Competitive Provision of Tune-ins under Common Private Information*

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Abstract

Television (TV) stations forego millions of dollars of advertising revenues by airing tune-ins (preview advertisements) for their upcoming programs. In this paper, I analyze the equilibrium as well as welfare properties of tune-ins in a duopolistic TV market that lasts for two periods. Importantly, each TV station is fully informed about its own as well as its rival's program. Viewers receive information via tune-ins, if any, or alternatively by sampling a program for a few minutes (and switching across stations). I find that equilibrium tune-in decisions do not necessarily depend on TV stations' knowledge of their rival's program. In this case, the opportunity costs of tune-ins could be so high that a regime without any tune-ins may be socially better. However, when tune-ins depend on both of the upcoming programs, it is possible that they enhance welfare by helping viewers avoid some of the inefficient program sampling they would otherwise do in a regime without any tune-ins.

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1 Introduction

In this paper, I analyze the provision of tune-ins (preview advertisements for broadcasters' upcoming programs) in an oligopolistic television (TV) market. Tune-ins constitute an important component of TV advertising. Anand and Shachar [1998] report that three major network stations in the U.S. devoted approximately 2 of 12 minutes of non-program time to tune-ins in 1995. More recently, CBS ran 42 tune-ins during the 2013 Super Bowl, which made up approximately 20.6% of all advertising time (source: Kantar Media). This implies quite a large opportunity cost for CBS given that the average price for a 30-second commercial was approximately $4 million. Table 1 presents the percentage of total advertising time allocated to tune-ins during Super Bowl over 2006-2010, and the corresponding (approximate) opportunity cost incurred by the broadcasting station.

Year	Time (mm:ss)	% of all ad time	Value (million)
2006	7:20	16.6%	$36.7
2007	9:35	22.2%	$45.7
2008	8:35	19.0%	$46.4
2009	7:10	15.9%	$43.0
2010	8:15	17.2%	$49.1

Table 1. Network self-promotion in the Super Bowl. (*source: Kantar Media*)

Why would TV stations pass up the opportunity of earning several millions of dollars from sponsor advertisements (henceforth, ads) and instead choose to promote their own programs? Generally speaking, tune-ins are informative ads that help viewers better evaluate the expected utility of watching the promoted program.[1] Upon seeing a tune-in, some viewers will realize a high match and watch the promoted program rather than switch to another station. Similarly, some will realize a bad match and switch away. Holding constant the aggregate audience size, I refer to the net increase in a station's audience share as a result of this two-way flow as the "business-stealing" role of tune-ins. A tune-in may also persuade some viewers to stay tuned rather than switch off completely. In this case, the tune-in has a "demand creation" role. Overall, these two factors determine the effectiveness of a tune-in and whether the increase it creates in

[1] Although an individual can turn to TV schedules that appear in conventional magazines or in online websites, an important fraction of viewers remain imperfectly informed due to the costs associated with information acquisition. Moreover, individuals have limited memories.

total viewership is enough to offset the opportunity cost it involves. In fact, a week after the 2013 Super Bowl, Nielsen announced that CBS took 8 of the 10 top spots in ratings, thus justifying to some extent CBS's strategy of airing a high number of tune-ins.

The TV industry has some distinctive features. First, existence of TV programs is *a priori* known to everyone. Therefore, a TV station's decision to air or not to air a tune-in must account for the possible inferences its viewers will draw in the absence of a tune-in. Second, TV stations are generally well-informed about their rivals' programs. This means that their tune-ins (or lack thereof) may convey indirect information about their rivals' upcoming programs. Third, TV programs are typically not only vertically but also horizontally differentiated. In other words, there is generally no consensus among viewers about the superiority of any two programs. Forth, before making a final decision, viewers can switch across TV stations and learn the attributes of a program by sampling it for a few minutes. However, this typically results in a lower *ex-post* utility than what could have been attained if the viewer watched the same program (or chose the outside activity) from the very beginning. And fifth, by placing a program's tune-in in other similar programs, TV stations can target viewers based on their preferences. In this sense, tune-ins reach a non-random group of viewers.

The objective of this paper is to analyze the properties as well as the welfare implications of equilibrium tune-in provision, while capturing some of the above features of the TV market. I construct a simple Hotelling [1929] model with a continuum of viewers distributed along the unit line with respect to their ideal programs. There are two TV stations each airing two consecutive programs. Viewers know the earlier programs in both stations but are uncertain about the locations of the upcoming programs. TV stations, on the other hand, are fully informed about their own as well as their rival's upcoming program (and viewers know that the stations know them). Each TV station may promote its upcoming program to its first-period audience by airing a tune-in. Viewers may alternatively learn the attributes of a program by briefly sampling it (and switching back and forth between stations when desired). The sampling process entails a positive opportunity cost – viewers incur a disutility for any missed portion of the final choice they make. Thus, while tune-ins involve positive opportunity costs for TV stations, they help viewers make better-informed decisions and lower their sampling costs.

The main findings can be summarized as follows. First, provided that the opportunity cost of airing a tune-in is not too high, the business-stealing motive alone is generally sufficient to ensure that TV stations air tune-ins in equilibrium. Second, even if TV stations are fully informed about their rival's upcoming program, their tune-in decisions do not necessarily depend on this information. When they do depend, however, TV stations air fewer tune-ins on average and viewers make interim-stage inferences not only for the upcoming program of the station they watch but also for that of the other station. As a result, the resulting aggregate welfare is generally higher compared to when tune-in decisions are made independently. Third, when tune-in decisions do not depend on the knowledge of the rival's program, the opportunity costs TV stations incur by airing tune-ins could be so high that a regime without any tune-ins may be socially better. In other words, it may be welfare-improving if the two stations shared a common ownership or if they coordinated on airing no tune-ins. However, when tune-ins depend on both upcoming programs, they may enhance welfare by helping viewers avoid some of the inefficient program sampling they would otherwise do in a regime without any tune-ins.

The sampling process I adopt plays an important role in the analysis. Broadly speaking, it is a dynamic learning process in which a decision-maker chooses among one certain (the outside option) and two uncertain (the second-period TV programs) alternatives until she finds the optimal time to stop. This approach is closely related to multi-armed bandit problems in which a single decision-maker sequentially experiments among a fixed set of alternatives (see, among others, Rothschild [1974] and Bergemann and Valimaki [1996]). In my model, each uncertain alternative (i.e., each TV program) fully unfolds as the decision-maker (i.e., the viewer) experiments it for a fixed amount of time, there are increasing returns to engaging in an alternative (viewers do not derive any utility from watching only a portion of a TV program) and time is finite. Many real-life decision problems resemble this framework. Examples include a student choosing from a set of elective courses at the beginning of a semester, a group of tourists bar-hopping to find the most enjoyable pub, or a gambler trying to find the "best" slot machine in a casino. In all of these cases, the alternatives are mutually exclusive within a given period, so experimentation involves a positive opportunity cost. Moreover, as the time is finite, experimentation will potentially alter the relative utility of the current choice versus the other alternatives – an important feature of the sampling process I adopt.

Despite the peculiar features of the TV market, the main elements of the analysis can be extended to other markets, especially to those that are segmented with respect to consumer preferences. For instance, one may look at other media markets that share similar features with the TV market (e.g., radio market, market for movies, internet news portals). One may also extend the analysis to finite-horizon dynamic learning environments or to multi-armed bandit problems with competing firms. For instance, a student's choice of which elective courses to take may be highly influenced by the information professors provide in their first classes. Similarly, most products carry information on their packages and the level of information provided is controlled by firms. In a model with exogenous market segmentation (say, due to brand loyalty), firms can influence consumers' experimentation behavior by choosing how much information to provide. Although my model does not involve any pricing, the main insights would be useful in analyzing this problem. Bergemann and Valimaki [1996] study a single consumer sequentially experimenting among a set of products sold by different sellers. While their focus is on oligopoly pricing and how it interacts with the learning process, one may consider analyzing optimal advertising strategies in a similar setup. To the best of my knowledge, there are no papers that analyze this problem in an oligopolistic environment. Saak [2012] studies a similar problem in a monopolistic environment where the firm sells a new experience good over time to a population of heterogeneous forward-looking buyers.[2]

This paper contributes to the literature on verifiable information disclosure and directly informative advertising. Balestrieri and Izmalkov [2011], Celik [2014] and Sun [2011] focus on the disclosure of horizontal attributes in a Hotelling framework. In contrast to the celebrated "information unraveling" result of the quality disclosure literature, these papers show that equilibria typically involve partial information revelation when

[2] The current analysis may also be helpful in studying a model of electoral competition whereby political candidates advertise through media (which can be quite segmented in terms of the political attitudes of its audience) before the electoral voting takes place. Janssen and Teteryatnikova [2015] approach this problem in a two-candidate setup. In their analysis, there is no media and disclosure reaches everyone. In this sense, my approach is complementary to theirs.

products have horizontal attributes.[3] Koessler and Renault [2012] study a more general model that allows for both horizontal and vertical differentiation, and identify the conditions under which the fully-revealing equilibrium is the unique outcome. Moreover, they find that full revelation is always an equilibrium if product and consumer types are independently distributed. None of these papers consider consumer search. Anderson and Renault [2006] allow for search in a random-utility model in which they analyze the choice of advertising content and the information disclosed to consumers. They show that a monopolist advertises only product information, price information, or both, and prefers to convey only limited product information if possible.

Turning to competition, Anderson and Renault [2009] analyze disclosure of horizontal attributes in a duopoly setting, allowing for comparative advertising whereby firms can advertise their rival's product characteristics. They find that, if comparative advertising is used in equilibrium, then it will be used by the firm with a lower intrinsic quality. They also show that even though comparative advertising benefits consumers, it may lower the aggregate welfare. Janssen and Teteryatnikova [2014] focus on equilibrium properties in a Hotelling setting with no intrinsic quality differences. They find that full information disclosure is the unique outcome only if pricing and disclosure decisions are made simultaneously, and comparative advertising is allowed. Otherwise, a large set of non-disclosure equilibria exist. Meurer and Stahl [1994] analyze the welfare properties of informative advertising in a duopoly model *à la* Grossman and Shapiro [1984], where a fraction of buyers are uninformed about the product characteristics. Anand and Shachar [2009] consider a similar setup in which a firm can advertise only through one or both of two available media channels and consumer preferences over product attributes are perfectly correlated with their choice of media channel. However, ads are noisy in their analysis, meaning that consumers may get the wrong idea from an ad.[4]

To the best of my knowledge, there are no previous theoretical studies of tune-ins. There are, however, empirical studies that analyze the effects of tune-ins on viewers'

[3] The pioneering works on verifiable quality disclosure are Grossman [1981], Grossman and Hart [1980] and Milgrom [1981]. They all reach the 'information unraveling' result in a monopolistic setting: quality is fully revealed in all perfect Bayesian equilibria as long as there is a credible and costless way of communicating it. There is a large literature that offers various extensions to this framework. See Dranova and Jin [2010] for a recent survey on the subject.

[4] See Renault [2015] for an overview of the recent literature on advertising and verifiable disclosure.

choices. Anand and Shachar [1998] estimate the differential effects of tune-ins on viewing decisions for regular and special shows, and find a significant difference. Moshkin and Shachar [2002] consider the informational role of tune-ins in inducing viewers to continue watching the same TV station (the so-called 'lead-in' effect) and propose a method to identify it. Using a panel dataset on TV viewing, they find strong evidence for this role of tune-ins. Anand and Shachar [2011] consider tune-ins as noisy signals of program attributes. They find that while exposure to tune-ins improves the matching of viewers and programs, in some cases it decreases a viewer's tendency to watch a program.[5]

The rest of the paper is organized as follows. In section 2, I introduce the main model and characterize the equilibria. Section 3 argues when it may be welfare improving to ban tune-ins. Section 4 discusses the findings and concludes.

2 The Model

There are two TV stations, Y and Z, each airing two consecutive 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 its own as well as its rival's program. There are $A \geq 2$ time slots during each program that can be used for non-program content, where A is an exogenously given integer. 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 have already been 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. In the first period, each TV station may choose to air a tune-in to promote its upcoming 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. Hence, TV stations incur an opportunity cost for placing tune-ins. I assume that a TV station

[5] This paper is also related to the scarce literature on quality signaling with multiple senders when firms have common knowledge of product qualities. For examples, see Fluet and Garella [2002], Hertzendorf and Overgaard [2001] and Yehezkel [2008].

cannot lie in a tune-in (i.e., each station is legally bound to advertise a preview of the actual program) and that the tune-in is fully informative. The objective of each TV station is to maximize its total advertising revenue, which equals the size of its audience in each period times the per-viewer revenue it earns. Per-viewer revenue is $(A-1)p$ if a station airs a tune-in, and Ap if it does not.

