave differently in each one. Only the first five cases are analyzed in detail. The remaining four cases are symmetric with the first four ones.

Case (1): $(y, z) = (0, 0)$.
S: Station Y does, Z does not air a tune-in. Among those who watched Y in the first period, $\lambda \leq \frac{1}{4}$ stay with Y while the others switch to Z before the second period starts. After seeing that $z = 0$, $\lambda > v + c$ switch off. The ones who watched Z in the first period end up sampling both stations and eventually turn their TVs off. So

$$U_\lambda^S = \begin{cases} v - \lambda & \text{,if } 0 \leq \lambda \leq v + c \\ -c & \text{,if } v + c < \lambda \leq \frac{1}{2} \\ -2c & \text{,if } \frac{1}{2} < \lambda \leq 1 \end{cases}.$$

NS: Station Y does, Z does not air a tune-in. Among those who watched Y in the first period, $\lambda \leq \frac{1}{4} + \frac{c}{2}$ stay with Y after seeing a tune-in for $y = 0$ while the others switch to Z. The ones who watched Z in the first period only sample Y since they infer that $z = 0$. But they eventually turn their TVs off. So

$$U_\lambda^{NS} = \begin{cases} v - \lambda & \text{,if } 0 \leq \lambda \leq v + c \\ -c & \text{,if } v + c < \lambda \leq 1 \end{cases}.$$

NT: A random half of viewers start with Y and the other half with Z. Viewers with locations $\lambda \leq \frac{1}{4} + \frac{3c}{2}$ settle on the first station they sampled, thus incurring no sampling cost, while those with $\frac{1}{4} + \frac{3c}{2} \leq \lambda < v + c$ sample both stations and choose one at random. All others switch off after sampling both stations. So

$$U_\lambda^{NT} = \begin{cases} v - \lambda & \text{,if } 0 \leq \lambda \leq \frac{1}{4} + \frac{3c}{2} \\ v - c - \lambda & \text{,if } \frac{1}{4} + \frac{3c}{2} < \lambda \leq v + c \\ -2c & \text{,if } v + c < \lambda \leq 1 \end{cases}.$$

So, we have the following:

$$U_\lambda^S - U_\lambda^{NT} = \begin{cases} 0 & \text{,if } 0 \leq \lambda \leq \frac{1}{4} + \frac{3c}{2} \\ c & \text{,if } \frac{1}{4} + \frac{3c}{2} < \lambda \leq \frac{1}{2} \\ 0 & \text{,if } \frac{1}{2} < \lambda \leq 1 \end{cases}.$$

$$U_\lambda^{NS} - U_\lambda^{NT} = \begin{cases} 0 & \text{,if } 0 \le \lambda \le \frac{1}{4} + \frac{3c}{2} \\ c & \text{,if } \frac{1}{4} + \frac{3c}{2} < \lambda \le 1 \end{cases}.$$

Integrating over λ, we get:

$$E_\lambda \left[U_\lambda^S - U_\lambda^{NT} \mid (y,z) = (0,0) \right] = \left(\frac{1}{4} - \frac{3c}{2} \right) c.$$
$$E_\lambda \left[U_\lambda^{NS} - U_\lambda^{NT} \mid (y,z) = (0,0) \right] = \left(\frac{3}{4} - \frac{3c}{2} \right) c.$$

Case (2): $(y,z) = (0, \frac{1}{2})$.

S: Station Y does, Z does not air a tune-in. Among those who watched Y in the first period, $\lambda \le \frac{1}{4}$ stay with Y while the others switch to Z and stay there. Among those who watched Z in the first period, a random half stay with Z. After seeing that $z = \frac{1}{2}$, they infer that $y = 0$, so $\frac{1}{2} \le \lambda \le \frac{1}{2} + v + c$ stay and the others switch off. The other half start sampling with Y. After seeing that $y = 0$, they infer $z \in \{0, \frac{1}{2}, 1\}$, so all switch to Z. Those with $\frac{1}{2} \le \lambda \le \frac{1}{2} + v + c$ stay, the others switch off. So

$$U_\lambda^S = \begin{cases} v - \lambda & \text{,if } 0 \le \lambda \le \frac{1}{4} \\ v - (\frac{1}{2} - \lambda) & \text{,if } \frac{1}{4} < \lambda \le \frac{1}{2} \\ \frac{1}{2}(v - \lambda + \frac{1}{2}) + \frac{1}{2}(v - c - \lambda + \frac{1}{2}) & \text{,if } \frac{1}{2} < \lambda \le \frac{1}{2} + v + c \\ \frac{1}{2}(-c) + \frac{1}{2}(-2c) & \text{,if } \frac{1}{2} + v + c < \lambda \le 1 \end{cases}.$$

