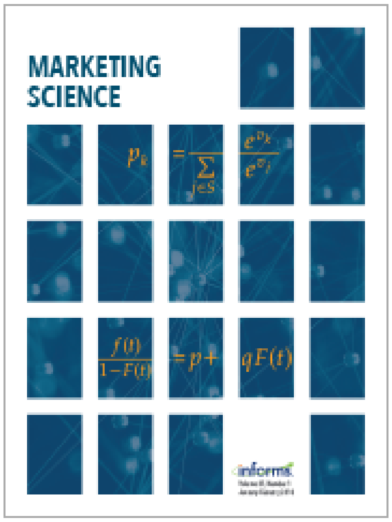

Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

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MARKETING SCIENCE
Vol. 23, No. 1, Winter 2004, pp. 120–133
ISSN 0732-2399 | EISSN 1526-548X | 04 | 2301 | 0120

DOI 10.1287/mksc.1030.0042

Is Having More Channels Really Better? A Model of Competition Among Commercial Television Broadcasters

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Competitive behavior in commercial television broadcasting is modeled to examine program choice and the effects of more channels being available on firm strategy. Specifically, broadcasters compete by selecting both the "type" and quality level of a program to offer, but do not compete on price. We obtain five major results. First, a comparison of monopoly and duopoly markets indicates that broadcasters in an industry with a larger number of competitors may provide programs of lower quality compared to broadcasters in an industry with a smaller number. Second, in terms of viewer welfare, having more channels available is not necessarily "better." Third, broadcasters tend to choose an intermediate level of differentiation in terms of the types of programs they provide, resulting in a "counterprogramming" strategy. In other words, avoidance of price competition is not required for competitors to differentiate themselves from each other. Fourth, if one broadcaster starts the evening with a higher-quality (higher-rated) program than its competitor, its second program should also be of higher quality. Finally, a broadcaster's first program should be of equal or higher quality than its second program. Put another way, it always behooves a broadcaster to "lead with its best."

Key words: competition; competitive strategy; entertainment marketing; game theory; market structure; media; product policy
History: This paper was received July 18, 2001, and was with the authors 13 months for 3 revisions; processed by James Hess.

1. Introduction

The television broadcasting industry has undergone significant technological change over the past 20 years. Partially as a result of advances in technology, and a worldwide trend toward deregulation, the regulatory environment for television broadcasters in many countries has also drastically changed. The impact of both these technological and regulatory changes has been to greatly increase the scope of competition in terms of the number of potential program alternatives that a television viewer can choose from at any given time. From the immediate post-World War II period until the early 1980s, most viewers in the United States were only able to receive a handful of channels (three to six in most local television markets), and in most other countries the number of channels available was even more limited. The limited choice in this period was due to a combination of the limitations of terrestrial over-the-air broadcasting technology and how television broadcasters were regulated. Television viewers in many places now have nearly 100 channels to choose from, and advances in digital cable and digital direct broadcast satellite technology offer the possibility of giving viewers 600 channels to choose from in the not-so-distant future.

Commercial television broadcasting, along with other advertising-supported media industries, differs from most other major industries in the way the market functions. The industry is made up of two distinct, but closely related, markets, one for viewers and the other for advertisers (Barwise and Ehrenberg 1988, Dukes and Gal-Or 2003, Vogel 1998). While viewers may pay a fixed fee to watch television at all (i.e., for a cable subscription or a television license), they pay essentially nothing for watching any particular program. Instead of charging viewers directly, commercial television broadcasters receive their revenues from selling time to advertisers. Advertisers are willing to spend more for air time (say, a 30-second spot) in programs that have a greater number of viewers (have higher ratings) than in programs with fewer viewers. As a result, the number of "eyeballs" watching a program drives a broadcaster's revenues.

Another important aspect of the television industry is that providing watchable (i.e., high-quality) television programs is extremely expensive. In the late 1990s, the average cost of producing a one-hour prime-time U.S. network program was $1.5 million (Vogel 1998). Moreover, lowering production values in an effort to reduce costs tends to greatly reduce the appeal of a program to viewers (Barwise and Ehrenberg 1988, Jankowski and Fuchs 1995).

Commercial television broadcasting is an important industry both in terms of its sheer size (the U.S. industry alone had $80 billion in revenues in 1998) and its social and cultural significance. Given its importance, its distinctive "two-market" structure, and its rapidly changing technological, regulatory, and competitive environment, we investigate three critical questions by analyzing a spatial model of product positioning in which broadcasters compete through the selection of program type (modeled as a horizontal dimension) and program quality (a vertical dimension). First, what is the basic nature of competition in terms of programming strategy? We find that broadcasters strive to minimize competition when the costs of producing high-quality programs is relatively high in a particular time slot. They accomplish this through both the choice of the type of program they offer (i.e., the usual optimal strategy is for broadcasters to "counterschedule" their programs) and the quality of those programs. Using the terminology of the spatial competition literature, broadcasters usually choose an intermediate level of differentiation, neither minimally nor maximally differentiating themselves on the horizontal dimension. Within an evening's schedule of programs, we find that a broadcaster should never schedule a program in the first time slot of the evening that is of a lower quality than the program scheduled in the second time slot, but the broadcaster may find it optimal to offer a program of lower quality in the second time slot relative to the quality of the program in the first time slot. In addition, if a broadcaster offers a program of higher quality than its rival in the first time slot, it is optimal for that broadcaster to also offer a relatively higher-quality program in the subsequent time slot.

Second, how do the optimal strategies of broadcasters differ in markets with more competitors versus those with fewer competitors? Of particular concern are the implications of having markets with a greater number of competitors on the quality of television programs offered. This issue is not well understood, and industry participants and observers have offered contradictory opinions. According to Barwise and Ehrenberg (1988),

> As viewers we mostly watch the programs that have higher production values—bigger budgets, better performers, more rehearsal, better scripts and locations—especially when we have otherwise comparable choices on other channels. This will lead to increased spending on program quality as more channels become available to compete for more viewers' attention.

In contrast, Don Hewitt (the executive producer of *60 Minutes*, and reported in Jankowski and Fuchs 1995), responding to a question about the effect on quality of the projected increase in the number of television channels that will be available to viewers in the future, indicated that

> If viewers ten years hence are still trying to find eight hours a day of worthwhile television fare, they're not going to find it then any more than they can find it now.