On the other side of the market, there is a continuum of a unit mass of potential viewers. They are uniformly distributed along the unit interval with respect to their ideal programs. A viewer who is located at $\lambda \in [0,1]$ obtains a net utility $u_t(\lambda, x) = v_t - |\lambda - x|$ in period $t = 1, 2$ from watching a program located at x.[6] Viewers' ideal programs stay the same over the periods. Not watching TV yields zero benefits.[7]

Since the main focus of this paper is on the optimal tune-in behavior of TV stations and how this depends on their knowledge of the rival's upcoming program, I assume that viewers have complete information about the first programs, and for simplicity that viewers with $\lambda \in [0, \frac{1}{2}]$ watch Y and viewers with $\lambda \in (\frac{1}{2}, 1]$ watch Z in the first period. This would be the case, for instance, if period 1 had a relatively large v_1, station Y aired a program located at 0 and Z aired a program located at 1. Since the first-period viewer behavior is fixed, I drop the t subscript from now on, and thus $u(\lambda, x) = v - |\lambda - x|$ measures the second period utility. Viewers do not know where on the unit interval the second programs are located at. Denote the location of the second program of station Y with y and that of Z with z. I assume that prior beliefs for y and z are independent and are each given by a discrete uniform density function with three equally likely locations, 0, $\frac{1}{2}$ and 1. Viewers know that the stations know the location of their own as well as their rival's program. To ease notation, let $q_j(y, z)$ be a binary variable that summarizes the tune-in strategy of station j, $j = Y$, Z, where $q_j(y, z) = 1$ if station j airs a tune-in when the two programs are located at (y, z), and 0 otherwise.

A viewer makes a decision at each instance that maximizes her total utility. I allow viewers to switch between stations or switch off completely whenever they wish so. However, this comes at a cost. To model this costly switching process, I assume that

[6] Alternatively, v_t can be interpreted as the quality of the period-t program.

[7] Given that the value of not watching TV is zero, the degree of disutility associated with a mismatch can be captured by varying v_t. Similarly, one can introduce nuisance costs associated with the amount of non-program minutes. This, too, can be captured by varying v_t.

the amount of time required to learn the true location of a program is constant and the same for all programs and all viewers. Let k denote this amount of time. If a viewer samples a program for k minutes and then decides to watch it until the end with no further sampling, then she is able to enjoy the program fully. If, on the other hand, she switches away (to the other station or switch off completely) after k minutes, then she will have missed the first k minutes of her final choice, and therefore will not receive the full benefit of doing it. In other words, sampling a program entails a positive opportunity cost. For simplicity, I assume that each missed k minutes of a viewer's final choice lowers the net utility of that choice by $c > 0$, and this is same for all options. I will henceforth refer to it as the "sampling cost." I assume that k is relatively short, and as such, c is relatively small compared to v (to be more specific, I assume $v > 2c$).

The particular way I model program sampling offers tractability for an otherwise complicated process, and plays an important role in the analysis. Most importantly, the opportunity cost of sampling is irreversible once a viewer chooses to engage in sampling, and this alters the relative utility of the current choice versus the other options. This means that some viewers may end up watching a program, which they would not choose to watch under perfect information. As a result, when v is at an intermediate value such that all viewers engage in sampling but not all watch TV at the end, the aggregate audience size will be higher the more uncertainty viewers have about program attributes. Similarly, for the same range of v, aggregate audience size will be increasing in c. As described in the Introduction, the particular way I model the sampling process resembles finite-horizon learning models in many ways. If there are increasing returns to engaging in an activity, similar results would arise in these environments, too.

The timing of the game is as follows. First, Nature selects the values of y and z independently from a discrete uniform density function with support $\left\{0, \frac{1}{2}, 1\right\}$. These are observed by the TV stations but not by the viewers. In the first period, viewers with $\lambda \in [0, \frac{1}{2}]$ watch Y and those with $\lambda \in (\frac{1}{2}, 1]$ watch Z.[8] TV stations decide whether to air a tune-in for their upcoming programs or not. Viewers update their beliefs based on

[8] In practice, a viewer can sample the other station in the first period in the hope of seeing a tune-in, the chances of which could be quite slim. However, since the same viewer can always sample the other station's upcoming program in the second period and learn its location perfectly and since she incurs the same sampling cost in either case, switching in the first period is strictly dominated.

whether or not they were exposed to a tune-in. The second programs start and viewers decide on their sampling behavior. In case of indifference, a viewer equally randomizes between the two stations (this applies to both sampling and watching). Once viewers' program sampling is finalized, audience shares of the stations, and in turn the payoffs are realized. All aspects of the game are common knowledge. As a tie-breaking rule, I assume that viewers choose to watch TV if they are indifferent between watching and switching off, and stations choose not to air a tune-in if they are indifferent between airing one and not airing any.

The equilibrium concept used is strong perfect Bayesian equilibrium (SPBE).[9] I focus on symmetric strategies whereby each TV station makes an optimal tune-in decision taking as given its rival's program location and viewers' behavior, and viewers make optimal sampling and viewing decisions after observing the tune-in decision of the station they have watched (and their inferences about the upcoming programs are correct). Most importantly, beliefs off the equilibrium path are identical across viewers. Off-equilibrium beliefs become important when a TV station airs a tune-in that was unanticipated by viewers. The concept of SPBE does not impose any restrictions on how these beliefs are formed. Given the common private information assumption, a deviation may potentially be taken as an informative signal by viewers about the rival station's program.

2.1 Benchmark

I start with two benchmark situations: (i) perfect information about program attributes, and (ii) incomplete information with no tune-ins. Although the first one is a hypothetical situation, it serves as a useful benchmark to observe the role of incomplete information. The second one is a relevant situation because it may possibly arise as an equilibrium outcome. Moreover, it will serve as an important benchmark for understanding the optimal sampling behavior of viewers.

(i) Perfect information:

Under perfect information, viewers do not engage in sampling and there is no need for tune-ins. Hence, all we need to determine is which station each viewer watches, and

[9] This concept follows from Fudenberg and Tirole [1991].

then aggregate the viewership to reach the final audience shares. Recall that the utility of watching a program located at x for a viewer at λ is $u(\lambda, x) = v - |\lambda - x|$. If, for instance, $y < z$ and $(z - y) < 2v$, then there will be a unique indifferent viewer located at $\frac{y+z}{2}$. Viewers with locations $\max\{y - v, 0\} \leq \lambda < \frac{y+z}{2}$ will watch program y while the ones with locations $\frac{y+z}{2} < \lambda \leq \min\{z + v, 1\}$ will watch z. If $y = z$, then the two stations equally share the viewers with $\lambda \in [\max\{y - v, 0\}, \min\{y + v, 1\}]$. The following table presents the audience share for each station (the fraction of the population watching that station) under full information, where, in each cell, the first number indicates station Y and the second one indicates station Z.

	$z = 0$	$z = \frac{1}{2}$	$z = 1$
$y = 0$	$\min\left\{\frac{v}{2}, \frac{1}{2}\right\}, \min\left\{\frac{v}{2}, \frac{1}{2}\right\}$	$\frac{1}{4}, \frac{1}{4} + \min\left\{v, \frac{1}{2}\right\}$	$\min\left\{v, \frac{1}{2}\right\}, \min\left\{v, \frac{1}{2}\right\}$
$y = \frac{1}{2}$	$\frac{1}{4} + \min\left\{v, \frac{1}{2}\right\}, \frac{1}{4}$	$\min\left\{v, \frac{1}{2}\right\}, \min\left\{v, \frac{1}{2}\right\}$	$\frac{1}{4} + \min\left\{v, \frac{1}{2}\right\}, \frac{1}{4}$
$y = 1$	$\min\left\{v, \frac{1}{2}\right\}, \min\left\{v, \frac{1}{2}\right\}$	$\frac{1}{4}, \frac{1}{4} + \min\left\{v, \frac{1}{2}\right\}$	$\min\left\{\frac{v}{2}, \frac{1}{2}\right\}, \min\left\{\frac{v}{2}, \frac{1}{2}\right\}$

Table 2. Audience shares of Y and Z under full information.

(ii) Incomplete information with no tune-ins:

This is the most natural benchmark to start with under incomplete information. When tune-ins are not allowed, off-equilibrium beliefs are irrelevant, so we just need to focus on viewers' optimal sampling/switching behavior. Without any new information provided, viewers make their second-period sampling/watching decisions based fully on their prior beliefs. Since their priors are symmetric across the two stations, if they decide to engage in sampling, then they will pick randomly (with equal chances) one of the stations.

Given the symmetry, it suffices to analyze the behavior of viewers with locations $\lambda \in \left[0, \frac{1}{4}\right]$. Assume $\frac{1}{4} < v + c < \frac{1}{2}$ for now. First, take a viewer with $\lambda < \frac{1}{2} - v - c$. Viewers in this range would only watch a program located at 0. Even if the sampling cost is incurred, turning TV off is better for them than watching a program located at $\frac{1}{2}$ or 1. Suppose a viewer in this range samples one of the two upcoming programs, and it turns out to be different than 0. Now that the first k minutes are gone, sampling the other station has an expected utility of $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c)$. On the other hand, if she switches off without sampling the other station, she would enjoy the outside option at a utility of $-c$. Thus, she should engage in a second sampling if $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c) \geq -c$, or equivalently if $v - \lambda \geq 2c$. Evaluated at $\lambda = \frac{1}{2} - v - c$, this implies $v - \frac{1}{4} \geq \frac{c}{2}$. Hence, when

$v \geq \frac{1}{4} + \frac{c}{2}$, all viewers with $\lambda < \frac{1}{2} - v - c$ engage in a second sampling. Likewise, since sampling lowers the relative utility of the remaining options equally, the expected utility of engaging in the first sampling is positive for exactly the same parameter values, i.e., if $v \geq \frac{1}{4} + \frac{c}{2}$.[10] When $v < \frac{1}{4} + \frac{c}{2}$, on the other hand, those viewers for whom $v - \lambda \geq 2c$ do engage in sampling (and a second sampling if the first one is unsuccessful), while $\lambda \in \left(v - 2c, \frac{1}{2} - v - c\right)$ do not watch TV at all.

Now, take a viewer with $\lambda \in \left[\frac{1}{2} - v - c, \frac{1}{4}\right]$ and suppose that this viewer samples station Y. Again, assume $\frac{1}{4} < v + c < \frac{1}{2}$ for now. If $y = 0$, she surely stays with Y since this is her first-best choice. If it turns out that $y = \frac{1}{2}$, she may also want to check out station Z in the hope of finding $z = 0$. If she finds out $z = 1$, she would switch back to station Y, because watching $y = \frac{1}{2}$ is still better than switching off. If instead $z = \frac{1}{2}$, then she would be indifferent between the two stations. Thus, the expected utility of switching to Z when $y = \frac{1}{2}$ is $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(v - c - \frac{1}{2} + \lambda)$. This expression is greater than the utility of staying with Y, $v - (\frac{1}{2} - \lambda)$, when $\lambda < \frac{1}{4} - \frac{3c}{2}$. Thus, when $y = \frac{1}{2}$, it is optimal to also sample Z for the viewers with locations $\frac{1}{2} - v - c \leq \lambda < \frac{1}{4} - \frac{3c}{2}$. Note that $\frac{1}{2} - v - c \leq \frac{1}{4} - \frac{3c}{2}$ exactly when $v \geq \frac{1}{4} + \frac{c}{2}$. Finally, if $y = 1$, 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 the utility of switching off, $-c$, when $v \geq \frac{1}{4} + \frac{c}{2}$, which is again the same condition. One also has to check if engaging in the first sampling is optimal. As before, given that it is optimal when $v \geq \frac{1}{4} + \frac{c}{2}$ to do a second sampling after seeing $y = \frac{1}{2}$ or 1, it must be optimal to do the first sampling, too. When $v < \frac{1}{4} + \frac{c}{2}$, on the other hand, viewers with $\lambda \in \left[\frac{1}{2} - v - c, \frac{1}{4}\right]$ do not watch TV at all and instead take the outside option from the beginning. This is exactly for the same reasons a viewer does not choose to sample z after observing $y = \frac{1}{2}$ or 1.

To summarize, when $v < \frac{1}{4} + \frac{c}{2}$, there is a non-empty set of initial Y-viewers, $\lambda \in \left(v - 2c, \frac{1}{2} - v + 2c\right)$, who take the outside option from the beginning. A tune-in may help the TV station persuade these viewers to stay tuned. The others engage in program sampling and do so until they find a good match. When $v \geq \frac{1}{4} + \frac{c}{2}$, all viewers engage in sampling. If the first program sampled is within $\frac{1}{4} + \frac{3c}{2}$ units from the viewer's location,

[10] The expected utility of the first sampling is $\frac{1}{3}(v - \lambda) + \frac{2}{3}\left[\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c)\right]$, which is positive if and only if $\frac{5}{9}[v - \lambda - 2c] > 0$. This is the same condition as before.

then she watches that program without any further sampling. Otherwise, she samples the program at the other station, too (and switch off at the end if she cannot find anything she likes). In this case, the tune-in serves the business-stealing motive by deterring viewers from switching to the other station. Table 3 presents the audience shares for $v < \frac{1}{2} - c$.[11]

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

Table 3a. Audience shares of Y and Z with no tune-ins when $v < \frac{1}{4} + \frac{c}{2}$.

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

Table 3b. Audience shares of Y and Z with no tune-ins when $\frac{1}{4} + \frac{c}{2} \leq v < \frac{1}{2} - c$.