NS: Both stations air a tune-in. $\lambda \le \frac{1}{4} + \frac{c}{2}$ among those who watched Y in the first period stay with Y after seeing a tune-in for $y = 0$ while the others switch to Z and stay there. Behavior of the ones who watched Z in the first period is similar. Those with $\lambda > \frac{3}{4} + \frac{c}{2}$ initially switch to Y in the hope of finding out $y = 1$. After discovering that $y = 0$, $\frac{3}{4} + \frac{c}{2} < \lambda \le \frac{1}{2} + v$ come back to Z while the others turn their TVs off. So

$$U_\lambda^{NS} = \begin{cases} v - \lambda & \text{,if } 0 \le \lambda \le \frac{1}{4} + \frac{c}{2} \\ v - (\frac{1}{2} - \lambda) & \text{,if } \frac{1}{4} + \frac{c}{2} < \lambda \le \frac{1}{2} \\ v - (\lambda - \frac{1}{2}) & \text{,if } \frac{1}{2} < \lambda \le \frac{3}{4} + \frac{c}{2} \\ v - c - (\lambda - \frac{1}{2}) & \text{,if } \frac{3}{4} + \frac{c}{2} < \lambda \le \frac{1}{2} + v \\ -c & \text{,if } \frac{1}{2} + v < \lambda \le 1 \end{cases}.$$

NT: A random half of viewers start with Y and the other half with Z. Viewers with locations $\frac{1}{4} - \frac{3c}{2} \le \lambda \le \frac{1}{4} + \frac{3c}{2}$ settle on the first station they sampled, thus incurring no sampling cost, while the others may end up sampling both stations. For $\lambda \le \frac{1}{4} - \frac{3c}{2}$, if the viewer is lucky and started with Y, she stays there. If she started with Z, she also samples Y. Similarly, $\frac{1}{4} + \frac{3c}{2} \le \lambda \le \frac{3}{4} + \frac{3c}{2}$ end up at Z either immediately or after initially sampling Y. All others sample both stations and those with $\frac{3}{4}+\frac{3c}{2}\leq\lambda\leq\frac{1}{2}+v+c$ stay tuned. So

$$U_\lambda^{NT}=\begin{cases}\frac{1}{2}\left(v-\lambda\right)+\frac{1}{2}\left(v-c-\lambda\right) & \text{,if } 0\leq\lambda<\frac{1}{4}-\frac{3c}{2}\\ \frac{1}{2}\left(v-\lambda\right)+\frac{1}{2}(v-\frac{1}{2}+\lambda) & \text{,if } \frac{1}{4}-\frac{3c}{2}\leq\lambda\leq\frac{1}{4}+\frac{3c}{2}\\ \frac{1}{2}(v-\frac{1}{2}+\lambda)+\frac{1}{2}(v-c-\frac{1}{2}+\lambda) & \text{,if } \frac{1}{4}+\frac{3c}{2}<\lambda\leq\frac{1}{2}\\ \frac{1}{2}(v-\lambda+\frac{1}{2})+\frac{1}{2}(v-c-\lambda+\frac{1}{2}) & \text{,if } \frac{1}{2}<\lambda\leq\frac{3}{4}+\frac{3c}{2}\\ v-c-(\lambda-\frac{1}{2}) & \text{,if } \frac{3}{4}+\frac{3c}{2}<\lambda\leq\frac{1}{2}+v+c\\ -2c & \text{,if } \frac{1}{2}+v+c<\lambda\leq 1\end{cases}.$$