Our analysis indicates that a range of the cost-of-quality provision exists in which broadcasters in markets with fewer competitors provide higher-quality programs than do broadcasters in markets with a greater number of competitors. Thus, the optimal strategy of broadcasters moves toward relative "narrowcasting" as the number of competitors increases.

In general, having more options to choose from is considered to be unambiguously beneficial for consumers. Thus, the final research question is the implications of having more viewing options (the primary impact of the recent technological and regulatory changes) for the viewing publics' well-being. In what may be the most unexpected, and in many ways counterintuitive, result of our analysis, we find that increasing the number of viewing options (the number of broadcasters in the market) does not necessarily make the average viewer better off. Under a set of very plausible circumstances viewers are, on average, better off when they have fewer viewing options from which to choose. Our findings in this area are due to the interplay between having a larger number of broadcasters in the market (which results in viewers, on average, having the choice of an alternative that more closely matches their tastes) and the effect this larger number of broadcasters has in reducing the average quality of programs provided. Over some ranges of the cost-of-quality provision, the quality-reduction effect dominates the increased average match of program types to viewer tastes, resulting in a reduction in average utility levels. These results prove robust under a number of extensions to our basic model. For instance, the viewer welfare results still obtain when broadcasters compete in a dynamic game that allows for the well-known "lead-in effect" (Rust and Eechambadi 1989, Shachar and Emerson 2000) to be operative.

Although our discussion in this paper focuses on U.S. television broadcasting, the analysis and its implications apply beyond the television industry. For example, many features of the analysis reflect the functioning of other advertising-supported media markets such as radio, newspapers, magazines, and more recently, large portal and other content sites on the World Wide Web. Thus, our findings are likely to have relevant implications for a number of media industries.

Most published studies on the television industry (e.g., Danaher and Mawhinney 2001, Gensch and Shaman 1980, Rust and Eechambadi 1989, Shachar and Emerson 2000) focus on *program scheduling*. That is, given a set of television programs, how should a broadcaster schedule them over an evening or over a week to attract viewers? While scheduling is an important issue for the industry, it is not the only one. As opposed to scheduling, *programming* focuses on the decision of what programs to produce (see, e.g., Rust and Eechambadi 1989). Because programming involves many factors that are critically important to the industry (such as production cost, program quality, syndication, and program distribution), it is surprising that little published research exists in this area. We hope to begin to fill this research gap by explicitly modeling aspects of programming strategy.

In the field of marketing, studies of strategic competition are closely linked to the research tradition of spatial competition (e.g., Ansari et al. 1994, Carpenter 1989, Desai 2001, Hauser 1988, Moorthy 1988, Vandenbosch and Weinberg 1995). Several aspects of our analysis distinguish it from this existing literature.

Most extant studies of competitive positioning assume that firms compete both in product and price space. While locating close to competition is clearly desirable if one wants to "steal" demand from competitors, it is now well understood that the existence of price competition discourages firms from doing so. Where the equilibrium exists depends on the interplay of this pair of strategic forces, which are known as the "market power effect" (of price) and the "market share effect" (of demand) in the literature. In a number of studies it has been found that the market power effect dominates the market share effect, resulting in firms seeking maximum differentiation (see, e.g., D'Aspremont et al. 1979, Shaked and Sutton 1982). The television broadcasting market exhibits a very limited degree of price competition, with broadcasters competing primarily on product attributes. Existing theory suggests that the broadcasters should minimally differentiate as a result of the sole market share effect. However, our theoretical analysis shows that they may still differentiate, as they do in practice, because competition on some other product dimension (program quality in our model) may also induce differentiation.

We relax one assumption commonly made in the literature, that of inelastic demand. In a spatial setting, inelastic demand allows a firm to retain all the customers in its hinterland, no matter how far away it is located from them. This assumption is frequently made to make the analysis tractable, but obviously comes at the expense of deviating from reality and losing generalizability. Similar to the approach taken by a number of researchers, including Economides (1984), Lerner and Singer (1937), and Moorthy (1988), we allow for elastic demand through the use of a rectangular demand curve. That is, viewers either do not watch, or watch a single program.[1] The major finding of past studies that use this approach to model inelastic demand is that firms tend to move away from each other. However, because price competition plays a critical part in all the abovementioned studies, it is thus arguable that price competition forms a confounding factor for product differentiation. To what extent the elastic demand induces differentiation, by itself, or together with nonprice factors, remains to be addressed.

The remainder of this paper is structured as follows. In the next section, we set up the basic theoretical model, while in §3 we examine monopoly and duopoly market behavior on the part of commercial television broadcasters, and explore the impact of market structure on viewer well-being. In §4 we extend the static model to a two-period dynamic model to examine the implications of the lead-in effect. In the concluding section, we provide a summary of our findings and suggest a number of potentially fruitful directions for future research.

2. The Conceptual Model and Its Assumptions

2.1. The Basic Framework

Following the well-established research stream based on the work of Hotelling (1929), our analysis makes use of a two-dimensional (quality/location) "linear city" spatial competition model. We assume that program "type" characteristics can be represented by a single "horizontal" dimension bounded within the unit interval. We first examine a static model, and then extend it into two periods. Consistent with the empirical reality of television broadcasting, much of our analysis is based on the assumption that the number of broadcasters is exogenously determined. Finally, we assume that each broadcaster has only a single "channel" in the market. Relaxing this assumption would greatly complicate the analysis and probably would not alter our main findings. Having said this, it is our belief that relaxing this assumption

[1] Although this is not necessarily the actual buying pattern for most consumer products, especially nondurables, it largely holds for the television market because a viewer typically watches one channel at any given moment (even those with sets that have picture-in-picture tuners), or they do not watch any channel at all.

would lead to a number of other important findings; however, doing so is beyond the scope of the present study.

2.2. Viewer Behavior

We model the potential utility a viewer receives from watching a particular program as depending on both the extent to which the program's "type" matches the viewer's taste, and the quality of that program, assuming that quality depends only on the program's production values. The objective behind this structure is to allow for the possibility that a viewer who is not a "fan" of crime dramas may be willing to view a particular crime drama program if that program is particularly well done. Formally, a viewer's utility function for a particular program is given by

$$u_k^i = v^i - |x_k - d^i|, \tag{1}$$

where x_k is viewer k's ideal point along the horizontal dimension, d^i is the "type" of broadcaster i's program (i.e., the program's location along the horizontal dimension), the term $-|x_k - d^i|$ measures the extent to which a viewer's tastes match the program's type,[2] and v^i is the quality level of broadcaster i's program. This formulation assumes that higher quality is always preferred by viewers, that all viewers judge quality in the same way, and that all viewers place the same weight on quality when evaluating viewing options.