It is important to highlight that incomplete information lowers the aggregate audience size relative to perfect information when v is relatively small (i.e., when $v < \frac{1}{4} + \frac{c}{2}$), and expands it as v gets relatively larger. When v is relatively small, some viewers who would normally stay tuned under perfect information switch off without any sampling because of the uncertainty they face. When v is relatively large, on the other hand, all viewers engage in sampling in equilibrium and some face the hold-up problem at the end since the cost of sampling becomes sunk once it takes place. For instance, when $\frac{1}{4} + \frac{c}{2} \leq v < \frac{1}{2} - c$, all viewers sample at least one of the two upcoming programs and some will have a negative *ex-post* net utility (which can be as low as $-2c$). Thus, a regime with no tune-in does not only help a TV station save on the opportunity costs tune-ins involve but does it also increase the aggregate audience size, a win-win situation.[12] However, use of tune-ins will typically change this situation since TV stations will compete for viewers to deter them from switching away.

[11] When $v \geq \frac{1}{2} - c$, just replace $v + c$ with $\frac{1}{2}$ for all cases in Table 3b except for $(y, z) = (0, 0)$, $(1, 1)$.
[12] Note that *ex-ante* commitment to a no tune-in policy would be optimal in such a case.

2.2 Common private information

I now turn to the analysis of equilibrium tune-in provision under common private information when TV stations can use tune-ins to promote their upcoming programs. A key feature of the analysis is that a TV station's equilibrium tune-in behavior may indirectly reveal information about its rival's upcoming program. In deriving equilibria below, I mainly focus on $\frac{1}{4}+\frac{c}{2} \leq v < \frac{1}{2}-c$. The case $v \geq \frac{1}{2}-c$ is similar and I present the results for these two cases together in Proposition 1. When $v < \frac{1}{4}+\frac{c}{2}$, some viewers switch off right away in the absence of a tune-in. In this case, tune-ins expand viewership by creating new demand. I present the main result for this case in Proposition 2. Full derivation of all SPBE and further details are relegated into an Online Appendix.

A no tune-in SPBE exists only if neither station has any incentive to air a tune-in. For $\frac{1}{4}+\frac{c}{2} \leq v < \frac{1}{2}-c$, the audience share of each station in a no tune-in SPBE will be as in Table 3b. Suppose that station Y deviates by airing a tune-in for $y=0$ (the analysis is symmetric for $y=\frac{1}{2}$). This is an off-equilibrium action, so one needs to specify off-equilibrium beliefs. I will here focus on **passive** off-equilibrium beliefs whereby viewers' prior beliefs about the competing program remain unchanged in response to an unanticipated tune-in.[13] Hence, after seeing an unexpected tune-in for $y=0$, the first-period viewers of Y will continue to believe that z is equally likely to be 0, $\frac{1}{2}$ or 1. Take a viewer with $\frac{1}{4} < \lambda \leq \frac{1}{2}$. Having seen a tune-in for $y=0$, this viewer may consider checking out station Z in the hope of finding $z=\frac{1}{2}$. If it turns out that $z=0$, she would stay at Z as this would give her a utility of $v-\lambda$ (compared to $v-\lambda-c$ if she switches back to Y, or $-c$ if she switches off). If $z=1$, on the other hand, switching back to Y gives her a utility of $v-\lambda-c$, whereas switching off yields $-c$, so she would switch back to Y if $\lambda \leq v$. Thus, having seen a tune-in for $y=0$, switching to Z yields a higher expected utility than staying with Y if

$$\frac{1}{3}(v-\lambda)+\frac{1}{3}\left(v-\frac{1}{2}+\lambda\right)+\frac{1}{3}(v-\lambda-c) > v-\lambda,$$

which is true if and only if $\lambda > \frac{1}{4}+\frac{c}{2}$. When $z=0$ or $\frac{1}{2}$, viewers with $\lambda \leq \frac{1}{4}+\frac{c}{2}$ stay

[13] As mentioned before, the concept of SPBE imposes no restrictions on off-equilibrium beliefs other than requiring that they are identical across viewers. In particular, off-equilibrium beliefs following a deviation could also be **non-passive**, thereby revealing information about the rival station's program. I present other SPBE under non-passive beliefs below, and provide full derivations in the Online Appendix.

with Y while $\lambda \in (\frac{1}{4}+\frac{c}{2}, \frac{1}{2}]$ switch to Z, meaning that station Y generates an audience size of $\frac{1}{4}+\frac{c}{2}$ by unexpectedly airing a tune-in for $y=0$. If it did not air a tune-in, its audience size would be $\frac{v+c}{2}$ when $z=0$ and $\frac{1}{4}$ when $z=\frac{1}{2}$, as given in Table 3b. Given that $\frac{v+c}{2}<\frac{1}{4}$, deviation is profitable in both cases if

$$ApN\left[\left(\frac{1}{4}+\frac{c}{2}\right)-\frac{1}{4}\right] > pN\frac{1}{2},$$

where the left-hand side is the expected increase in the second-period total advertising revenue with a tune-in, and the right-hand side is the (opportunity) cost of the tune-in. After simplifying, this condition reduces to $A>\frac{1}{c}$.

The analysis is very similar for $v \geq \frac{1}{2}-c$. For instance, when $(y,z)=(0,0)$, a random half of $\lambda \in [0, v+c]$ watch Y in the second period (note that this set also includes viewers who switch from station Z). However, what matters for station Y is the fraction of its own first-period viewers who continue watching Y. While only a random half of this group will do so in the absence of a tune-in, all $\lambda \leq \frac{1}{4}+\frac{c}{2}$ will watch if Y instead airs a tune-in. Hence, when $v \geq \frac{1}{2}-c$, deviation is profitable if $\left(\frac{1}{4}+\frac{c}{2}\right)-\frac{1}{4} > \frac{1}{2A}$, or equivalently if $A>\frac{1}{c}$. In order to focus more on the informational effects of tune-ins and to minimize the role of exogenous costs in non-disclosure, I will henceforth assume that $A>\frac{1}{c}$. This is also in line with the majority of the verifiable quality disclosure literature. With this assumption, the above unilateral deviations are always profitable and therefore a no tune-in SPBE does not exist.

(Large A assumption) $A>\frac{1}{c}$.[14]

A feature that is common to all SPBE is that $q_Y(1,z)=0$ for all z, and $q_Z(y,0)=0$ for all y; i.e., regardless of the rival's upcoming program, neither station will air a tune-in for the program that offers the poorest match for its own first-period audience. This is immediate since a TV station could only gain (and not lose) by concealing the least favorable information (see Lemma 1 in the Online Appendix). However, this does not mean that a station's upcoming program is never fully revealed to its *own* first-period

[14]The large A assumption would be readily satisfied if the TV stations had a high number of non-program minutes, or if they could use 'crawls,' which are scrolling texts at the bottom of the TV screen. In the latter case, the opportunity cost of a tune-in would be zero, and as such, the large A assumption would be satisfied for any $c>0$.

audience. In fact, there is a **fully self-revealing** SPBE in which station Y airs a tune-in as long as $y \neq 1$ and Z airs a tune-in as long as $z \neq 0$. These strategies do not depend on the rival's program, and therefore, viewers' priors for the other station's upcoming program remain unchanged.

To see the working of this SPBE, suppose $y = 0$ and station Y airs a tune-in. The viewers of Y will continue to think that z is equally likely to be 0, $\frac{1}{2}$ or 1, and so, as derived earlier, those with $\lambda \geq \frac{1}{4} + \frac{c}{2}$ will switch to Z. If Y instead does not air a tune-in, then its viewers will infer that $y = 1$. As a result, all will switch to Z. Since the worst they can encounter in Z is $z = 1$, none of them will ever switch back to Y. In this sense, punishment for not airing a tune-in is very large. By airing a tune-in, station Y can ensure that $\lambda \leq \frac{1}{4} + \frac{c}{2}$ stay tuned. Since $\frac{1}{4} + \frac{c}{2} > \frac{1}{2A}$ by the large A assumption, station Y will never deviate from airing a tune-in for $y = 0$ (and similarly for $y = \frac{1}{2}$). Therefore this fully self-revealing SPBE always exists. Table 4 presents the audience shares in this SPBE for $\frac{1}{4} + \frac{c}{2} \leq v < \frac{1}{2} - c$.

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

Table 4. Audience shares of Y and Z in the fully self-revealing SPBE when $\frac{1}{4} + \frac{c}{2} \leq v < \frac{1}{2} - c$.

Under passive beliefs, there is only one other SPBE. In this SPBE, each station airs a tune-in unless its own **or** its rival's upcoming program is a poor match for its current audience. In other words, by airing a tune-in, a station signals that the rival's program is similar. By the same token, not airing a tune-in is not fully penalized anymore; viewers understand that it could be so because the rival station's program is not a good match. I will henceforth call this SPBE as the **cross-signaling** SPBE. In Proposition 1 below, I summarize all equilibria for $v \geq \frac{1}{4} + \frac{c}{2}$.

Proposition 1 *When $v \geq \frac{1}{4} + \frac{c}{2}$,*

(1) There is a fully self-revealing SPBE in which $q_Y(y, z) = 1$ as long as $y \neq 1$, and $q_Z(y, z) = 1$ as long as $z \neq 0$. This SPBE always exists.

(2) There is a cross-signaling SPBE in which $q_Y(y,z) = 1$ as long as $y \neq 1$ or $z \neq 1$, and $q_Z(y,z) = 1$ as long as $y \neq 0$ or $z \neq 0$. This SPBE exists if only if $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$.

(3) There are no other SPBE under passive beliefs.

Part (1) of the proposition follows directly from the observations above. Moreover, I show in the Online Appendix (Lemmas 2-3) that the fully self-revealing SPBE is the only SPBE, for any belief structure, in which $q_Y(y,1) = 1$ for some y and $q_Z(0,z) = 1$ for some z (e.g., station Y airs a tune-in for $y = 0$ even when $z = 1$). Otherwise, in all other SPBE, $q_Y(y,1) = 0$ for all y and $q_Y(1,z) = 0$ for all z (and symmetric for station Z). The cross-signaling SPBE is one of these SPBE and I articulate more on it in the next few paragraphs. For a more detailed proof of part (2) of Proposition 1, please see Lemmas 4-6 in the Online Appendix. For part (3) of the proposition, please refer to Lemmas 4-5 and 7-8 in the Online Appendix.

In the cross-signaling SPBE, tune-ins induce different inferences about the rival station's program than the fully self-revealing SPBE. If, for instance, station Y airs a tune-in for $y = 0$, its viewers will infer that z equals 0 or $\frac{1}{2}$. As a result, viewers with $\lambda \leq \frac{1}{4}$ (rather than $\lambda \leq \frac{1}{4} + \frac{c}{2}$ as in the fully self-revealing SPBE) will stay with Y and the rest will switch to Z. Similarly, if Y airs a tune-in for $y = \frac{1}{2}$, viewers with $\lambda \geq \frac{1}{4}$ will stay with Y and $\lambda < \frac{1}{4}$ will switch to Z. Inferences in a cross-signaling SPBE are also less pessimistic in the absence of a tune-in. If, for instance, Y does not air a tune-in, then it could be that either $y = 1$ or $z = 1$ (or both). Given symmetry, viewers will be indifferent as to which station to sample first. Suppose a viewer samples Y first. If $y = 0$, then she will infer that $z = 1$, so there is no need to sample Z. But when $y = 1$, she can say nothing about z. Provided that $v \geq \frac{1}{4} + \frac{c}{2}$, she samples station Z, too.[15] Arguing along similar lines, one can reach the audience shares in Table 4.

As described in Proposition 1, the cross-signaling SPBE can be sustained only if $v < \frac{1}{2} - c - \frac{1}{A}$. When $v + c$ is large, each station has a profitable deviation by not airing a tune-in when they are expected to air one. For instance, when $(y,z) = (0,0)$, station Y can achieve an audience share of $\min\left\{\frac{v+c}{2}, \frac{1}{4}\right\}$ in the absence of a tune-in. Its

[15] This is so because second sampling is optimal if $\frac{1}{3}(v - c - \lambda) + \frac{2}{3}(-2c) \geq -c$, or equivalently if $v - \lambda \geq 2c$. Evaluated at $\lambda = \frac{1}{2} - v - c$, this implies $v \geq \frac{1}{4} + \frac{c}{2}$.

on-equilibrium audience size is $\frac{1}{4}$ as given in Table 5. Hence, deviation is profitable if $\frac{1}{4} - \min\left\{\frac{v+c}{2}, \frac{1}{4}\right\} \leq \frac{1}{2A}$, or if $v + c \geq \frac{1}{2} - \frac{1}{A}$.

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

Table 5. Audience shares of Y and Z in the cross-signaling SPBE when $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$.

An important feature of the cross-signaling SPBE is that the aggregate audience share is the same as in a no tune-in regime. In contrast to the fully self-revealing SPBE, now neither station airs a tune-in for a program that is unanimously more superior for its first-period viewers than its rival's upcoming program. When, for instance, station Y airs a tune-in for $y = 0$, it is understood that z is either 0 or $\frac{1}{2}$. If it turns out that $z = 0$, those who have switched to Z and have locations $v < \lambda \leq v + c$ will stay tuned rather than switch off despite a negative net final utility. Thus, in the cross-signaling SPBE, stations only lose on the forgone revenue they could have earned from commercials, but otherwise maintain the same *ex-ante* expected audience share as in a no tune-in regime.