So, we have the following:

$$U_\lambda^{S}-U_\lambda^{NT}=\begin{cases}\frac{c}{2} & \text{,if } 0\leq\lambda<\frac{1}{4}-\frac{3c}{2}\\ \frac{1}{4}-\lambda & \text{,if } \frac{1}{4}-\frac{3c}{2}\leq\lambda\leq\frac{1}{4}\\ \lambda-\frac{1}{4} & \text{,if } \frac{1}{4}<\lambda\leq\frac{1}{4}+\frac{3c}{2}\\ \frac{c}{2} & \text{,if } \frac{1}{4}+\frac{3c}{2}<\lambda\leq\frac{1}{2}\\ 0 & \text{,if } \frac{1}{2}<\lambda\leq\frac{3}{4}+\frac{3c}{2}\\ \frac{c}{2} & \text{,if } \frac{3}{4}+\frac{3c}{2}<\lambda\leq 1\end{cases}.$$

$$U_\lambda^{NS}-U_\lambda^{NT}=\begin{cases}\frac{c}{2} & \text{,if } 0\leq\lambda<\frac{1}{4}-\frac{3c}{2}\\ \frac{1}{4}-\lambda & \text{,if } \frac{1}{4}-\frac{3c}{2}\leq\lambda\leq\frac{1}{4}+\frac{c}{2}\\ \lambda-\frac{1}{4} & \text{,if } \frac{1}{4}+\frac{c}{2}<\lambda\leq\frac{1}{4}+\frac{3c}{2}\\ \frac{c}{2} & \text{,if } \frac{1}{4}+\frac{3c}{2}<\lambda\leq\frac{3}{4}+\frac{c}{2}\\ -\frac{c}{2} & \text{,if } \frac{3}{4}+\frac{c}{2}<\lambda\leq\frac{3}{4}+\frac{3c}{2}\\ 0 & \text{,if } \frac{3}{4}+\frac{3c}{2}<\lambda\leq\frac{1}{2}+v\\ (\lambda-\frac{1}{2})-v & \text{,if } \frac{1}{2}+v<\lambda\leq\frac{1}{2}+v+c\\ c & \text{,if } \frac{1}{2}+v+c<\lambda\leq 1\end{cases}.$$

Integrating over λ, we get:

$$\begin{aligned}E_\lambda\left[U_\lambda^{S}-U_\lambda^{NT}\mid(y,z)=\left(0,\frac{1}{2}\right)\right] &= \left(\frac{3}{4}-\frac{9c}{2}\right)\frac{c}{2}+\frac{9c^2}{2}\\ &= \left(\frac{3}{8}+\frac{9c}{4}\right)c.\\ E_\lambda\left[U_\lambda^{NS}-U_\lambda^{NT}\mid(y,z)=\left(0,\frac{1}{2}\right)\right] &= \left(\frac{3}{4}-\frac{5c}{2}\right)\frac{c}{2}+4c^2+\left(\frac{1}{2}-v\right)c\\ &= \left(\frac{7}{8}+\frac{9c}{4}-v\right)c.\end{aligned}$$

Case (3): $(y,z)=(0,1)$.

S: Neither station airs a tune-in. Among those who watched Y in the first period, a random half stay with Y and infer that $z=1$ after seeing $y=0$. So, $0\leq\lambda\leq v+c$ stay and the others switch off. The other half initially switch to Z. All of these viewers also sample Y after discovering that $z=1$ and $0\leq\lambda\leq v+c$ stay. Behavior of the viewers who watched Z in the first period is just symmetric. So,

$$U_\lambda^{S}=\begin{cases}\frac{1}{2}\left(v-\lambda\right)+\frac{1}{2}\left(v-c-\lambda\right) & \text{,if } 0\leq\lambda\leq v+c\\ \frac{1}{2}\left(-c\right)+\frac{1}{2}\left(-2c\right) & \text{,if } v+c<\lambda<1-(v+c)\\ \frac{1}{2}\left(v-1+\lambda\right)+\frac{1}{2}\left(v-c-1+\lambda\right) & \text{,if } 1-(v+c)\leq\lambda\leq 1\end{cases}.$$