A viewer determines which program to watch (or whether to watch at all) by comparing the utility level of all available programs, as well as the null alternative of watching nothing (which provides a utility level of zero), and selects the alternative (perhaps the null alternative) that provides the greatest utility level. As a result, the viewer selects her most preferred program or, if there is "nothing worth watching," turns off the television. A viewer's formal decision rule can be stated as: view program i if $u^i > \max\{u^j, j \in \Omega, j \neq i\}$ and $u^i > 0$; view program i or j with equal probability if $u^i > \max\{u^k, k \in \Omega, k \neq i, k \neq j\}$, $u^j > \max\{u^k, k \in \Omega, k \neq i, k \neq j\}$, $u^i = u^j > 0$; or watch nothing if $\max\{u^i, i \in \Omega\} \leq 0$, where Ω is the set of all available program alternatives.

The analysis contained in this paper is based on the assumption that viewer tastes follow a uniform distribution across the horizontal dimension (x_k). This allows us to concentrate on the consequences of competitive forces. However, numerical analysis using bipolar and unimodal distributions based on the symmetric beta distribution reveals that most of our findings hold under these alternative distributions of viewer tastes.

[2] This term has its maximum, at zero, when the program's type and the viewer's tastes are perfectly aligned.

2.3. Broadcasters' Revenues and Costs

In the "two-market" structure of commercial television, a broadcaster's revenues are derived from selling time to advertisers. The revenue a broadcaster can receive for a program depends almost entirely on the number of viewers (the ratings) a program receives.[3] Consequently, we can view the advertising rate per ratings point (r) as being exogenously determined, and the total revenue that broadcaster i receives from airing a program as equaling rq_i, where q_i are the ratings for (the percentage of viewers watching) broadcaster i's program. Thus, consistent with market reality, a broadcaster with higher ratings will receive more revenue for a given amount (e.g., 30 seconds) of advertising time.

There are both relatively controllable and uncontrollable elements of television program quality. The relatively uncontrollable elements include such things as the likability of the underlying concept of a program and the extent to which the viewing public becomes attached to the characters portrayed in a program. For instance, a family situation comedy such as *Malcolm in the Middle* is likely to be perceived as relatively high quality if the situations portrayed in the program "ring true" with our own experiences of family life, and if we like and can relate to Malcolm and other members of his family.

While the uncontrollable elements of program quality are undeniably important, the importance of the controllable element of program quality, a program's production values, should not be underestimated, and the level of those production values are directly linked to the size of a program's budget. Barwise and Ehrenberg (1988, p. 96) clearly make this point when they state:

> Television producers can also cut costs by using fewer or cheaper production resources: fewer cameras, fewer locations, more work in the studio, fewer and lesser stars, less rehearsal, a lower allowance of film stock per minute of final output, less expert editing, and so on .... However, substantially reducing production values almost inevitably tends to reduce the appeal of the program for the viewer.

Similar arguments have been made by Jankowski and Fuchs (1995) and others.

[3] We have conducted an empirical analysis of the relationship between ratings and advertising rates for syndicated television programs. This analysis reveals that 90% of the variance in advertising rates (for a 30-second spot) can be explained by ratings levels. Confirming these empirical findings, our conversations with media buyers in one mid-size North American media market revealed that a ratings point is worth $900 per 30-second spot in that market regardless of the demographic composition of that audience. Technical Appendix 1 (see http://mktsci.pubs.informs.org) contains a more detailed summary of our empirical analysis.

While recognizing that the quality of a TV program extends beyond program cost, we believe that production value captures an important portion of a program's inherent quality. In practice, the Australian Broadcasting Tribunal (ABT) relies on program cost as a proxy for program quality (Wright 1994). Our models will thus focus on the economic aspect (i.e., the controllable elements) of program quality.

Not only is providing high-quality (i.e., high production value) programs expensive, incremental improvements in quality appear to be increasingly difficult to obtain as quality levels increase. To capture this situation, we assume that the cost-of-quality provision is quadratic in the level of quality, with parameter c_0. In this formulation, the marginal cost-of-quality provision is increasing, thus, broadcasters do not necessarily want to select a high-quality level for their programs. In addition, consistent with the literature on product positioning, we assume that the cost of providing a program of a given quality is independent of the program's "type."

By combining the revenue and cost components (and normalizing fixed costs to zero), broadcaster i's profits equal $rq^i - c_0(v^i)^2$. We can further normalize this expression by r, allowing us to write broadcaster i's profit function as[4]

$$\pi^i = q^i - c(v^i)^2. \tag{2}$$

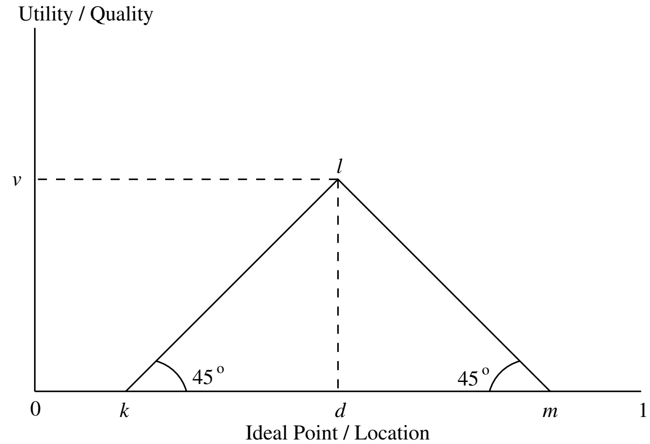
3. Analysis of the Model

In this section, we first provide an intuitive understanding of the mechanics underlying our theoretical framework, and then examine the behavior of a monopoly broadcaster. Following this, we proceed to our prime focus, the study of duopoly competition.