When $v \geq \frac{1}{2} - c$, unlike the other two cases, off-equilibrium beliefs make a difference. In particular, three other SPBE exist under the following non-passive off-equilibrium beliefs: if station Y deviates and airs a tune-in, then it must be that $z = 0$ or $\frac{1}{2}$ (symmetric for station Z). These are a no tune-in SPBE, and two other symmetric SPBE: one in which $q_Y(y, z) = 1$ only when $(y, z) \in \left\{(0, 0), \left(0, \frac{1}{2}\right)\right\}$ (and $q_Z(y, z) = 1$ only when $(y, z) \in \left\{\left(\frac{1}{2}, 1\right), (1, 1)\right\}$), and a second one in which $q_Y(y, z) = 1$ only when $(y, z) \in \left\{\left(\frac{1}{2}, 0\right), \left(\frac{1}{2}, \frac{1}{2}\right)\right\}$ (and $q_Z(y, z) = 1$ only when $(y, z) \in \left\{\left(\frac{1}{2}, \frac{1}{2}\right), \left(1, \frac{1}{2}\right)\right\}$). Importantly, the latter two SPBE are cross-signaling both on and off the equilibrium path. That is, they do reveal information about the competing station's upcoming program. The no tune-in SPBE, on the other hand, is not cross-signaling on the equilibrium path, but is supported by off-equilibrium beliefs that are cross-signaling: if, say, station Y deviates by airing a tune-in for $y = 0$ (or for $y = \frac{1}{2}$), then viewers believe that z is either 0 or $\frac{1}{2}$. And these beliefs are exactly what preclude TV stations from deviating. See Lemmas 7 and 8 in the Online Appendix for further details.

Small v and new demand creation

When v is small, viewers become more hesitant to engage in program sampling. As a result, in the absence of a tune-in, a substantial fraction of viewers switch off right away. This has two important implications. First, tune-ins now increase the audience size mainly by creating new demand (i.e., persuading viewers not to switch off). Second, fewer viewers engage in sampling and therefore the hold-up problem is less severe. These two implications together make airing a tune-in more valuable for each TV station.

Proposition 2 *When $v < \frac{1}{4} + \frac{c}{2}$, the fully self-revealing SPBE is the unique SPBE.*

The fully self-revealing SPBE exists for small v for the same reasons as before: if a station fails to air a tune-in, all of its viewers switch off and never come back. Station Y, for instance, generates an audience share of v on the equilibrium path by airing a tune-in for $y = 0$. If it doesn't air a tune-in, on the other hand, its audience share will be 0. Since $v > \frac{1}{2A}$ (which is true given that $v > 2c$), a deviation is never profitable (similar for $y = \frac{1}{2}$). Table 6 presents the audience shares for this case.

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

Table 6. Audience shares of Y and Z in the fully self-revealing SPBE when $v < \frac{1}{4} + \frac{c}{2}$.

As mentioned in the previous subsection, in a no tune-in regime, a non-empty set of initial Y-viewers $\lambda \in \left(v - 2c, \frac{1}{2} - v + 2c\right)$ switch off right away after the first program. When $(y, z) = (0, 0)$, on the equilibrium path, station Y gets an audience size of $\frac{v}{2} - c$ as given in Table 3a. If Y instead (unexpectedly) airs a tune-in for $y = 0$, all $\lambda \leq v$ would watch Y (and only $\lambda \in \left[\frac{1}{2} - v + 2c, \frac{1}{2}\right]$ would switch to Z). Here, the tune-in persuades the viewers $\lambda \leq v - 2c$ to stay with Y rather than sample Z, and viewers $\lambda \in (v - 2c, v]$ to stay tuned rather than switch off. Deviation is clearly profitable by the large A assumption: $v - \left(\frac{v}{2} - c\right) > \frac{1}{2A}$.

Similarly, the other SPBE cannot be maintained for small v. In the cross-signaling SPBE, a sizable fraction of viewers switch off in the absence of a tune-in, and deviation becomes profitable because of the new demand creation motive. For instance, if station Y does not air a tune-in, then the viewers $\lambda \in \left(v - 3c, \frac{1}{2} - v + 3c\right)$ turn their TVs off immediately (see Lemma 6 in the Online Appendix). This means that station Y can increase its audience share by $3c$ by unexpectedly airing a tune-in for $y = 0$, say, when $(y, z) = (0, 1)$, which makes deviation profitable. The SPBE that are supported by non-passive off-equilibrium beliefs also require v to be large (the no tune-in SPBE requires $v \geq \frac{1}{2} - c - \frac{1}{A}$ and the remaining two SPBE require $v \geq \frac{1}{4} + \frac{3c}{4} - \frac{1}{4A}$; see Lemmas 7 and 8 in the Online Appendix for details). As a result, when $v < \frac{1}{4} + \frac{c}{2}$, the fully self-revealing SPBE arises as the unique SPBE.

3 Social Value of Tune-ins

In this section, I analyze the social value of tune-ins and consider the effects of a possible ban on their use. I assume $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$ for all computations, and comment on high v and low v cases at the end of the section. As described in Section 2, there are two SPBE that coexist: the fully self-revealing SPBE and the cross-signaling SPBE. I calculate the *ex-ante* expected social welfare under these two SPBE as well as a no tune-in regime, and then make a comparison. In particular, I consider when a ban on tune-ins may improve the *ex-ante* expected social welfare from a planner's point of view.

A TV station's *ex-ante* expected per-viewer revenue is given by the average revenue it would earn in the nine possible (y, z) pairs. In a regime of no tune-ins, station Y, for instance, generates a per-viewer revenue of $\frac{Ap}{2}$ in the first period. Per-viewer revenue in the second period is the average of the audience shares given in Table 3b, multiplied with pA. Given that stations Y and Z are *ex-ante* identical, the *ex-ante* expected per-viewer revenue of each station can be expressed as

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

where the superscript NT stands for 'no tune-in.' In the fully self-revealing SPBE, station Y airs a tune-in in six of the nine (y, z) pairs. Thus, the per-viewer revenue it generates in the first period is $\left(\frac{6}{9}\,(A - 1) + \frac{3}{9}A\right)\frac{p}{2} = \left(\frac{A}{2} - \frac{1}{3}\right)p$. Per-viewer revenue in the second period is the average of the audience shares given in Table 4, multiplied with pA. Hence,

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

where the superscript SR stands for 'self-revealing,' and $j = Y,\ Z$. Similarly, in the cross-signaling SPBE, station Y is expected to air a tune-in in four of the nine possible (y, z) pairs. Given the audience shares in Table 5, it then follows that

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

where the superscript CS stands for 'cross-signaling.' Taking differences, we reach

$$E[\Pi_j^{NT} - \Pi_j^{SR}] = (2c + 3)\,\frac{p}{9}, \tag{1}$$

$$E[\Pi_j^{NT} - \Pi_j^{CS}] = \frac{2p}{9}. \tag{2}$$

Simple comparison yields that $E[\Pi_j^{NT} - \Pi_j^{SR}] > E[\Pi_j^{NT} - \Pi_j^{CS}] > 0$. Hence, expected revenues are highest in a regime of no tune-ins and lowest in the fully self-revealing SPBE. As described earlier, the expected second-period audience size in a regime of no tune-ins is the same as in the cross-signaling SPBE. However, in a regime of no tune-ins, TV stations generate higher revenues in the first period. As for the cross-signaling SPBE versus the fully self-revealing SPBE, the former is less costly than the latter because it involves fewer tune-ins. Moreover, the cross-signaling SPBE is associated with a higher expected audience size in the second period since viewers will have less precise information about the upcoming programs in the cross-signaling SPBE and therefore will engage in more program sampling (and given that the cost of sampling becomes sunk once it happens, a higher fraction of those who do sampling will stay tuned).

In the Appendix, I describe how to calculate the *ex-ante* expected utility of a random viewer in regime i ($i = NT,\ SR,\ CS$), denoted by $E[U^i]$. As provided at the end of the Appendix, the resulting expected utility differences are given by

$$E\left[U^{SR} - U^{NT}\right] = \frac{1}{9}\,(7 - 4v - 10c)\,c, \tag{3}$$

$$E\left[U^{CS} - U^{NT}\right] = \left(\frac{1}{3} - c\right) c. \tag{4}$$

Given that $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$, both of the terms above are strictly positive. It is also straightforward to verify that $E\left[U^{SR} - U^{NT}\right] > E\left[U^{CS} - U^{NT}\right]$. Hence, perhaps not surprisingly, expected viewer utility is highest in the equilibrium configuration with the highest number of tune-ins, and lowest in the one with no tune-ins.

Let W^i denote the expected social welfare in regime i ($i = NT$, SR, CS). I use the conventional approach and let W^i equal the *ex-ante* expected total revenue of the two stations plus the *ex-ante* expected aggregate viewer utility. Given the expected revenue difference in (1) and the expected viewer utility difference in (3), the difference in the expected social welfare between SR and NT regimes can be expressed as

$$\begin{aligned} W^{SR} - W^{NT} &= N\left[E\left[U^{SR} - U^{NT}\right] - 2E[\Pi_j^{NT} - \Pi_j^{SR}]\right] \\ &= N\left[\frac{1}{9}(7 - 4v - 10c)\,c - \left(\frac{2}{3} + \frac{4cA}{9}\right)p\right]. \end{aligned} \tag{5}$$

Even though viewers are unambiguously better off in the fully self-revealing SPBE, the average amount of revenue stations lose could be very high (the second term in the above brackets). This is due not only to the opportunity costs stations incur by airing tune-ins, but also to the reduced aggregate audience size since viewers make better-informed decisions with better information. *Ceteris paribus*, $W^{SR} - W^{NT}$ will tend to be positive as p approaches 0, and negative as c approaches 0, or as A grows sufficiently large. In the former case ($p \to 0$), the revenue earned from commercials is too little compared to viewer well-being, so $W^{SR} - W^{NT}$ has the same sign as $E\left[U^{SR} - U^{NT}\right]$. Since viewers make better-informed decisions and incur lower sampling costs in the fully self-revealing SPBE, $E\left[U^{SR} - U^{NT}\right] > 0$ and hence $W^{SR} > W^{NT}$. When c approaches 0, the change in viewer well-being across the two regimes will be negligible, and hence now $W^{SR} - W^{NT}$ will have the same sign as $E[\Pi_j^{SR} - \Pi_j^{NT}]$. Because of the lose-lose situation stations face in the fully self-revealing SPBE (air more tune-ins and get fewer viewers on average), $E[\Pi_j^{SR} - \Pi_j^{NT}] < 0$ for any positive p, so $W^{SR} < W^{NT}$ in this case. When A grows large, on the other hand, although the cost of a tune-in becomes negligible, the reduction in the audience size under the SR regime (because of better-informed viewing decisions) will imply a large revenue loss in the second period compared to a no tune-in regime. Therefore, once again, the aggregate welfare under the NT regime will be higher.

The curve indicated by $W^{SR} = W^{NT}$ in Figure 1 is, for a given v and A, the locus of

(c, p) for which (5) equals zero. In other words, it is given by the equation

$$p = \frac{(7 - 4v - 10c)\, c}{6 + 4cA}.$$

For all (c, p) values that are under this locus, $W^{SR} > W^{NT}$. Similarly, for all values above, $W^{SR} < W^{NT}$. As A increases, this locus shifts downwards and as a result the region where the SR regime dominates shrinks.

[FIGURE 1 APPROXIMATELY HERE]

For the cross-signaling SPBE, using expressions (2) and (4), the difference in the expected social welfare between CS and NT regimes can similarly be expressed as

$$\begin{aligned} W^{CS} - W^{NT} &= N\left[E\left[U^{CS} - U^{NT}\right] - 2E[\Pi_j^{NT} - \Pi_j^{CS}]\right] \\ &= N\left[\left(\frac{1}{3} - c\right)c - \frac{4p}{9}\right]. \end{aligned} \tag{6}$$

Once again, for the same reasons as above, $W^{CS} - W^{NT}$ will tend to be positive as $p \to 0$, and negative as $c \to 0$ (recall that $c < \frac{1}{8}$, so $\frac{1}{3} - c > 0$). Now, however, it will not depend on how small or large A is, because the expected aggregate audience size is the same in the cross-signaling SPBE as in a no tune-in regime. Thus, the sign of $W^{CS} - W^{NT}$ will be solely determined by how viewer well-being improves relative to the cost of tune-ins. The bell-shaped curve labeled by $W^{CS} = W^{NT}$ in Figure 1 indicates the locus of (c, p) values for which the expression in (6) equals zero; i.e.,

$$p = \frac{9}{4}\left(\frac{1}{3} - c\right)c.$$

For all (c, p) values under this locus, $W^{CS} > W^{NT}$, and for all values above, $W^{CS} < W^{NT}$.