NS: Both stations air a tune-in. So, $\lambda \le \frac{1}{4}+\frac{c}{2}$ continue to stay with Y while $\frac{1}{4}+\frac{c}{2} < \lambda \le v$ come back to Y after initially sampling Z. Behavior of the viewers who watched Z in the first period is just symmetric. So,

$$U_\lambda^{NS} = \begin{cases} v-\lambda & \text{,if } 0 \le \lambda \le \frac{1}{4}+\frac{c}{2} \\ v-c-\lambda & \text{,if } \frac{1}{4}+\frac{c}{2} < \lambda \le v \\ -c & \text{,if } v < \lambda < 1-v \\ v-c-(1-\lambda) & \text{,if } 1-v \le \lambda < \frac{3}{4}-\frac{c}{2} \\ v-(1-\lambda) & \text{,if } \frac{3}{4}-\frac{c}{2} \le \lambda \le 1 \end{cases}.$$

NT: The viewing choices here are similar with the previous case.

$$U_\lambda^{NT} = \begin{cases} \frac{1}{2}(v-\lambda)+\frac{1}{2}(v-c-\lambda) & \text{,if } 0 \le \lambda \le \frac{1}{4}+\frac{3c}{2} \\ v-c-\lambda & \text{,if } \frac{1}{4}+\frac{3c}{2} < \lambda \le v+c \\ -2c & \text{,if } v+c < \lambda < 1-(v+c) \\ v-c-(1-\lambda) & \text{,if } 1-(v+c) \le \lambda < \frac{3}{4}-\frac{3c}{2} \\ \frac{1}{2}(v-1+\lambda)+\frac{1}{2}(v-c-1+\lambda) & \text{,if } \frac{3}{4}-\frac{3c}{2} \le \lambda \le 1 \end{cases}.$$

So, we have the following:

$$U_\lambda^{S} - U_\lambda^{NT} = \begin{cases} 0 & \text{,if } 0 \le \lambda \le \frac{1}{4}+\frac{3c}{2} \\ \frac{c}{2} & \text{,if } \frac{1}{4}+\frac{3c}{2} \le \lambda < \frac{3}{4}-\frac{3c}{2} \\ 0 & \text{,if } \frac{3}{4}-\frac{3c}{2} \le \lambda \le 1 \end{cases}.$$

$$U_\lambda^{NS} - U_\lambda^{NT} = \begin{cases} \frac{c}{2} & \text{,if } 0 \le \lambda \le \frac{1}{4}+\frac{c}{2} \\ -\frac{c}{2} & \text{,if } \frac{1}{4}+\frac{c}{2} < \lambda \le \frac{1}{4}+\frac{3c}{2} \\ 0 & \text{,if } \frac{1}{4}+\frac{3c}{2} < \lambda \le v \\ \lambda - v & \text{,if } v < \lambda \le v+c \\ c & \text{,if } v+c < \lambda < 1-(v+c) \\ 1-\lambda-v & \text{,if } 1-(v+c) < \lambda < 1-v \\ 0 & \text{,if } 1-v < \lambda < \frac{3}{4}-\frac{3c}{2} \\ -\frac{c}{2} & \text{,if } \frac{3}{4}-\frac{3c}{2} \le \lambda < \frac{3}{4}-\frac{c}{2} \\ \frac{c}{2} & \text{,if } \frac{3}{4}-\frac{c}{2} \le \lambda \le 1 \end{cases}.$$

Integrating over λ, we get:

$$\begin{aligned} E_\lambda\left[U_\lambda^{S} - U_\lambda^{NT} \mid (y,z)=(0,1)\right] &= \left(\frac{1}{4}-\frac{3c}{2}\right)c \\ E_\lambda\left[U_\lambda^{NS} - U_\lambda^{NT} \mid (y,z)=(0,1)\right] &= \left(\frac{5}{4}-\frac{3c}{2}-2v\right)c \end{aligned}$$

Case (4): $(y,z)=(\frac{1}{2},0)$.