3.1. The Modeling Framework and Behavior of a Monopoly Broadcaster

Figure 1 illustrates the demand side of the model based on the utility structure of Equation (1). In the figure, the horizontal axis measures both the range of ideal points of viewers for a program's type (bounded within the unit interval) and the location of the monopoly broadcaster's program (point d) along the type dimension. The vertical dimension measures both the utility level that a viewer receives from viewing the monopoly broadcaster's program, and the quality level of that program (v). Viewers who have

Figure 1 **The Basic Monopoly Demand-Side Model**



ideal points located at k or m are indifferent between viewing the monopoly broadcaster's program and doing something else. Viewers with ideal points that are to the left of k or to the right of m would prefer to engage in another activity rather than viewing the program. The utility levels of viewers whose ideal points lie between k and m are traced out by the triangle klm.[5,6] The area of this triangle is equal to the total viewer surplus from the broadcaster's program. Because the distribution of viewer ideal points along the type dimension is assumed to be uniform, the distance between points k and m is equal to the monopoly broadcaster's ratings (i.e., the fraction of all potential viewers that actually view the program).

The impact of higher program-quality levels on the part of the monopoly broadcaster is examined in Figure 2. For illustrative purposes, the monopolist's location is fixed at $d = 1/2$. However, at a quality level of v, the monopolist is indifferent between any location along the type dimension between v and $1 - v$, inclusive. The monopolist would never select a location to the left of v or to the right of $1 - v$ because it would then inefficiently "overcover" the market.

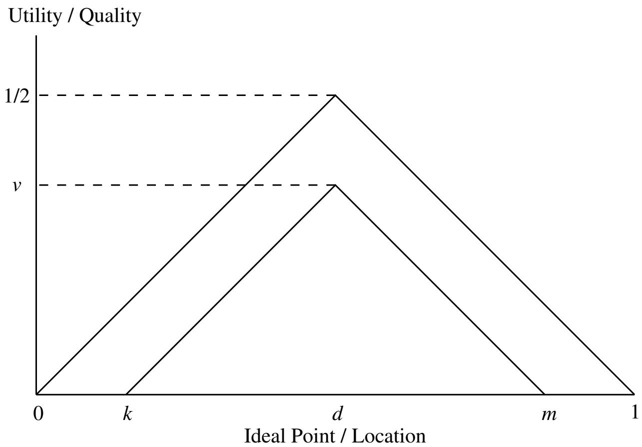
In Figure 2 a comparison is made between program-quality levels of v and $1/2$. The increase in ratings (demand) that the broadcaster receives from a quality level of $1/2$ compared to the lower quality level v is equal to the distance from 0 to k plus the distance m to 1. Both the distance 0 to k and m to 1 is equal to the distance between v and $1/2$. Thus, a given increase in quality results in twice that level of increase in demand, leading to a marginal revenue from quality increases that equals two. However, once quality levels reach $1/2$, the market is fully covered

[4] Under this normalization, c represents an "index" of the cost of quality relative to the advertising rate (i.e., $c = c_0/r$). For ease of exposition, we will refer to c simply as "the cost-of-quality provision" in the remaining sections. Note that c becomes lower when r is higher (all other things being equal). As we will see from the equilibrium results, this is likely to be the reason why U.S. commercial broadcasters, who serve a large and affluent market, are able to produce such high-quality television programming.

[5] The 45° lines kl and lm result from the use of the absolute value ideal-point term in the viewers' utility functions.

[6] We thank the area editor for suggesting the use of viewer-surplus "triangles."

Figure 2 **The Effect of Program Quality on the Monopoly Broadcaster's Ratings**



(all potential viewers are watching the monopolist's program), and any incremental increase in quality results in no additional increase in demand. In other words, the marginal revenue from quality increases becomes zero. As a result, the monopoly broadcaster will never set a quality level that is greater than 1/2.

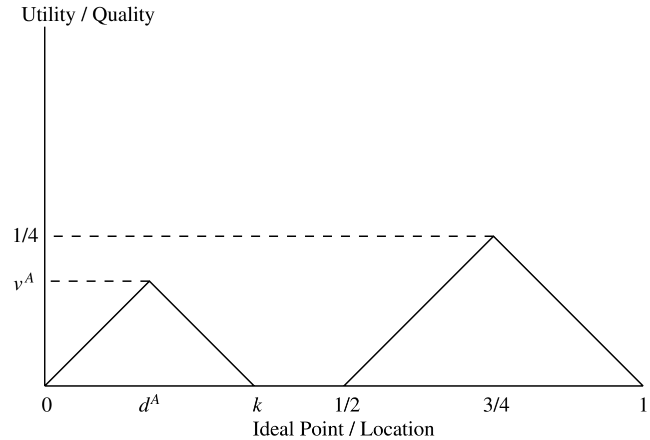
The cost structure given in (2) implies that the marginal cost-of-quality provision is $2cv$. Thus, the optimal quality level for the monopolist is $v = 1/c$.[7] The market is not fully covered when $c > 2$, and the monopolist is indifferent between choosing any location within $[1/c, 1-1/c]$. When $c \leq 2$, the monopolist locates at the center with a quality of 1/2, and the market is fully covered.

3.2. Duopoly Competitive Behavior

The equilibrium results for a competitive duopoly for all values of c are briefly summarized in §3.2.1. However, for ease of exposition, and to highlight the main substantive results, we focus on the discussion of a specific value of c ($c = 2.7$).

3.2.1. An Overview of the General Pure Strategy Duopoly Equilibrium.[8] In our analysis, we assume that each broadcaster maximizes profit by simultaneously selecting its quality level and program type. When there are two broadcasters (A and B) in the market, two exclusive cases can be distinguished—one in which there is *no competition* in the center and the other in which the duopolists directly compete. Without loss of generality, broadcaster A is assumed to be on the left-hand side of the market. In this model, both broadcasters first attempt to capture the

Figure 3 **Local Monopoly Case in a Duopoly Market**



greatest number of viewers from their "uncontested hinterlands" before competing for the "contested" demand in the market center. It is thus optimal that $d^A = v^A$ and $d^B = 1 - v^B$.