Investigating Figure 1 carefully, one can see that the cross-signaling SPBE produces the highest expected welfare when (c, p) values fall under the $W^{CS} = W^{NT}$ locus and above the $W^{SR} = W^{CS}$ locus. Similarly, the intersection of the areas under the $W^{SR} = W^{NT}$ locus and the $W^{SR} = W^{CS}$ locus is where W^{SR} is the highest. In all other regions, the no tune-in regime produces the highest expected welfare.

Proposition 3 *A ban on the use of tune-ins improves the ex-ante expected social welfare if and only if*

$$p \geq \max\left\{\frac{(7 - 4v - 10c)\, c}{6 + 4cA}, \frac{9}{4}\left(\frac{1}{3} - c\right)c\right\}.$$

In summary, if the sampling cost is relatively low or the price of a commercial is relatively high, then a regime without any tune-ins generates the highest welfare. Otherwise, a regime that provides 'just enough' information to viewers will be welfare superior. Thus, it may be welfare improving if the two stations were commonly owned by the same media company that maximized total ad revenues. In such a case, as long as v is relatively large, a no tune-in SPBE exists.

Tune-ins clearly benefit viewers. Without tune-ins, viewers engage in too much inefficient program sampling and some end up watching TV despite a negative utility. In the fully self-revealing SPBE, TV stations are forced to air too many tune-ins and this implies a large opportunity cost. Moreover, the higher the number of tune-ins, the more informed choices viewers make, implying a smaller audience size in the second period. As a result, the stations are double jeopardized compared to a no tune-in regime. The former one of these two factors is also present in the cross-signaling SPBE; stations lose on the forgone revenue they could have earned from commercials. However, the expected aggregate audience size in the cross-signaling SPBE is the same as in a no tune-in regime. This is the main reason why the cross-signaling SPBE may produce the highest expected welfare even if a no tune-in regime welfare-dominates the fully self-revealing SPBE.

When v is large, the hold-up problem becomes less severe and fewer viewers regret their initial choices. This makes the fully-revealing SPBE less penalizing. As a result, the fully-revealing SPBE will have a relatively larger set of parameters where it is socially the best. However, the main trade-off remains the same: if p is relatively high, then advertising revenues become more important and a regime with no tune-ins will raise the highest *ex-ante* welfare. Similarly, if c is relatively high, then the most informative regime will be the best one. On the other hand, when v is small, tune-ins create new demand thereby expanding the set of viewers who watch TV. In this case, not only the viewers but also the TV stations benefit from tune-ins. As a result, the fully-revealing SPBE will yield the highest *ex-ante* welfare even when p is relatively high. In other words, the fully-revealing SPBE is not only the unique market outcome when v is small, but also the socially optimal outcome.

4 Conclusion

This paper has presented a theoretical analysis of tune-ins by competing broadcasters in a horizontally differentiated duopoly TV market. Tune-ins are purely informative signals that inform viewers about the horizontal attributes of a program. They generally serve two purposes: create new demand and steal business from the rival station. An important element of the model is the common private information assumption; while the viewers are uncertain about program attributes, each TV station is perfectly informed about its own as well as its rival's program. As a result, the tune-in decision of a station may reveal indirect information about the rival station's program.

The main findings can be summarized as follows. The business-stealing motive alone is generally sufficient to induce TV stations to air a tune-in for their upcoming programs, despite the opportunity cost in terms of lost advertising revenue. In equilibrium, tune-ins are not necessarily informative of the rival station's program. When they are, however, the resulting aggregate welfare is generally higher compared to when tune-in decisions are made independently. Finally, when the sampling cost is relatively small or the price of a commercial is relatively high, a ban on tune-ins improves welfare by increasing TV stations' advertising revenues, though it is harmful for viewers.

As described in the Introduction, the TV market has highly idiosyncratic features. In order to capture these features, I have made simplifying assumptions. For instance, the particular way I have modeled viewers' sampling behavior relies on a central opportunity cost interpretation, causing a change in the relative utility of the current choice versus the other options. Moreover, I assume that sampling each program takes the same amount of time and costs the same for all viewers. An extension may focus on a more general sampling/switching process that relaxes these (and possibly other) restrictions.

I have not allowed any switching costs in the analysis. In general, one can distinguish between sampling and switching costs. A small but positive switching cost creates state dependence whereby viewers stay with their initial choices when they expect the same utility in both stations. This gives each station more market power, thereby lowering their incentives to air tune-ins. As a result, business-stealing motive alone may no longer be enough to induce tune-ins in equilibrium.

Appendix: Expected utility calculation

To find the expected viewer utility, one needs to calculate the expected utility of a random viewer in all of the nine possible program combinations, and then take the average of those. This is a tedious but otherwise straightforward task. For brevity, I find below the expected utility of a random viewer only for $(y,z) = \left(0, \frac{1}{2}\right)$ under three specifications; the fully self-revealing SPBE (SR), the cross-signaling SPBE (CS), and the no tune-in SPBE (NT). Derivations are made under the assumption that $\frac{1}{4} + c \le v < \frac{1}{2} - c$. It is straightforward to repeat the same analysis for the other (y,z) pairs (note that one only needs to analyze five more cases, because the remaining three cases are symmetric). At the end, I present the results for the other cases and calculate the resulting expected viewer utility.

In the SR regime, both stations air a tune-in when $(y,z) = \left(0, \frac{1}{2}\right)$. Among those who watched Y in the first period, $\lambda \le \frac{1}{4} + \frac{c}{2}$ stay with Y after seeing a tune-in for $y = 0$ while the others switch to Z and stay there. Behavior of the viewers 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,

$$U_\lambda^{SR} = \begin{cases} v - \lambda & , 0 \le \lambda \le \frac{1}{4} + \frac{c}{2} \\ v - \left|\frac{1}{2} - \lambda\right| & , \frac{1}{4} + \frac{c}{2} < \lambda \le \frac{3}{4} + \frac{c}{2} \\ v - c - \lambda + \frac{1}{2} & , \frac{3}{4} + \frac{c}{2} < \lambda \le \frac{1}{2} + v \\ -c & , \frac{1}{2} + v < \lambda \le 1 \end{cases} .$$

In the CS regime, station Y does, Z does not air a tune-in when $(y,z) = \left(0, \frac{1}{2}\right)$. 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 $z \in \left\{0, \frac{1}{2}, 1\right\}$, so all switch to Z. Those with $\frac{1}{2} \le \lambda \le \frac{1}{2} + v + c$ eventually stay, the others switch off. So,

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

Finally, in the NT regime, a random half of viewers start with Y and the other half start with Z. Viewers with locations $\frac{1}{4}-\frac{3c}{2}\leq\lambda\leq\frac{1}{4}+\frac{3c}{2}$ settle in the first station they sample, thus incurring no sampling cost, while the others will continue sampling. For $\lambda\leq\frac{1}{4}-\frac{3c}{2}$, if the viewer is has started with Y, she stays there. If she started with Z, then she also samples Y. Similarly, $\frac{1}{4}+\frac{3c}{2}\leq\lambda\leq\frac{3}{4}+\frac{3c}{2}$ 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. Hence,

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

Taking the differences, we can express $E\left[U^{SR}-U^{NT}\right]$ as:

$$E\left[U^{SR}-U^{NT}\right]=\int_0^{\frac{1}{4}-\frac{3c}{2}}\frac{c}{2}d\lambda+\int_{\frac{1}{4}-\frac{3c}{2}}^{\frac{1}{4}+\frac{c}{2}}\left(\frac{1}{4}-\lambda\right)d\lambda+\int_{\frac{1}{4}+\frac{c}{2}}^{\frac{1}{4}+\frac{3c}{2}}\left(\lambda-\frac{1}{4}\right)d\lambda+\int_{\frac{1}{4}+\frac{3c}{2}}^{\frac{3}{4}+\frac{c}{2}}\frac{c}{2}d\lambda$$
$$+\int_{\frac{3}{4}+\frac{c}{2}}^{\frac{3}{4}+\frac{3c}{2}}\left(-\frac{c}{2}\right)d\lambda+\int_{\frac{1}{2}+v}^{\frac{1}{2}+v+c}\left(\lambda-\frac{1}{2}-v\right)d\lambda+\int_{\frac{1}{2}+v+c}^{1}cd\lambda.$$

After simple algebra, this expression becomes

$$E\left[U^{SR}-U^{NT}\mid(y,z)=\left(0,\frac{1}{2}\right)\right]=\left(\frac{7}{8}-\frac{c}{4}-v\right)c.$$

Similarly, $E\left[U^{CS}-U^{NT}\right]$ can be expressed as:

$$E\left[U^{CS}-U^{NT}\right]=\int_0^{\frac{1}{4}-\frac{3c}{2}}\frac{c}{2}d\lambda+\int_{\frac{1}{4}-\frac{3c}{2}}^{\frac{1}{4}}\left(\frac{1}{4}-\lambda\right)d\lambda+\int_{\frac{1}{4}}^{\frac{1}{4}+\frac{3c}{2}}\left(\lambda-\frac{1}{4}\right)d\lambda+\int_{\frac{1}{4}+\frac{3c}{2}}^{\frac{1}{2}}\frac{c}{2}d\lambda+\int_{\frac{3}{4}+\frac{3c}{2}}^{1}\frac{c}{2}d\lambda,$$

which leads to

$$E\left[U^{CS}-U^{NT}\mid(y,z)=\left(0,\frac{1}{2}\right)\right]=\frac{3c}{8}.$$

The case $(y,z)=\left(\frac{1}{2},1\right)$ is perfectly symmetric with $(y,z)=\left(0,\frac{1}{2}\right)$, and therefore generates the same expected viewer utility. By this reasoning, we need to find the expected utility only for five of the remaining eight cases. The calculations follow exactly the same steps as above. For convenience, I report the results here:

$\cdot$ $(y,z)=(0,0)$ (symmetric with $(y,z)=(1,1)$):

$$E\left[U^{SR}-U^{NT}\mid(y,z)=(0,0)\right]=\left(\frac{3}{4}-\frac{3c}{2}\right)c,$$
$$E\left[U^{CS}-U^{NT}\mid(y,z)=(0,0)\right]=\left(\frac{1}{4}-\frac{3c}{2}\right)c.$$

$\cdot$ $(y,z)=(\frac{1}{2},0)$ (symmetric with $(y,z)=\left(1,\frac{1}{2}\right)$):

$$E\left[U^{SR}-U^{NT}\mid(y,z)=\left(\frac{1}{2},0\right)\right]=\left(\frac{5}{8}-\frac{c}{4}\right)c,$$
$$E\left[U^{CS}-U^{NT}\mid(y,z)=\left(\frac{1}{2},0\right)\right]=\frac{3c}{8}.$$

$\cdot$ $(y,z)=(0,1):$

$$E\left[U^{SR}-U^{NT}\mid(y,z)=(0,1)\right]=\left(\frac{5}{4}-\frac{3c}{2}-2v\right)c,$$
$$E\left[U^{CS}-U^{NT}\mid(y,z)=(0,1)\right]=\left(\frac{1}{4}-\frac{3c}{2}\right)c.$$

$\cdot$ $(y,z)=(1,0):$

$$E\left[U^{SR}-U^{NT}\mid(y,z)=(1,0)\right]=\left(\frac{3}{4}-\frac{3c}{2}\right)c,$$
$$E\left[U^{CS}-U^{NT}\mid(y,z)=(1,0)\right]=\left(\frac{1}{4}-\frac{3c}{2}\right)c.$$

$\cdot$ $(y,z)=(\frac{1}{2},\frac{1}{2}):$

$$E\left[U^{SR}-U^{NT}\mid(y,z)=\left(\frac{1}{2},\frac{1}{2}\right)\right]=\left(\frac{1}{2}-3c\right)c,$$
$$E\left[U^{CS}-U^{NT}\mid(y,z)=\left(\frac{1}{2},\frac{1}{2}\right)\right]=\left(\frac{1}{2}-3c\right)c.$$

Finally, taking the average over all nine possible (y,z) cases, we reach equations (3) and (4), which are used in welfare calculations in section 3:

$$E\left[U^{SR}-U^{NT}\right]=\frac{1}{9}(7-4v-10c)\,c,$$
$$E\left[U^{CS}-U^{NT}\right]=\left(\frac{1}{3}-c\right)c.$$