S: Station Y does, Z does not air a tune-in. Among those who watched Y in the first period, $\lambda \ge \frac{1}{4}$ stay with Y while the others initially switch to Z and stay there after seeing that $z=0$. Among those who watched Z in the first period, the random half that started sampling with Y

are lucky as they infer that $z = 0$. So, those with $\frac{1}{2} \leq \lambda \leq \frac{1}{2} + v + c$ stay, the others turn their TVs off. The other half sample both stations and those with $\frac{1}{2} \leq \lambda \leq \frac{1}{2} + v + c$ end up watching Y. So,

$$U_\lambda^S = \begin{cases} v - \lambda & \text{, if } 0 \leq \lambda < \frac{1}{4} \\ v - \left(\frac{1}{2} - \lambda\right) & \text{, if } \frac{1}{4} \leq \lambda \leq \frac{1}{2} \\ \frac{1}{2}\left(v - \lambda + \frac{1}{2}\right) + \frac{1}{2}\left(v - c - \lambda + \frac{1}{2}\right) & \text{, if } \frac{1}{2} < \lambda \leq \frac{1}{2} + v + c \\ \frac{1}{2}(-c) + \frac{1}{2}(-2c) & \text{, if } \frac{1}{2} + v + c < \lambda \leq 1 \end{cases}.$$

NS: Station Y does, Z does not air a tune-in. Among those who watched Y in the first period, $\lambda \geq \frac{1}{4} - \frac{c}{2}$ stay with Y while the others initially switch to Z and stay there after seeing that $z = 0$. The viewers who watched Z in the first period switch to Y and those with $\frac{1}{2} \leq \lambda \leq \frac{1}{2} + v + c$ stay there. So,

$$U_\lambda^{NS} = \begin{cases} v - \lambda & \text{, if } 0 \leq \lambda < \frac{1}{4} - \frac{c}{2} \\ v - (\frac{1}{2} - \lambda) & \text{, if } \frac{1}{4} - \frac{c}{2} \leq \lambda \leq \frac{1}{2} \\ v - (\lambda - \frac{1}{2}) & \text{, if } \frac{1}{2} < \lambda \leq \frac{1}{2} + v + c \\ -c & \text{, if } \frac{1}{2} + v + c < \lambda \leq 1 \end{cases}.$$

NT: Same with Case (2). So,

$$U_\lambda^{NT} = \begin{cases} \frac{1}{2}(v - \lambda) + \frac{1}{2}(v - c - \lambda) & \text{, if } 0 \leq \lambda < \frac{1}{4} - \frac{3c}{2} \\ \frac{1}{2}(v - \lambda) + \frac{1}{2}(v - \frac{1}{2} + \lambda) & \text{, if } \frac{1}{4} - \frac{3c}{2} \leq \lambda \leq \frac{1}{4} + \frac{3c}{2} \\ \frac{1}{2}(v - \frac{1}{2} + \lambda) + \frac{1}{2}(v - c - \frac{1}{2} + \lambda) & \text{, if } \frac{1}{4} + \frac{3c}{2} < \lambda \leq \frac{1}{2} \\ \frac{1}{2}(v - \lambda + \frac{1}{2}) + \frac{1}{2}(v - c - \lambda + \frac{1}{2}) & \text{, if } \frac{1}{2} < \lambda \leq \frac{3}{4} + \frac{3c}{2} \\ v - c - (\lambda - \frac{1}{2}) & \text{, if } \frac{3}{4} + \frac{3c}{2} < \lambda \leq \frac{1}{2} + v + c \\ -2c & \text{, if } \frac{1}{2} + v + c < \lambda \leq 1 \end{cases}.$$

So, we have the following:

$$U_\lambda^S - U_\lambda^{NT} = \begin{cases} \frac{c}{2} & \text{, if } 0 \leq \lambda < \frac{1}{4} - \frac{3c}{2} \\ \frac{1}{4} - \lambda & \text{, if } \frac{1}{4} - \frac{3c}{2} \leq \lambda < \frac{1}{4} \\ \lambda - \frac{1}{4} & \text{, if } \frac{1}{4} \leq \lambda \leq \frac{1}{4} + \frac{3c}{2} \\ \frac{c}{2} & \text{, if } \frac{1}{4} + \frac{3c}{2} < \lambda \leq \frac{1}{2} \\ 0 & \text{, if } \frac{1}{2} < \lambda \leq \frac{3}{4} + \frac{3c}{2} \\ \frac{c}{2} & \text{, if } \frac{3}{4} + \frac{3c}{2} < \lambda \leq 1 \end{cases}.$$