Figures 3, 4, and 5 illustrate important elements of duopoly competition. For expositional purposes, and without loss of generality, the three figures are based on fixing the second broadcaster's (broadcaster B's) quality level at 1/4, and its location at 3/4, while broadcaster A always marginally covers the left-hand side of the market. The figures focus on the demand that broadcaster A receives as it changes its quality levels. Figure 3 portrays the case where both broadcasters act as local monopolists. As with the pure monopoly case, broadcaster A's marginal revenue from increases in quality is equal to two as long as $v^A < 1/4$. If broadcaster A raises its quality level above 1/4, then it enters into direct competition with broadcaster B. The effect of this competition is to reduce the marginal revenue from quality increases beyond $v^A = 1/4$ to one.[9] Figure 4 depicts this situation. Viewers whose ideal points are in the range $[1/2, k]$ would prefer to watch either broadcaster A's or B's program, as opposed to not watching television at all. However, in contrast to the local monopoly case, where broadcaster A would obtain all viewers in this range, viewers with ideal points located in the range $[h, k]$ (half of the $[1/2, k]$ range) choose to view broadcaster B's program, thereby reducing the marginal revenue from quality increases on the part of broadcaster A from two to one.

If broadcaster A selects a quality level of 1/2, then the situation is as shown in Figure 5, in which broadcaster A weakly dominates broadcaster B. In this figure, broadcaster A is preferred by all viewers with ideal points within the range $[0, 3/4)$, while viewers in the range $[3/4, 1]$ are indifferent between the

[7] This equals r/c_0, implying that a higher advertising rate per ratings point results in higher optimal quality provision on the part of the broadcaster, all other things being equal.

[8] The detailed analysis of these equilibrium results is available in Technical Appendix 2 (see http://mktsci.pubs.informs.org).

[9] Broadcaster A's marginal revenue curve is discontinuous at $v^A = 1/4$.

Figure 4 Direct Competition in a Duopoly Market

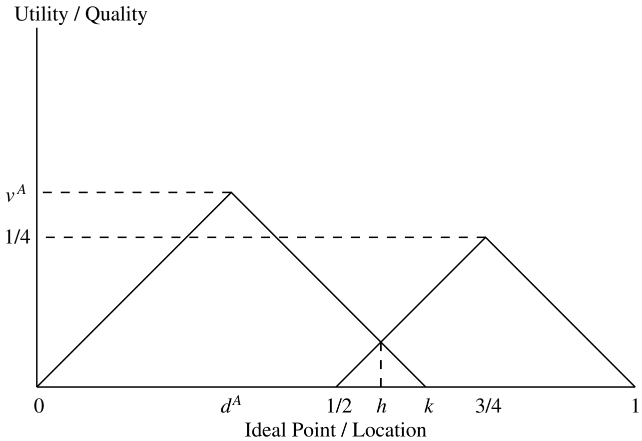
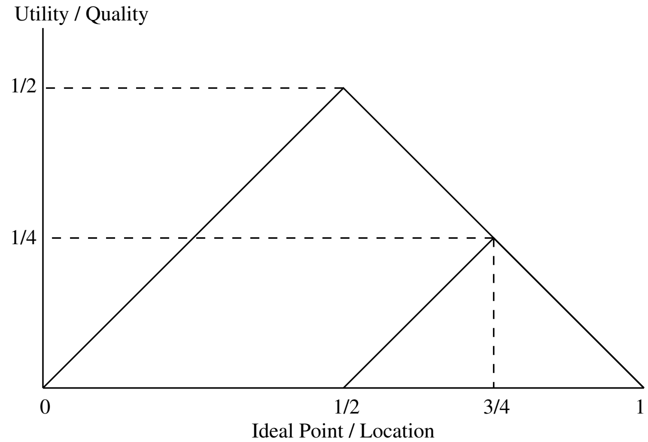


Figure 5 Broadcaster *A* Weakly Dominates Broadcaster *B*



two broadcasters. As a result, half of the viewers are expected to select broadcaster A in the $[3/4, 1]$ range. The net effect of this situation is that broadcaster A is expected to capture seven-eighths of the market, while B is expected to capture only one-eighth of the market. In addition, if broadcaster A increases its quality level by an infinitesimal amount (i.e., $v^A = 1/2+\varepsilon$), then it will capture the entire market. Because it enables broadcaster A to capture the entire market, it would be optimal for A to follow this strategy even though this would result in the market being overcovered. In order to survive, broadcaster B would then have to respond with an even higher quality level, which would result in its capturing the entire market. This situation represents a quality analogue of a price war in a Bertrand pricing game (a "quality war"). No Nash equilibrium in pure strategies exists if a quality war is initiated.[10]

To summarize, when c is comparatively low, the broadcasters can afford to provide high-quality programs that not only allow them to keep their hinterlands covered, but also aggressively compete for the market center. Indeed, when $0 \leq c < 8/3$, no pure-strategy Nash equilibrium exists as the duopolists try to drive one another out of the market by engaging in a quality war. Conversely, when it is very expensive to provide quality (i.e., $c \geq 4$), the broadcasters will be motivated to behave as local monopolists, and set $v^* = 1/c$ at equilibrium. When c is in the middle range (i.e., $8/3 \leq c < 4$), the boundary situation between local monopoly and direct competition occurs. The broadcasters provide programs with a quality level of $v^{A*} = v^{B*} = 1/4$, respectively, and their markets marginally touch each other at the center.[11] In this paper, our focus is on this case (i.e., where a pure Nash equilibrium strategy exists), and we choose $c = 2.7$ to represent this case.

3.2.2. The Duopoly Broadcaster's Optimal Positioning When $c = 2.7$. As the previous section indicates, the pure-strategy equilibrium when $c = 2.7$ is $v^{A*} = v^{B*} = 1/4$, and $d^{A*} = 1/4$ and $d^{B*} = 3/4$.[12] The two broadcasters take differentiated positions from one another along the horizontal dimension, but not to the full extent. Consequently, the absence of price competition does not automatically lead to minimum differentiation. Instead, competition on other factors, quality in this instance, can produce competitive effects similar to the market power effect. The result that broadcasters A and B differentiate ("counterprogram") is consistent with the programming strategy frequently adopted by the major television networks. These results can be summarized as follows:

Theorem 1. *In a duopoly market, television broadcasters tend to differentiate from each other and adopt a "counterprogramming" strategy.*

3.2.3. Program Quality When $c = 2.7$. A comparison of program quality between the monopoly and duopoly markets indicates that the duopolists actually provide a *lower*-quality level ($v^{A*} = v^{B*} = 1/4$) than the monopolist ($v^* = 0.37$) when $c = 2.7$.[13] This result seems counterintuitive as one might expect that

[10] In this paper, we focus on situations where an equilibrium in pure strategies exists. We leave the issue of examining the nature of the equilibrium for low values of c for future research.