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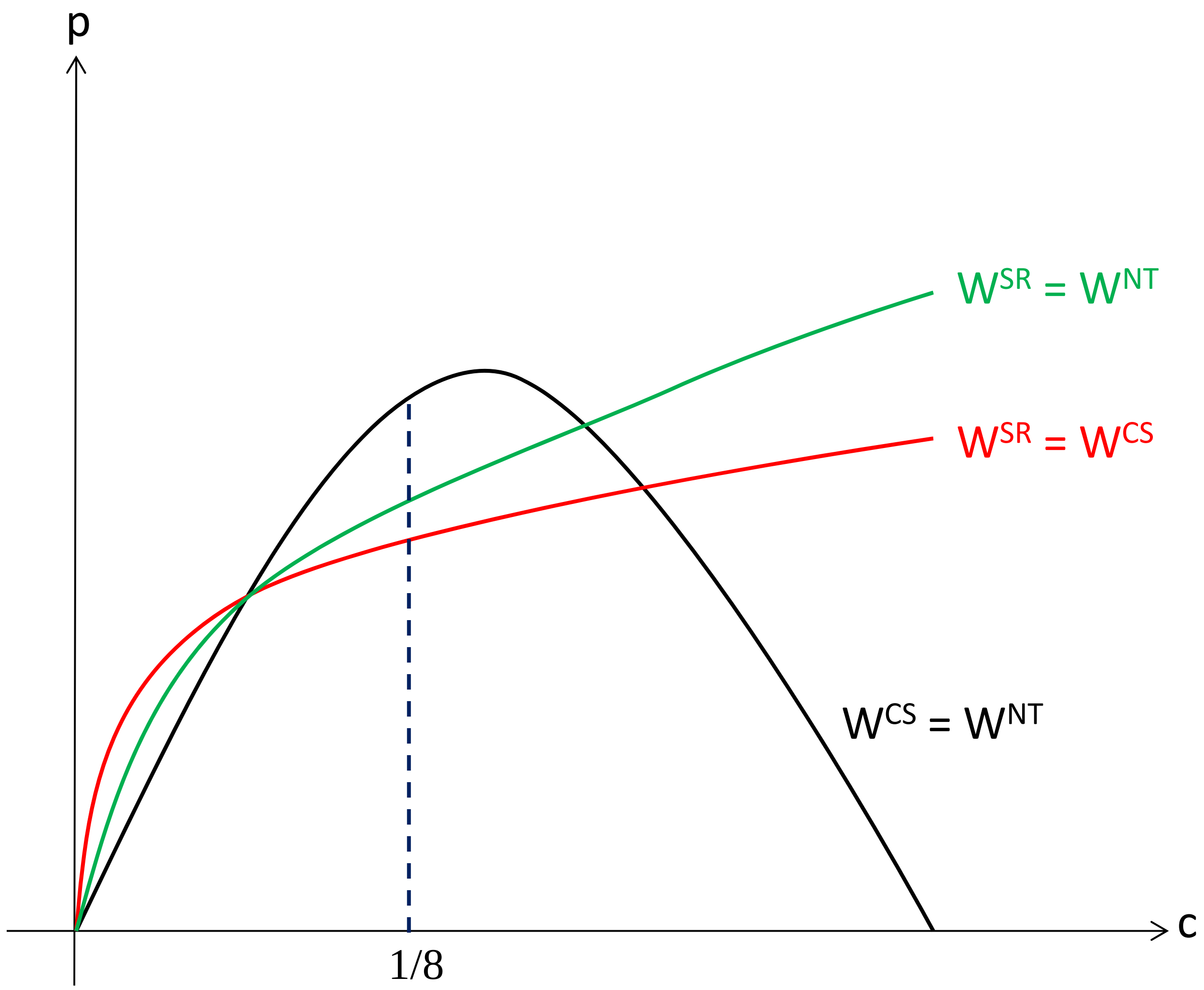

Figure 1. Expected welfare comparison

Online Appendix: Full analysis of all SPBE

I here characterize all symmetric SPBE of the game presented in the main text. I do so by presenting a series of lemmas. All results are presented for station Y only (everything is symmetric for Z). Station Y can only influence the viewing decisions of its own first-period audience by airing a tune-in (or not airing), and this is all that matters for station Y to deviate or not. Below, unless stated otherwise, I focus on station Y's first-period audience only for all calculations.

Lemma 1 *In every SPBE, $q_Y(1,z) = 0$ for all z.*

Proof: This is straightforward. A station would never reveal its worst program by dedicating a costly tune-in to it. Assume on the contrary that there is an SPBE in which $q_Y(1,z) = 1$ for some z. If, after seeing a tune-in for $y = 1$, Y-viewers assign any positive probability on the equilibrium path to $z = 0$ or $z = \frac{1}{2}$, then all will switch away from Y (some will switch off right away if v is small) and never come back – even if it turns that $z = 1$. It is thus profitable to deviate and not air a tune-in for $y = 1$, thereby saving on the cost of the tune-in. The remaining possibility (that viewers assign a positive probability only to $z = 1$ after seeing a tune-in) cannot arise, because, given that it is optimal to air a tune-in when $(y,z) = (1,1)$, it must be then profitable for Y to deviate and air a tune-in for $y = 1$ when $z = 0$ or $z = \frac{1}{2}$, so as to mislead viewers to think that $z = 1$. Thus, it must be that $q_Y(1,z) = 0$ for all z. Note that this proof does not make any use of passive beliefs, so it holds for all belief structures. Also note this result does not mean that viewers won't fully infer $y = 1$ in equilibrium. It may be the case that in equilibrium station Y airs a tune-in whenever $y = 0$ or $\frac{1}{2}$, so not seeing a tune-in would then mean that $y = 1$.

Remark 1: *Lemma 1 implies that there are no SPBE in which station Y airs a tune-in for all (y,z). This means that $q_Y = 0$ is never an off-equilibrium message by station Y. However, viewers may still find out an off-equilibrium situation at the interim-stage.*

Lemma 2 *If $q_Y(0,1) = 1$ in some SPBE, then $q_Y\left(\frac{1}{2},1\right) = 1$ in the same SPBE (and vice versa).*

Proof: Take a candidate SPBE in which $q_Y(0,1) = 1$, but $q_Y\left(\frac{1}{2},1\right) = 0$. In the event Y does not air a tune-in, regardless of what $q_Y(0,0)$, $q_Y\left(0,\frac{1}{2}\right)$, $q_Y\left(\frac{1}{2},0\right)$ and $q_Y\left(\frac{1}{2},\frac{1}{2}\right)$ are in equilibrium, Y-viewers' beliefs are going to be more inclined towards station Z. To see this, suppose $q_Y(0,0) = q_Y\left(0,\frac{1}{2}\right) = q_Y\left(\frac{1}{2},0\right) = q_Y\left(\frac{1}{2},\frac{1}{2}\right) = 1$. This means that, conditional on $q_Y = 0$, equilibrium inferences are $(y,z) \in \left\{(1,0), \left(1,\frac{1}{2}\right), (1,1), \left(\frac{1}{2},1\right)\right\}$. With these inferences, since it is much more likely that $y = 1$ than $z = 1$, no first-period Y-viewer will continue to stay with Y. Having $q_Y(0,0)$ and/or $q_Y\left(\frac{1}{2},\frac{1}{2}\right) = 0$ does not change anything since these are symmetric changes for both stations. The best scenario for station Y is when $q_Y\left(\frac{1}{2},0\right) = 0$. In this case, inferences will be such that $\mathrm{pr}\left(y = \frac{1}{2}\right) = \frac{2}{5}$ and $\mathrm{pr}(y = 1) = \frac{3}{5}$ for station Y, while $\mathrm{pr}\left(z = \frac{1}{2}\right) = \frac{1}{5}$ and $\mathrm{pr}(z = 0) = \mathrm{pr}(z = 1) = \frac{1}{5}$ for Z. It can be again easily verified that, even in this best scenario, all Y-viewers will switch away from Y after seeing $q_Y = 0$. Some or all of these viewers will switch to station Z (and some will switch off right away if v is small). When they find out that $z = 1$, their interim beliefs will be $y \in \left\{\frac{1}{2},1\right\}$. First suppose $v - c < \frac{1}{2}$. Switching back to Y is optimal for those λ for whom $\frac{1}{2}\left(v - c - \left(\frac{1}{2} - \lambda\right)\right) + \frac{1}{2}\max\{-2c, v - c - (1-\lambda)\} \geq \max\{-c, v - (1-\lambda)\}$. This is satisfied for $\lambda \geq \frac{1}{2} - (v - c)$. Hence, when $(y,z) = \left(\frac{1}{2},1\right)$, the number of viewers from the initial Y audience that end up watching Y is $v - c$. When v is small, this number is going to be even smaller since some viewers will have already switched off. Now, suppose Y instead airs a tune-in for $y = \frac{1}{2}$ when $(y,z) = \left(\frac{1}{2},1\right)$. If $q_Y\left(\frac{1}{2},0\right) = q_Y\left(\frac{1}{2},\frac{1}{2}\right) = 0$ on the equilibrium path, then airing a tune-in for $y = \frac{1}{2}$ is an off-equilibrium action. In this case, Y-viewers are free to believe anything about z. Suppose some of them switch to Z based on their inferences. However, when $z = 1$, those for whom $v - c - \left(\frac{1}{2} - \lambda\right) \geq -c$ (i.e., $\lambda \in \left[\frac{1}{2} - \min\left\{v, \frac{1}{2}\right\}, \frac{1}{2}\right]$) will switch back to Y, implying an audience size of $\min\left\{v, \frac{1}{2}\right\}$ from the set of initial Y-viewers. Thus, by deviating from $q_Y\left(\frac{1}{2},1\right) = 0$, station Y is able to increase its second period audience size from $v - c$ to $\min\left\{v, \frac{1}{2}\right\}$, a net increase of $\min\left\{c, \frac{1}{2} - (v - c)\right\}$. If this is greater than $\frac{1}{2A}$, then station Y will deviate and air a tune-in for $y = \frac{1}{2}$ when $(y,z) = \left(\frac{1}{2},1\right)$. Note that when $c < \frac{1}{2} - (v - c)$ (i.e., when $v < \frac{1}{2}$), the net increase in audience will be c, which is greater than $\frac{1}{2A}$ by the large A assumption.

Suppose that $\frac{1}{2} - (v - c) \leq \frac{1}{2A}$, so the above deviation is not profitable. However, then, Y will have an incentive to deviate from $q_Y(0,1) = 1$ by not airing a tune-in. On the equilibrium path when Y airs a tune-in, it will at best get all of its viewers to stay tuned (this happens if viewers infer $z = 1$ after seeing a tune-in for $y = 0$). When it deviates, on the other hand, all of its viewers will initially switch to Z. When they find out that $z = 1$, their interim beliefs will be $y \in \left\{\frac{1}{2}, 1\right\}$ and $\lambda \geq \frac{1}{2} - \min\left\{v - c, \frac{1}{2}\right\}$ will switch back to Y. Deviation is profitable if $\frac{1}{2} - \min\left\{v - c, \frac{1}{2}\right\} \leq \frac{1}{2A}$, which is true since $\frac{1}{2} - (v - c) \leq \frac{1}{2A}$. Hence, for $\frac{1}{2} < v < \frac{1}{2} + c$, station Y will deviate either by airing a tune-in for $y = \frac{1}{2}$ when $(y, z) = \left(\frac{1}{2}, 1\right)$, or otherwise by not airing a tune-in for $y = 0$ when $(y, z) = (0, 1)$. Similarly, when $v - c \geq \frac{1}{2}$, station Y will strictly benefit by not airing a tune-in for $y = 0$. Thus, the candidate SPBE is invalidated and as a result, Lemma 2 follows. The analysis is exactly the same for the 'vice versa' part and is therefore skipped. Note that this proof again does not depend on the use of passive beliefs, so it is true for all belief structures.

Lemma 3 *If* $q_Y(0,1) = q_Y\left(\frac{1}{2}, 1\right) = 1$ *in some SPBE, then* $q_Y(0,z) = q_Y\left(\frac{1}{2}, z\right) = 1$ *for all* z *in the same SPBE.*

Proof: Take a candidate SPBE in which $q_Y(0,1) = q_Y\left(\frac{1}{2}, 1\right) = 1$, but $q_Y(0,0) = 0$. In the event that Y does not air a tune-in, regardless of what $q_Y\left(0, \frac{1}{2}\right)$, $q_Y\left(\frac{1}{2}, 0\right)$ and $q_Y\left(\frac{1}{2}, \frac{1}{2}\right)$ are in equilibrium, Y-viewers' beliefs are going to be more inclined towards station Z (for the same reasons as in Lemma 2, but now even more aggravated). Therefore, they all sample Z first (again, this is under the assumption that v is large enough – if v is small, then some viewers will switch off, which at the end makes deviation even more desirable). When $z = 0$, depending on the equilibrium value of $q_Y\left(\frac{1}{2}, 0\right)$, their interim beliefs will be either $(y, z) \in \{(0,0), (1,0)\}$ or $(y, z) \in \left\{(0,0), \left(\frac{1}{2}, 0\right), (1,0)\right\}$. In the first case, none of the initial Y-viewers return to Y, because they incur the sampling cost if they do so – even if $y = 0$. In the second case, viewers for whom $\lambda \geq \frac{1}{4} + \frac{3c}{2}$ switch back to Y in the hope of finding $y = \frac{1}{2}$ (the threshold viewer is found by $\frac{2}{3}(v - c - \lambda) + \frac{1}{3}\left(v - c - \left(\frac{1}{2} - \lambda\right)\right) = v - \lambda$) – again, if v is small, a smaller fraction of these viewers will switch back. When $y = 0$, two stations offer the same utility for these viewers, so a random half of $\lambda \in \left[\frac{1}{4} + \frac{3c}{2}, \min\left\{v + c, \frac{1}{2}\right\}\right]$ stay with Y, and the remaining random half switch back to Z. Hence, when $(y, z) = (0, 0)$, at most $\frac{1}{2}\left(\min\left\{v + c, \frac{1}{2}\right\} - \frac{1}{4} - \frac{3c}{2}\right)$

viewers from the initial Y audience end up watching Y. If Y instead airs a tune-in for $y = 0$ when $(y, z) = (0, 0)$, equilibrium inferences of the audience will be either $(y, z) = (0, 1)$ or $(y, z) \in \left\{\left(0, \frac{1}{2}\right), (0, 1)\right\}$. In the first case, viewers with $\lambda \leq \min\left\{v, \frac{1}{2}\right\}$ stay tuned in Y while the rest switch off. In the second case, viewers with $\lambda \leq \frac{1}{4} + \frac{c}{2}$ stay tuned and the rest switch to Z. When they find out $z = 0$, none of those who switched will go back to Y since both stations offer the same program type. As a result, at worst $\frac{1}{4} + \frac{c}{2}$ viewers from the initial Y audience will watch Y in the second period. Hence, by airing an unexpected tune-in, station Y is able to increase its second period audience size by $\frac{1}{4} + \frac{c}{2} - \frac{1}{2}\left(\min\left\{v + c, \frac{1}{2}\right\} - \frac{1}{4} - \frac{3c}{2}\right)$, which equals $\frac{1}{8} + \frac{5c}{4} + \frac{1}{2}\left(\frac{1}{2} - \min\left\{v + c, \frac{1}{2}\right\}\right)$. For large A, this is greater than $\frac{1}{2A}$. and so station Y would deviate and air a tune-in for $y = 0$ when $(y, z) = (0, 0)$.