$$U_\lambda^{NS} - U_\lambda^{NT} = \begin{cases} \frac{c}{2} & \text{, if } 0 \leq \lambda < \frac{1}{4} - \frac{3c}{2} \\ \frac{1}{4} - \lambda & \text{, if } \frac{1}{4} - \frac{3c}{2} \leq \lambda < \frac{1}{4} - \frac{c}{2} \\ \lambda - \frac{1}{4} & \text{, if } \frac{1}{4} - \frac{c}{2} \leq \lambda < \frac{1}{4} + \frac{3c}{2} \\ \frac{c}{2} & \text{, if } \frac{1}{4} + \frac{3c}{2} < \lambda \leq \frac{3}{4} + \frac{3c}{2} \\ c & \text{, if } \frac{3}{4} + \frac{3c}{2} < \lambda \leq 1 \end{cases}.$$

Integrating over λ, we get:

$$\begin{aligned} E_\lambda\left[U_\lambda^S - U_\lambda^{NT} \mid (y,z) = \left(\frac{1}{2}, 0\right)\right] &= \left(\frac{3}{4} - \frac{9c}{2}\right)\frac{c}{2} + \frac{9c^2}{2} \\ &= \left(\frac{3}{8} + \frac{9c}{4}\right)c. \\ E_\lambda\left[U_\lambda^{NS} - U_\lambda^{NT} \mid (y,z) = \left(\frac{1}{2}, 0\right)\right] &= \left(\frac{5}{4} - \frac{9c}{2}\right)\frac{c}{2} + 4c^2 \\ &= \left(\frac{5}{8} + \frac{7c}{4}\right)c. \end{aligned}$$

Case (5): $(y,z) = (\frac{1}{2}, \frac{1}{2})$.

S: Both stations air a tune-in. $\frac{1}{4} \leq \lambda \leq \frac{3}{4}$ stay with the stations they watched in the in the first period. The others initially switch to the other station; those with $\lambda < \frac{1}{2} - v - c$ and $\lambda > \frac{1}{2} + v + c$ switch off while the others stay. So,

$$U_\lambda^S = \begin{cases} -c & \text{, if } 0 \leq \lambda < \frac{1}{2} - v - c \\ v - (\frac{1}{2} - \lambda) & \text{, if } \frac{1}{2} - v - c \leq \lambda \leq \frac{1}{2} \\ v - (\lambda - \frac{1}{2}) & \text{, if } \frac{1}{2} < \lambda \leq \frac{1}{2} + v + c \\ -c & \text{, if } \frac{1}{2} + v + c < \lambda \leq 1 \end{cases}.$$

NS: Both stations air a tune-in. $\frac{1}{4} - \frac{c}{2} \leq \lambda \leq \frac{3}{4} + \frac{c}{2}$ stay with the stations they watched in the in the first period. The others initially switch to the other station and stay there, except for $\lambda < \frac{1}{2} - v - c$ and $\lambda > \frac{1}{2} + v + c$. So, U_λ^{NS} remains the same as above.

NT: Those with $\frac{1}{4} - \frac{3c}{2} \leq \lambda \leq \frac{3}{4} + \frac{3c}{2}$ stay with the stations they sample first. Others sample both stations and those with $\frac{1}{2} - v - c \leq \lambda \leq \frac{1}{4} - \frac{3c}{2}$ and $\frac{3}{4} + \frac{3c}{2} \leq \lambda \leq \frac{1}{2} + v + c$ choose to watch one of them at random. The others turn their TVs off. So,

$$U_\lambda^{NT} = \begin{cases} -2c & \text{, if } 0 \leq \lambda < \frac{1}{2} - v - c \\ v - c - (\frac{1}{2} - \lambda) & \text{, if } \frac{1}{2} - v - c \leq \lambda < \frac{1}{4} - \frac{3c}{2} \\ v - (\frac{1}{2} - \lambda) & \text{, if } \frac{1}{4} - \frac{3c}{2} \leq \lambda \leq \frac{1}{2} \\ v - (\lambda - \frac{1}{2}) & \text{, if } \frac{1}{2} < \lambda \leq \frac{3}{4} + \frac{3c}{2} \\ v - c - (\lambda - \frac{1}{2}) & \text{, if } \frac{3}{4} + \frac{3c}{2} < \lambda \leq \frac{1}{2} + v + c \\ -2c & \text{, if } \frac{1}{2} + v + c < \lambda \leq 1 \end{cases}.$$