[11] This "sticky" range for c in which both broadcasters set program quality at 1/4 is a result of the discontinuity in both broadcasters' quality provision marginal revenue curves.

[12] In the Appendix to this paper, we show that this is indeed an equilibrium, and that it is, in fact, a unique equilibrium.

[13] In Technical Appendix 3 (see http://mktsci.pubs.informs.org), we extend this analysis to compare quality levels provided in a triopoly market compared to a duopoly market. This analysis indicates that for certain values of c, program quality is greater under the duopoly structure vis-à-vis the triopoly structure.

with more competitors, the quality levels would be higher as a result of intensified competition. However, because providing quality television programs is costly, broadcasters make a tradeoff between the gains in viewership by increasing quality and the higher programming costs. The existence of a second competitor (as opposed to a pure monopoly) halves the marginal revenue of quality improvement once the two broadcasters directly compete, thereby discouraging them from investing in relatively high-quality levels. This result can be summarized as follows:

Theorem 2. *Having more competitors can result in each competitor offering lower-quality programs compared to when there are fewer competitors.*

Although together the "big three" networks (ABC, CBS, and NBC) still command the largest TV audience, they have seen their shares of television sets in use decline continuously since the early 1980s as a result of the increasing number of program options available (Comstock and Scharrer 1999, Table 1.1). Theorem 2 suggests that, given this changed competitive environment, the big three networks may find it optimal to decrease the costs of programming.

The recent history of the U.S. television industry is consistent with this. By the early 1990s, cable penetration (the technological enabler of increased competition) had reached 60% of U.S. households, making cable networks and FOX important competitors to the traditional three networks. In the 1991–1992 and 1992–1993 television seasons, CBS was the highest-rated network. However, in both years CBS not only did not lead the industry in profitability, but also it actually lost money—neither of which had ever occurred before in the industry's history. Jankowski and Fuchs (1995), both of whom were senior executives at CBS during this period, suggest that these losses were mainly due to spending too much on high-quality programming.

This event precipitated a shift in the competitive strategy of the three major networks. In particular, the big three had historically competed by offering increasingly more expensive (i.e., higher-quality) programming. Since the mid-1990s, they have attempted to find ways to lower programming costs. Within the context of our model, costs can be reduced by lowering program quality. However, the ability to lower quality and still produce a "watchable" program in a competitive environment is very limited. Consequently, the primary way for networks to do this is to switch to programming types which are less expensive to produce, (e.g., Barwise and Ehrenberg 1988, Jankowski and Fuchs 1995). For example, a one-hour theatrical program such as a situation comedy costs around $1.5 million to produce, while a one-hour newsmagazine costs as little as $250,000 (Vogel 1998). Indeed, from July 1996 to July 1998, ABC, CBS, NBC, CNN, and Fox more than doubled their newsmagazine airtime from a total of 26 hours per month to 63 hours in prime time (Wolf 1999). Other lower-cost program genres such as game shows and so-called "reality" programs have also become much more common in network prime time in recent years.

Another implication of Theorem 2 relates to the phenomenon of "narrowcasting." Recall that a broadcaster's market coverage (i.e., the range of viewer ideal points along the horizontal dimension captured by the broadcaster) depends upon its program quality. The lower-quality level in the duopoly market reduces the range of viewers a broadcaster can attract.

3.2.4. Viewer Welfare When $c = 2.7$. An important public policy question is whether total viewer welfare is greater in the duopoly market or the monopoly market. It is normally taken for granted that more competition is unambiguously better for consumers. However, although viewers on average receive a better match between their taste and the programs offered in the duopoly market, they can expect higher-quality levels under the monopoly. Because viewing utility depends upon both the taste dimension and the quality dimension, on average a viewer is not necessarily better-off or worse-off when a higher-quality program is provided, but the program is a greater distance from her ideal point, or vice versa.

Our model provides a natural setting to examine how viewer welfare is influenced by market structure. The total viewer surplus (TVS), which corresponds to the area of the viewer-surplus triangles in Figures 1 to 5, can be calculated for both the monopoly and duopoly markets. Specifically,

$$TVS^M = (1/2)(2)(1/2.7)^2 = 0.137$$

for the monopoly market, and

$$TVS^D = 2[(1/2)(2)(1/4)^2] = 0.125$$

for the duopoly market. In this instance (when $c = 2.7$) viewers are better-off in the monopoly market. This result, summarized in the theorem below, indicates that the higher-quality level the monopolist provides can more than offset its deficiency in program variety, and contradicts the commonly held view that more choice alternatives always make viewers better-off.[14]

Theorem 3. *The decrement in quality levels caused by having more broadcasters in the industry can be great enough to result in viewers having lower total surplus than would be the case if there were fewer broadcasters.*

[14] We also find that total viewer surplus can be higher in a duopoly market compared to a triopoly market.

One of the primary justifications for the regulation of television broadcasting is to ensure that the publicly owned broadcast frequency spectrum is used to "serve the public interest." Central to the public interest is providing viewer welfare. An assumption likely to be underlying much of the recent deregulation of television broadcasting is that allowing for a greater number of competitors is likely to result in greater viewer welfare through the provision of a larger number of viewing options. Our results indicate that this may be true only up to a certain point, after which the addition of another competitor actually reduces total viewer welfare.

4. A Two-Period Dynamic Model

The model we have analyzed so far captures monopoly and duopoly behavior in a single time slot. It illustrates the fundamental features of competition when broadcasters choose the quality and type of programs they offer and reveals the characteristics of the market equilibrium. However, it does not address a number of other important empirical features of the industry. To examine the robustness of the results derived in the previous section and to investigate the implications of these empirical features, we now extend the analysis to a dynamic setting.

One of most well-known dynamic aspects of television viewing is the so-called "lead-in effect," which refers to the tendency of a viewer to stay with the same channel across adjoining programs. The primary reason given for the existence of the lead-in effect is that watching TV is inherently a passive behavior (see, for example, Shachar and Emerson 2000). People tend to disproportionately watch temporally adjoining programs on the same channel because changing channels requires effort, even with the help of a remote control. Such effort can be physical (e.g., finding the remote control under the sofa cushions) and/or psychological (e.g., browsing through different channels and deciding which one to watch). Several empirical researchers have incorporated the lead-in effect into viewing choice models, and have shown that the effect is very significant in determining individuals' viewing behavior (e.g., Goettler and Shachar 2001, Rust and Alpert 1984, Rust and Eechambadi 1989, Shachar and Emerson 2000).