To show that $q_Y\left(\frac{1}{2}, \frac{1}{2}\right) = 1$, we follow exactly the same steps and it will yield the same result: By airing an unexpected tune-in, station Y is able to increase its second period audience size by $\frac{1}{8} + \frac{5c}{4} + \frac{1}{2}\left(\frac{1}{2} - \min\left\{v + c, \frac{1}{2}\right\}\right)$, which is greater than $\frac{1}{2A}$ for large A. Hence, station Y would deviate and air a tune-in for $y = \frac{1}{2}$ when $(y, z) = \left(\frac{1}{2}, \frac{1}{2}\right)$.

Now, given $q_Y(0, 0) = q_Y\left(\frac{1}{2}, \frac{1}{2}\right) = q_Y(0, 1) = q_Y\left(\frac{1}{2}, 1\right) = 1$ in a particular SPBE, it is easy to show that $q_Y\left(0, \frac{1}{2}\right) = q_Y\left(\frac{1}{2}, 0\right) = 1$. First, suppose on the contrary that $q_Y\left(0, \frac{1}{2}\right) = 0$. Again, all initial Y-viewers sample Z first. When $z = \frac{1}{2}$, the interim beliefs will be $(y, z) \in \left\{\left(0, \frac{1}{2}\right), \left(1, \frac{1}{2}\right)\right\}$. Those λ for whom $\frac{1}{2}(v - c - \lambda) + \frac{1}{2}\left(v - c - \left(\frac{1}{2} - \lambda\right)\right) \geq v - \left(\frac{1}{2} - \lambda\right)$ switch back to Y. This solves as $\lambda \leq \frac{1}{4} - c$ (again, if v is small, a lower subset will switch back to Y – which makes the result stronger). When they find out that $y = 0$, all of them stay with Y. Hence, when $(y, z) = \left(0, \frac{1}{2}\right)$, exactly $\frac{1}{4} - c$ viewers from the initial Y audience end up watching Y. Now, if Y instead airs a tune-in for $y = 0$ when $(y, z) = \left(0, \frac{1}{2}\right)$, equilibrium inferences of the audience will be $(y, z) \in \{(0, 0), (0, 1)\}$. In this case, no Y-viewer switches to Z and the viewers with $\lambda \leq \min\left\{v, \frac{1}{2}\right\}$ stay tuned in Y. By airing an unexpected tune-in, station Y is able to increase its second period audience size by $\min\left\{v, \frac{1}{2}\right\} - \left(\frac{1}{4} - c\right)$, which is greater than $\frac{1}{2A}$. Hence, deviation is profitable. The arguments are identical for $(y, z) = \left(\frac{1}{2}, 0\right)$. These observations establish Lemma 3. The construction has not used passive beliefs at all, so Lemma 3 is true for all belief structures.

Remark 2: *As described in the main text, the fully self-revealing SPBE always exists, driven by the (rationally) pessimistic inferences in the absence of a tune-in. If, for instance, station Y does not air a tune-in, its viewers will infer that $y = 1$. As a result, all will switch to Z and none will ever switch back to Y. In other words, punishment for not airing a tune-in is very large. Therefore, station Y will be forced to air a tune-in when $y = 0$ or $\frac{1}{2}$. Note that these arguments do not depend on how one specifies off-equilibrium beliefs, because off-equilibrium beliefs are irrelevant in the fully self-revealing SPBE (by Lemma 1, station Y would never consider airing a tune-in for $y = 1$). Lemmas 2 and 3 above also establish that the fully self-revealing SPBE is the only SPBE in which $q_Y(0,1) = q_Y\left(\frac{1}{2},1\right) = 1$.*

Lemma 4 *There are no SPBE in which only $q_Y(0,0) = 1$, or only $q_Y\left(0,\frac{1}{2}\right) = 1$, or only $q_Y\left(\frac{1}{2},0\right)$, or only $q_Y\left(\frac{1}{2},\frac{1}{2}\right) = 1$.*

Proof: Suppose there is an SPBE in which only $q_Y(0,0) = 1$. On the equilibrium path, when station Y airs a tune-in, viewers infer that $(y,z) = (0,0)$, so each station gets an audience of $\frac{1}{2}\min\left\{v,\frac{1}{2}\right\}$. However, if Y deviates and does not air a tune-in, since inferences will be symmetric, a random half of its viewers will initially stay with Y while the remaining half switches to Z (if v is small, then some viewers will switch off, again making the result stronger). Upon seeing $y = 0$, those who stayed with Y will infer (incorrectly) that $z \in \left\{\frac{1}{2},1\right\}$. Those with $\lambda > \frac{1}{4} + c$ switch to Z. Once they see that $z = 0$, they are indifferent between the two stations, so a random half of $\lambda \in (\frac{1}{4} + c, \min\left\{v + c, \frac{1}{2}\right\}]$ switch back to Y. Everything is identical for those who have initially switched to Z. As a result, stations Y and Z equally share the viewers with $\lambda \leq \min\left\{v + c, \frac{1}{2}\right\}$, yielding an audience size of $\frac{1}{2}\min\left\{v + c,\frac{1}{2}\right\}$ for each from the first-period Y-audience. Hence, station Y receives at least as many viewers as it would with a tune-in, which makes deviation profitable. Arguments are exactly the same for $q_Y\left(\frac{1}{2},\frac{1}{2}\right) = 1$.

Suppose now that only $q_Y\left(0,\frac{1}{2}\right) = 1$. Suppose Y airs a tune-in for $y = 0$ when $(y,z) = (0,0)$. In this case, viewers will incorrectly think that $z = \frac{1}{2}$, so $\lambda > \frac{1}{4}$ will switch to Z. Once they see $z = 0$, they will stay or switch off, but not come to Y. In case Y does not air a tune-in, on the other hand, $\lambda < \frac{1}{4}$ initially switch to Z – again assuming v

is not too small (to see this, first note that in case of $q_Y = 0$, $\lambda = \frac{1}{4}$ will be the indifferent viewer between the two stations. $\lambda < \frac{1}{4}$ will then switch to Z since it is more likely that $z = 0$). They will all stay at Z when they find out $z = 0$. Those who have stayed with Y will initially infer that $z \in \{0, 1\}$ upon seeing $y = 0$, so $\frac{1}{4} \leq \lambda \leq \min \left\{v + c, \frac{1}{2}\right\}$ will continue to stay with Y. Hence, if $\frac{1}{4} - \left(\min \left\{v + c, \frac{1}{2}\right\} - \frac{1}{4}\right) > \frac{1}{2A}$, then deviation is profitable. If this inequality is not satisfied, then Y deviates by not airing a tune-in for $y = 0$ when $(y, z) = \left(0, \frac{1}{2}\right)$. Again, $\lambda < \frac{1}{4}$ switch to Z in such a case, and once they see $z = \frac{1}{2}$, they infer $y \in \left\{\frac{1}{2}, 1\right\}$. Therefore, none will switch back to Y. On the other hand, station Y will get $\min \left\{v + c, \frac{1}{2}\right\} - \frac{1}{4}$. Hence, deviating by not airing a tune-in for $y = 0$ when $(y, z) = \left(0, \frac{1}{2}\right)$ is optimal if $\frac{1}{4} - \left(\min \left\{v + c, \frac{1}{2}\right\} - \frac{1}{4}\right) \leq \frac{1}{2A}$. As a result, station Y will deviate either from $q_Y(0, 0) = 0$, or otherwise from $q_Y\left(0, \frac{1}{2}\right) = 1$. Arguments are symmetric for $q_Y\left(\frac{1}{2}, 0\right) = 1$. These observations establish Lemma 4. Again, the construction has not used passive beliefs at all, so Lemma 4 holds for all belief structures.

Lemma 5 *There are no SPBE in which only* $q_Y(0, 0) = q_Y\left(\frac{1}{2}, \frac{1}{2}\right) = 1$.

Proof: This is obvious from Lemma 4. If Y airs a tune-in for $y = 0$, it perfectly reveals that $z = 0$, leading to an audience size of $\frac{1}{2} \min \left\{v, \frac{1}{2}\right\}$. By deviating from $q_Y(0, 0) = 1$, it is able to raise its audience (from the initial Y-viewers) to $\min \frac{1}{2} \left\{v + c, \frac{1}{2}\right\}$, for the same reasons as described in Lemma 4. Hence, deviation is always optimal.

Remark 3: *Lemmas 1-5 establish that, besides the fully self-revealing SPBE, there are only 4 other possibilities: an SPBE with no tune-ins, an SPBE in which only* $q_Y(0, 0) = q_Y\left(0, \frac{1}{2}\right) = 1$*, or only* $q_Y\left(\frac{1}{2}, 0\right) = q_Y\left(\frac{1}{2}, \frac{1}{2}\right) = 1$*, and an SPBE in which* $q_Y(y, z) = 1$ *when* $y, z = 0, \frac{1}{2}$*. The last one of these exists for* $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$ *as described in part (2) of Proposition 1. The other three SPBE exist if and only if viewers hold non-passive beliefs.*

Lemma 6 *A cross-signaling SPBE in which* $q_Y(y, z) = 1$ *exists when* $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$ *as long as* $(y, z) \in \left\{(0, 0), \left(0, \frac{1}{2}\right), \left(\frac{1}{2}, 0\right), \left(\frac{1}{2}, \frac{1}{2}\right)\right\}$.

Proof: Take Table 5 as given and assume $\frac{1}{4} + c \leq v < \frac{1}{2} - c$. To show that there are no profitable deviations, suppose station Y deviates from $q_Y(0, 0) = 1$ by not airing a tune-in. Given the symmetry of the posterior beliefs, a random half of its viewers will stay with Y while the other half will switch away. Those who stayed will think that $z = 1$ upon seeing $y = 0$, and the ones with locations less than $v + c$ will continue to stay. Those who have initially switched to Z will think that $y = 1$ upon seeing $z = 0$, and therefore none of them will switch back to Y. Hence, station Y will get an audience share of $\frac{v+c}{2}$. From Table 5, we see that station Y's on-equilibrium audience size is $\frac{1}{4}$ when $(y, z) = (0, 0)$. Note that all of these viewers are from station Y's first-period audience. As a result, deviation is unprofitable if $\frac{1}{4} - \frac{v+c}{2} > \frac{1}{2A}$, or if $v + c \leq \frac{1}{2} - \frac{1}{A}$. When $v + c \geq \frac{1}{2}$, station Y's deviation audience share becomes $\frac{1}{4}$ from its own first-period viewers, so deviation is surely profitable in this case. The same arguments apply equally to $\left(0, \frac{1}{2}\right)$, $\left(\frac{1}{2}, 0\right)$ and $\left(\frac{1}{2}, \frac{1}{2}\right)$. 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 $v + c$ from its first-period audience, and it cannot improve upon this by airing a tune-in. Therefore, a deviation is not profitable in these two cases, either.