So, we have the following:

$$U_\lambda^S - U_\lambda^{NT} = U_\lambda^{NS} - U_\lambda^{NT} = \begin{cases} c & \text{,if } 0 \leq \lambda < \frac{1}{4} - \frac{3c}{2} \\ 0 & \text{,if } \frac{1}{4} - \frac{3c}{2} \leq \lambda \leq \frac{3}{4} + \frac{3c}{2} \\ c & \text{,if } \frac{3}{4} + \frac{3c}{2} < \lambda \leq 1 \end{cases}$$

Integrating over λ, we get:

$$\begin{aligned} E_\lambda\left[U_\lambda^S - U_\lambda^{NT} \mid (y,z) = \left(\frac{1}{2}, \frac{1}{2}\right)\right] &= E_\lambda\left[U_\lambda^{NS} - U_\lambda^{NT} \mid (y,z) = \left(\frac{1}{2}, \frac{1}{2}\right)\right] \\ &= \left(\frac{1}{2} - 3c\right)c \end{aligned}$$

The remaining four cases are symmetric with the first four cases, and therefore are omitted. Finally, integrating over (y, z), we get the following:

$$
\begin{aligned}
E_\lambda \left[U_\lambda^S - U_\lambda^{NT}\right] &= \frac{1}{9}(3c) \\
E_\lambda \left[U_\lambda^{NS} - U_\lambda^{NT}\right] &= \frac{1}{9}\left(\frac{15}{2} - 6v - c\right)c
\end{aligned}
$$

These are the expressions I use for welfare comparison in Section 3.

References

[1] Anand, B. N. and R. Shachar (1998), “The Effectiveness and Targeting of Television Advertising,” *Journal of Economics and Management Strategy*, 7, 363-396.

[2] Anand, B. N. and R. Shachar (2005), “Advertising the Matchmaker,” mimeo, Harvard Business School and Tel Aviv University.

[3] Anand, B. N. and R. Shachar (2006), “Targeted Advertising as a Signal,” mimeo, Harvard Business School and Tel Aviv University.

[4] Anderson, S. P., A. de Palma and J.-F. Thisse (1992), *Discrete Choice Theory of Product Differentiation*, Cambridge, MA: The MIT press.

[5] Anderson, S. P. and R. Renault (1999), “Pricing, Product Diversity, and Search Costs: A Bertrand-Chamberlin-Diamond Model,” *Rand Journal of Economics*, 30:4, 719-735.

[6] Bagwell, K. (2007), “The Economic Analysis of Advertising,” M. Armstrong and R. Porter, eds. *Handbook of Industrial Organization Vol. 3*, Amsterdam: North-Holland, 1701-1844.

[7] Bagwell, K. and G. Ramey (1994), “Advertising and Coordination,” *Review of Economic Studies*, 61:1, 153-171.

[8] Bontems, P. and V. Meunier (2006), “Advertising and Price Signaling of Quality in a Duopoly with Endogenous Locations,” mimeo, Université des Sciences Sociales de Toulouse and University of Aarhus. Forthcoming in *Journal of Economics and Management Strategy*.

[9] Butters, G. R. (1977), “Equilibrium Distributions of Sales and Advertising Prices,” *Review of Economic Studies*, 44:3, 465-491.

[10] Christou, C. and N. Vettas (2008), “On Informative Advertising and Product Differentiation,“ *International Journal of Industrial Organization*, 26:1, 92-112.

[11] Çelik, L. (2008a), “Monopoly Provision of Tune-ins,” mimeo, CERGE-EI.

[12] Çelik, L. (2008b), "Viewer Sampling and Quality Signaling in a Television Market," mimeo, CERGE-EI.

[13] De Bijl, P. W. (1997), "Entry Deterrence and Signaling in Markets for Search Goods," *International Journal of Industrial Organization*, 16, 1-19.