To capture the dynamics brought about by the lead-in effect, we assume that broadcasters compete over two time slots in an evening, resulting in a two-period game.[15] As is done in most empirical studies (e.g., Rust and Alpert 1984), we incorporate the lead-in effect as a transaction cost term in a viewer's utility function. The parameter α is used to capture the disutility of switching if a viewer changes channels between the first and second time periods.

We denote the first-period quality levels by v_1^A and v_1^B and those of the second period by v_2^A and v_2^B. A viewer who has her ideal point at x, and watches broadcaster A in Period 1, receives a utility level of

$$U_2^A = v_2^A - |x - d_2^A|$$

if she continues to watch broadcaster A, and a level of

$$U_2^B = v_2^B - |x - d_2^B| - \alpha$$

if she switches to broadcaster B.

One important consideration with respect to the nature of viewer behavior in a dynamic setting is whether viewers are myopic or forward-looking in their decision making. Specifically, does a viewer make her viewing choices in a sequential fashion, deciding what (or whether) to watch at the start of Period 1, and then again at the start of Period 2, or does she plan her entire evening's viewing (i.e., simultaneously selecting for both periods) before the start of Period 1? In what follows below we examine the behavior of myopic (sequential decision-making) viewers. However, we have also examined the behavior of forward-looking viewers in depth. While some of the details differ, the substantive findings are essentially identical across these two styles of viewing behavior.[16]

Because channel switching is impossible when there is only a single broadcaster, the lead-in effect as we have modeled it has no impact on the behavior of a monopolist. As a result, we will only examine broadcaster behavior in a duopoly market.

4.1. Broadcaster's Optimal, Conditional Second-Period Quality Levels

The Appendix provides a detailed analysis of the two-period myopic viewer model. This analysis involves standard backward-induction methods in which we first solve for the optimal second-period quality and location decisions conditional on each broadcaster's first-period quality level, and then solve for each broadcaster's optimal first-period quality level.

The analysis reveals that when the market is fully covered, and a Nash equilibrium in pure strategies

[15] Implicitly we assume that the start of an "evening" is the start of prime-time network programing, and viewers have their sets turned off prior to the start of prime time. While this assumption does not hold in reality, we believe that altering it would not change our substantive results. There are two reasons for this: (1) with the exception of network-owned stations, the networks have little control over what programs their affiliates broadcast just prior to prime time, and (2) a very large plurality of viewers are actually likely to switch on their sets during prime time.

[16] Details of the forward-looking viewer analysis are available in Technical Appendix 4 (see http://mktsci.pubs.informs.org).

exists, then the optimal quality level for each broadcaster's second-period program is given by

$$v_2^{A*} = 1/4 + (1/2)(v_1^A - v_1^B),$$
$$v_2^{B*} = 1/4 - (1/2)(v_1^A - v_1^B). \qquad (3)$$

There are two interesting implications associated with these optimal second-period quality levels. First, although the lead-in effect induces this particular set of equilibrium quality choices, its magnitude (as captured by α) does not influence quality levels.[17] Put another way, it is the existence of the lead-in effect that matters, not its magnitude. The second, and perhaps more important, implication is that if one broadcaster offers a program in the first period that is of higher quality relative to its rival, its optimal strategy is to offer a relatively higher-quality program in the second period as well. We summarize this second point in the following theorem.

Theorem 4. *If a broadcaster offers a program with higher quality* (*leading to higher ratings*) *relative to its rival in the first period, it should offer a program with higher-relative quality* (*and thus a more highly-rated program*) *in the second time period as well.*

This theorem not only has implications for broadcasters' scheduling decisions, it is also potentially important for empirical models of viewer behavior. In terms of scheduling, it suggests that a broadcaster with a relatively high-quality program should schedule that program to air on the same evening that it offers other relatively high-quality programs in an effort to dominate the ratings for that evening. In practice, the major networks often design their schedules to do just that. For instance, NBC has "owned" Thursday evenings for over a decade by "stacking" that evening with a succession of high-budget/high-quality "must see TV" programs. CBS followed a similar strategy on Sunday evenings for many years. In addition, empirical estimates of the lead-in effect may be upwardly biased if a network does not account for its program-quality decisions.[18]

One important caveat to the findings is that, as we will see below, the two broadcasters will want to set quality levels that are identical with one another in each period (although they both may set a different quality level in each of the two periods). However, a broadcaster's ability to do this rests on the assumption that program quality is under its complete control. As we discussed in §2.3, there are reasons to believe that this is unlikely to be the case in practice.

4.2. Broadcaster's Optimal, Unconditional First-Period Quality Levels

Through the use of (3), each broadcaster's profit can be written as a function of the quality levels set by both of them in the first period. Doing this allows for the creation of a reaction function for each broadcaster that gives its optimal quality level as a function of its rival's quality level. By equating these two reaction functions, the optimal two-period quality levels (when a pure-strategy Nash equilibrium exists and the market is fully covered) for each broadcaster are found to be

$$v_1^{A*} = v_1^{B*} = 1/c - 1/8, \qquad v_2^{A*} = v_2^{B*} = 1/4.$$

The minimum value of c that allows for the existence of a pure-strategy Nash equilibrium depends on the level of the viewer channel-changing transaction cost term α. In particular, the greater the value of α, the greater is this value of c. Below, we examine the case where $\alpha = 0.01$ in greater detail.

4.2.1. The Two-Period Sequential Equilibrium When $\alpha = 0.01$. When $\alpha = 0.01$, the value of c must be greater than 2.37 for a pure-strategy equilibrium to exist. For values of c in the range (2.37, 8/3), the two broadcasters directly compete, but the broadcasters will each offer a higher-quality program in Period 1 than they offer in Period 2. When $c \geq 8/3$, both broadcasters will offer programs of equal quality in both periods, and this quality level will be identical to the quality levels obtained in the static model. These results can be summarized as

Theorem 5. *When a Nash equilibrium in pure strategies exists and the market is fully covered, a broadcaster should never lead with a first-period program that is of a lower-quality level than its second-period program, and may find it optimal to lead with a higher-quality program in the first period.*

This theorem is consistent with the well-known "quality" lead-in strategy in which a television network places either a new program (whose true quality is unlikely to be known to the broadcaster) or a lower-rated (likely lower-quality) program after a well-established (known high-quality) program.