As explained in the main text, v must be greater than $\frac{1}{4} + c$ in order to maintain this SPBE. Otherwise, a significant fraction of viewers switch off in the absence of a tune-in. To see this, suppose station Y does not air a tune-in. The inferences are such that Y did not air a tune-in because either $y = 1$ and/or $z = 1$. There are five possibilities:

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

These inferences are symmetric for y and z, and so viewers are indifferent between the two stations. Thus, a random half will sample z first. For those who stay with Y, the actual location of y will determine their further behavior. If $y = 0$, they infer that $z = 1$, so viewers with $\lambda \leq v + c$ stay with Y and the rest switch off. If $y = \frac{1}{2}$, they infer that $z = 1$, so $\frac{1}{2} - v - c \leq \lambda \leq \frac{1}{2}$ stay with Y and the rest switch off. If $y = 1$, they infer that $z \in \left\{0, \frac{1}{2}, 1\right\}$, each with equal probability. In this case, we know from the analysis in subsection 2.1.(ii) that $\lambda \in \left(v - 2c, \frac{1}{2} - v + 2c\right)$ will switch off if $v < \frac{1}{4} + \frac{c}{2}$, whereas all $\lambda \leq \frac{1}{2}$ will sample z if $v \geq \frac{1}{4} + \frac{c}{2}$. Take $v \geq \frac{1}{4} + \frac{c}{2}$. If it turns out that $z = 0$, all $\lambda \leq v + c$ watch Z and $v + c < \lambda \leq \frac{1}{2}$ switch off. Similarly, if $z = \frac{1}{2}$, all $\frac{1}{2} - v - c \leq \lambda \leq \frac{1}{2}$ watch Z and $\lambda < \frac{1}{2} - v - c$ switch off. If $z = 1$, on the other hand, all first-period Y-viewers will switch off (after having sampled both programs). For those first-period Y-viewers who switched to Z initially, the subsequent choices are similar.

Now, we need to check if the first sampling is desirable at all, conditional on not seeing a tune-in. For $\lambda < \frac{1}{2} - v - c$, the expected utility of sampling station Y is

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

It is easy to check that this value is non-negative when $\frac{1}{5}(2v - 2\lambda - 6c) \geq 0$, or equivalently when $\lambda \leq v - 3c$. But $v - 3c < \frac{1}{2} - v - c$ when $v < \frac{1}{4} + c$, so it follows that viewers with $\lambda \in \left(v - 3c, \frac{1}{2} - v - c\right)$ switch off right away in the absence of a tune-in. By monotonicity, $\frac{1}{2} - (v + c) \leq \lambda < \frac{1}{4}$ will also switch off in the absence of a tune-in. For $v < \frac{1}{4} + \frac{c}{2}$, the result is the same since $v - 3c < v - 2c$. As a result, when $v < \frac{1}{4} + c$, viewers with $\lambda \in \left(v - 3c, \frac{1}{2} - v + 3c\right)$ switch off right away in the absence of a tune-in. However, station Y can ensure an audience share of v by airing a tune-in when $(y, z) = (0, 1)$ or $\left(\frac{1}{2}, 1\right)$. Since $v - (v - 3c) > \frac{1}{2A}$ by the large A assumption, station Y would deviate from $q_Y(0, 1) = 0$ and $q_Y\left(\frac{1}{2}, 1\right) = 0$ by instead airing a tune-in. This means that v must be greater than $\frac{1}{4} + c$ in order to maintain the cross-signaling SPBE.

Lemma 7 *A no tune-in SPBE exists for* $v + c + \frac{1}{A} \geq \frac{1}{2}$ *when off-equilibrium beliefs are non-passive.*

Proof: Start from a no tune-in regime. First, when $y = 1$ or $z = 1$, station Y surely cannot increase its audience size by airing a tune-in. Under passive beliefs, if station Y deviates by airing a tune-in, say for $(y, z) = \left(0, \frac{1}{2}\right)$, $\lambda > \frac{1}{4} + \frac{c}{2}$ will switch to Z. Upon seeing $z = \frac{1}{2}$, those who have switched to Z will stay at Z. Thus, station Y's audience size will be $\frac{1}{4} + \frac{c}{2}$. The equilibrium audience size of station Y in a no tune-in SPBE for $(y, z) = \left(0, \frac{1}{2}\right)$ is $\frac{1}{4}$. Deviation is profitable if $\frac{1}{4} + \frac{c}{2} - \frac{1}{4} > \frac{1}{2A}$, or equivalently if $\frac{c}{2} > \frac{1}{2A}$. This is true under the large A assumption. Hence, under passive beliefs, a no tune-in SPBE does not exist.

Suppose now that viewers hold non-passive off-equilibrium beliefs such that if Y unexpectedly airs a tune-in for $y = 0$ or $\frac{1}{2}$, then they believe $z \in \left\{0, \frac{1}{2}\right\}$. When station Y deviates and airs a tune-in, say for $(y, z) = (0, 0)$ (or for $(y, z) = \left(0, \frac{1}{2}\right)$), $\lambda > \frac{1}{4}$ will switch to Z under these non-passive beliefs. Upon seeing $z = 0$ (or $z = \frac{1}{2}$), those who have switched to Z will stay at Z. Thus, station Y's audience size will be $\frac{1}{4}$. The equilibrium viewership of station Y from its own first-period audience in a no tune-in SPBE for $(y,z)=(0,0)$ is $\min\left\{\frac{v+c}{2},\frac{1}{4}\right\}$ (and $\frac{1}{4}$ for $(y,z)=\left(0,\frac{1}{2}\right)$). Deviation is clearly not profitable for $(y,z)=\left(0,\frac{1}{2}\right)$, since Y cannot generate any additional audience. For $(y,z)=(0,0)$, deviation is not profitable if $\frac{1}{4}-\frac{1}{2}\min\left\{v+c,\frac{1}{2}\right\}\leq\frac{1}{2A}$, or equivalently if $v+c+\frac{1}{A}\geq\frac{1}{2}$. Note that this is the same threshold as in the cross-signaling SPBE. Analysis is symmetric for $(y,z)=\left(\frac{1}{2},0\right)$ and $\left(\frac{1}{2},\frac{1}{2}\right)$. For $(y,z)=(0,1)$ and $(y,z)=\left(\frac{1}{2},1\right)$, station Y is able to get an audience of $\min\left\{v+c,\frac{1}{2}\right\}$ from the initial Y-viewers in a no tune-in SPBE, which cannot be increased by airing a tune-in. Hence, under non-passive beliefs, a no tune-in SPBE exists when $v+c+\frac{1}{A}\geq\frac{1}{2}$.

Lemma 8 *An SPBE in which only* $q_Y(0,0)=q_Y\left(0,\frac{1}{2}\right)=1$*, or only* $q_Y\left(\frac{1}{2},0\right)=q_Y\left(\frac{1}{2},\frac{1}{2}\right)=1$ *exists for* $\frac{1}{4}+\frac{3c}{4}-\frac{1}{4A}\leq v<\frac{1}{2}-c-\frac{1}{2A}$ *when off-equilibrium beliefs are non-passive.*

Proof: Take an SPBE in which only $q_Y(0,0)=q_Y\left(0,\frac{1}{2}\right)=1$. The other one is simply symmetric. When station Y does not air a tune-in, equilibrium inferences are

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

With these inferences, provided that v is large enough, $\lambda=\frac{1}{4}$ will be the indifferent viewer between sampling station Y and Z. Hence, those Y-viewers with $\lambda<\frac{1}{4}$ will find it optimal to switch to station Z while the rest will stay with Y upon observing $q_Y=0$. When $y=1$ or $z=1$, station Y surely cannot increase its audience size by airing a tune-in. Thus, the only two scenarios Y may find optimal to deviate and air a tune-in are $(y,z)=\left(\frac{1}{2},0\right)$ and $\left(\frac{1}{2},\frac{1}{2}\right)$. On the equilibrium path, Y gets an audience size of $\frac{1}{4}$ when $y=\frac{1}{2}$ (from its own first-period audience only): those who did not switch away ($\lambda\in\left[\frac{1}{4},\frac{1}{2}\right]$) continue to stay with Y once they find out $y=\frac{1}{2}$, and those who have switched to Z ($\lambda<\frac{1}{4}$) do not come back (when these viewers observe $z=0$ or $\frac{1}{2}$, they will infer that $y\in\{\frac{1}{2},1\}$, so none of them will ever switch back to Y). Suppose Y unexpectedly airs a tune-in for $y=\frac{1}{2}$. Under passive beliefs, viewers infer $z\in\left\{0,\frac{1}{2},1\right\}$ following a deviation by Y and so only $\lambda<\frac{1}{4}-\frac{c}{2}$ switch to station Z (as opposed to $\lambda<\frac{1}{4}$ under the particular non-passive beliefs considered here). And the additional $\frac{c}{2}$ viewers are valuable enough to make deviation profitable under passive beliefs (because $\frac{c}{2}>\frac{1}{2A}$). Hence, under passive beliefs, the described SPBE do not exist.

Suppose viewers hold non-passive off-equilibrium beliefs such that if Y unexpectedly airs a tune-in for $y = \frac{1}{2}$, then they believe $z \in \left\{0, \frac{1}{2}\right\}$. Under these beliefs, in case of a deviation, $\lambda < \frac{1}{4}$ will switch to station Z. Thus, when $(y, z) = \left(\frac{1}{2}, 0\right)$ or $\left(\frac{1}{2}, \frac{1}{2}\right)$, station Y ends up with the same audience size regardless of whether it airs a tune-in or not. Therefore, deviation is clearly not optimal.

Does Y have any incentive to deviate from $q_Y(0,0) = q_Y\left(0, \frac{1}{2}\right) = 1$? On the equilibrium path, when station Y airs a tune-in for $y = 0$, equilibrium inferences are $z \in \left\{0, \frac{1}{2}\right\}$. Those Y-viewers with $\lambda < \frac{1}{4}$ will stay with Y while the rest will switch to Z (and will not switch back to Y once they find out $z = 0$ or $\frac{1}{2}$). On the other hand, if Y does not air a tune-in, those Y-viewers with $\lambda \in \left[\frac{1}{4}, \frac{1}{2}\right]$ will initially stay with Y while the rest will switch to station Z. Once they find out $z = 0$ or $\frac{1}{2}$, they will infer that $y \in \{\frac{1}{2}, 1\}$, so none of them will ever switch back to Y. On the other hand, out of those who stayed with Y, only those with $\lambda \leq \min\left\{v + c, \frac{1}{2}\right\}$ will stay, so station Y will get an audience size of $\min\left\{v + c, \frac{1}{2}\right\} - \frac{1}{4}$ (from its own first-period audience only). Obviously, deviation is profitable if $\frac{1}{4} - \left(\min\left\{v + c, \frac{1}{2}\right\} - \frac{1}{4}\right) \leq \frac{1}{2A}$, or equivalently if $v + c + \frac{1}{2A} \geq \frac{1}{2}$. Otherwise, the above strategies constitute an SPBE.

We again need v to be large enough for this SPBE to exist. If, in the absence of a tune-in, a sizable fraction of viewers switch off right away, then station Y will find it optimal to air a tune-in for $y = \frac{1}{2}$. To be more precise, when $v \geq \frac{1}{4}$, if $\lambda \in \left[\frac{1}{4}, \frac{1}{4} + \frac{1}{2A}\right]$ switch off, then Y will want to air a tune-in and keep all $\lambda \geq \frac{1}{4}$ watching. This happens when $\lambda = \frac{1}{4} + \frac{1}{2A}$ switches off in the absence of a tune-in: $\frac{3}{7}\left(v - \left(\frac{1}{2} - \frac{1}{4} - \frac{1}{2A}\right)\right) + \frac{1}{7}\left(v - \frac{1}{4} - \frac{1}{2A}\right) + \frac{3}{7}(-c) < 0$, or equivalently if $v < \frac{1}{4} + \frac{3c}{4} - \frac{1}{4A}$. Note that this threshold is less than $\frac{1}{4} + \frac{c}{2}$ under the large A assumption (i.e., $A > \frac{1}{c}$), so $\lambda = \frac{1}{4} + \frac{1}{2A}$ does not sample Z even if she samples Y and it turns out $y = 1$, as supposed in the above calculation. Hence, for any $v < \frac{1}{4} + \frac{3c}{4} - \frac{1}{4A}$, it is optimal for station Y to deviate.

Note that the particular non-passive off-equilibrium beliefs that I used in the derivation of this SPBE are the most punishing off-equilibrium beliefs for the deviating station. This is so because, whenever these beliefs are relevant (i.e., whenever station Y unexpectedly airs a tune-in for $y = \frac{1}{2}$ or $y = 1$), deviation is unprofitable. Hence, this particular SPBE exists if and only if $v + c + \frac{1}{2A} < \frac{1}{2}$.

Main result: *Combining Lemmas 1-8 above, we reach the following conclusion: The fully self-revealing SPBE always exists and is the unique SPBE under passive beliefs when* $v < \frac{1}{4} + c$ *or when* $v \geq \frac{1}{2} - c - \frac{1}{A}$*, Otherwise, when* $\frac{1}{4} + c \leq v < \frac{1}{2} - c - \frac{1}{A}$*, there exists a second SPBE, referred to as the cross-signaling SPBE in the text. When off-equilibrium beliefs are unrestricted, there are three more SPBE: an SPBE with no tune-ins, an SPBE in which only* $q_Y(0, 0) = q_Y\left(0, \frac{1}{2}\right) = 1$*, and an SPBE in which only* $q_Y\left(\frac{1}{2}, 0\right) = q_Y\left(\frac{1}{2}, \frac{1}{2}\right) = 1$*. The first of these exists when* $v + c + \frac{1}{A} \geq \frac{1}{2}$*; this is the same threshold where the cross-signaling SPBE ceases to exist. The second and third SPBE exist when* $\frac{1}{4} + \frac{3c}{4} - \frac{1}{4A} \leq v < \frac{1}{2} - c - \frac{1}{2A}$.