[14] Diamond, P. A. (1971), "A Model of Price Adjustment," *Journal of Economic Theory*, 3, 156-168.

[15] Emerson, J. W. and R. Shachar (2000), "Cast Demographics, Unobserved Segments, and Heterogeneous Switching Costs in a Television Viewing Choice Model," *Journal of Marketing Research*, 37, 173-186.

[16] Fluet, C. and P. G. Garella (2002), "Advertising and Prices as Signals of Quality in a Regime of Price Rivalry," *International Journal of Industrial Organization*, 20, 907-930.

[17] Grossman, G. and C. Shapiro (1984), "Informative Advertising with Differentiated Products," *Review of Economic Studies*, 51, 63-81.

[18] Hertzendorf, M. N. and P. B. Overgaard (2001a), "Price Competition and Advertising Signals: Signaling by Competing Senders," *Journal of Economics and Management Strategy*, 10:4, 621-663.

[19] Hertzendorf, M. N. and P. B. Overgaard (2001b), "Prices as Signals of Quality in Duopoly," mimeo, Federal Trade Commission and University of Aarhus.

[20] Hotelling, H. (1929), "Stability in Competition," *Economic Journal*, 39, 41-57.

[21] Kihlstrom, R. E. and M. H. Riordan (1984), "Advertising as a Signal," *Journal of Political Economy*, 92, 427-450.

[22] Matthews, S. A. and D. Fertig (1990), "Advertising Signals of Product Quality," Discussion Paper No. 881, Northwestern University.

[23] Meurer, M. and D. O. Stahl, II (1994), "Informative Advertising and Product Match," *International Journal of Industrial Organization*, 12, 1-19.

[24] Milgrom, P. R. (1981), "Good News and Bad News: Representation Theorems and Applications," *Bell Journal of Economics*, 12, 380-391.

[25] Milgrom, P. R. and J. M. Roberts (1986a), "Prices and Advertising as Signals of Product Quality," *Journal of Political Economy*, 94, 796-821.

[26] Milgrom, P. R. and J. M. Roberts (1986b), "Relying on the Information of Interested Parties," *Rand Journal of Economics*, 17:1, 18-32.

[27] Moraga-González, J. L. (2000), "Quality Uncertainty and Informative Advertising," *International Journal of Industrial Organization*, 18, 615–640.

[28] Moshkin, N. V. and R. Shachar (2002), "The Asymmetric Information Model of State Dependence," *Marketing Science*, 21:4, 435-454.

[29] Nelson, P. J. (1975), "The Economic Consequences of Advertising," *Journal of Business*, 48, 213-41.

[30] Tirole, J. (1988), *The Theory of Industrial Organization*, Cambridge, MA: The MIT press.

[31] Wolinsky, A. (1984), "Product Differentiation with Imperfect Information," *Review of Economic Studies*, 51, 53-61.

Individual researchers, as well as the on-line and printed versions of the CERGE-EI Working Papers (including their dissemination) were supported from the following institutional grants:

- Economic Aspects of EU and EMU Entry [Ekonomické aspekty vstupu do Evropské unie a Evropské měnové unie], No. AVOZ70850503, (2005-2010);
- Economic Impact of European Integration on the Czech Republic [Ekonomické dopady evropské integrace na ČR], No. MSM0021620846, (2005-2011);

Specific research support and/or other grants the researchers/publications benefited from are acknowledged at the beginning of the Paper.

Published by
Charles University in Prague, Center for Economic Research and Graduate Education (CERGE)
and
Economics Institute ASCR, v. v. i. (EI)
CERGE-EI, Politických vězňů 7, 111 21 Prague 1, tel.: +420 224 005 153, Czech Republic.
Printed by CERGE-EI, Prague
Subscription: CERGE-EI homepage: http://www.cerge-ei.cz

Editors: Directors of CERGE and EI
Managing editors: Deputy Directors for Research of CERGE and EI

ISSN 1211-3298
ISBN 978-80-7343-159-4 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-148-7 (Národohospodářský ústav AV ČR, v. v. i.)

CERGE-EI
P.O.BOX 882
Politických vězňů 7
111 21 Praha 1
Czech Republic
http://www.cerge-ei.cz