Theorem 5 also has implications for empirical models of viewing behavior because there is the possibility that there are unobserved (on the part of an empirical researcher) elements of program quality that will

[17] However, it does influence the range over which a pure-strategy equilibrium exists.

[18] In a recent paper, Danaher and Mawhinney (2001) have proposed developing television viewer choice models using an experimental methodology based on treatments that consist of "rescheduled" television program lineups (i.e., presenting different sets of program lineups to respondents that differ from the order in which the networks actually present those programs). They argue that this approach has advantages over using models estimated using observational data in developing optimal network schedules. Their outlook on this issue is consistent with our findings that program quality and schedule structure may be confounded with one another.

influence both the viewership for a program, and the location of that program within a broadcaster's schedule. Most of the empirical models of viewing behavior (Goettler and Shachar 2001, Rust and Alpert 1984, Rust and Eechambadi 1989, Shachar and Emerson 2000) include schedule location (e.g., 8 PM versus 8:30 PM) as an explanatory variable. However, if a program's schedule location and its viewership are both influenced by its quality level, then empirical models of viewer behavior need to account for possible simultaneous equations bias, which has not been done to date.

5. Discussion

5.1. Summary

In this study, we present a model of competitive behavior that is tailored to the institutional setting of commercial television broadcasting. Specifically, broadcasters compete by selecting the "type" of program to offer and the quality level (production values) of their program offering, but do not compete on price. The purpose of developing this model is to address the likely impacts of technological and regulatory changes in the television broadcasting industry. Nevertheless, the underlying findings on product positioning and the impact of the number of competitors on the quality of product offerings are likely to hold for a wide range of advertising-supported industries such as Web-based portal servers and media (such as radio and newspapers) that are delivered either physically or electronically.

Our theoretical model suggests that broadcasters tend to choose an intermediate level of differentiation in terms of the type of programs they provide (they "counterprogram," but not to the full extent in a given time slot). This is different from most studies of competitive positioning which find that either minimum differentiation, or maximum differentiation, or a mixture of max-min will occur (e.g., D'Aspremont et al. 1979, Hotelling 1929, Neven and Thisse 1990, Shaked and Sutton 1982, Vandenbosch and Weinberg 1995). Second, depending on the cost of quality provision, broadcasters in industries with a greater number of competitors may set lower-quality levels compared to broadcasters in industries with fewer competitors. Finally, as viewers, having more channels available does not necessarily make us better-off. As a result, broadcasting regulations designed to provide the greatest number of choices to the viewing public may not, in actual fact, be in the public interest.

In an extension of our basic model to a dynamic two-period setting that allows us to examine the impact of the well-known lead-in effect on broadcasters' programming strategy, we find that a broadcaster that offers a higher-quality program relative to its rival in the first time slot has an incentive to also offer a higher-quality program relative to competition in the second time slot, resulting in it dominating an evening from a ratings perspective. In addition, we find that a broadcaster should never offer a lower-quality program in the first time slot compared to the program in the second time slot, but may find it optimal to "lead with its best" in the first period.

5.2. Future Research Directions

We conclude by highlighting several areas that are in our view in particular need of further research. First, as we indicated earlier, relaxing the assumption that each broadcaster has only a single "channel" is likely to lead to a number of additional interesting insights. Multioutlet ownership is on the rise in the industry. For example, General Electric/NBC owns, or partially owns, outlets such as NBC, MSNBC, CNBC, and PAX. We believe that such a study may provide important public policy implications concerning media ownership. Specifically, our intuition at this point is that a broadcaster will find it optimal to offer several different outlets, with the exact number of outlets determined by the broadcaster trading off the fixed costs associated with opening a new outlet versus increasing the quality level of programming on existing outlets. From the perspective of our graphical presentation in Figures 1 to 5, the effect of allowing for multiple outlet ownership is to create a number of relatively small viewer-surplus triangles, which have a smaller total area than would a lesser number of relatively large viewer-surplus triangles. As a result, we speculate that allowing for multiple outlet ownership may have an important adverse influence on viewer welfare. More generally, the question arises as to under what circumstances people are potentially worse-off when they have more rather than fewer choices.

The second area that may be worthwhile examining is the implications of uncertainty in developing broadcasters' programming strategies. There are at least three sources of uncertainty that should be considered: (1) uncertainty about the true quality of a broadcaster's own program prior to the debut of that program; (2) uncertainty about the true quality of a competitor's program prior to its debut; and (3) uncertainty about program quality on the part of at least a proportion of potential viewers that results from incomplete information. While program costs (production values) are highly correlated with program quality, that correlation is not perfect. Moreover, it is our belief that while a broadcaster will know the cost of its own programs, and have very good estimates of its competitors' program costs, viewers will largely be ignorant of this information.

Third, our analysis has focused solely on broadcasters following the traditional business model of relying almost exclusively on sales of advertising time as their revenue source. While this business model is still by far the dominant model in the industry based on ratings and revenues, other models based on fixed fees (used by HBO, Cinemax, and others) and purely variable fees (pay-per-view) are also used. One ironic turn of events is that while the percentage of programming on the traditional big three networks that is made up of comparatively expensive theatrical programs such as dramas and situation comedies has diminished since the early 1990s, the emphasis that HBO has placed on this type of programming (through such original HBO programs as the *Sopranos*, *Sex in the City*, and *Six Feet Under*) has greatly expanded over the same time period. Conversely, while pay-per-view television has existed for quite some time, its history has been more one of failure rather than success, and its fate is still under debate in the industry (Jankowski and Fuchs 1995). One of the most disastrous examples is NBC's attempt to provide selected events of the 1992 Barcelona Summer Olympic Games through pay-per-view. Given these different business models and their apparent different levels of success, an important area of future research (both for the television industry and for Web-based media outlets) is to look at the nature of competition and long-run equilibrium when firms using different business models compete with one another.[19]

Finally, our results suggest two different avenues for future empirical research. The first relates to the development of viewing-choice models intended to improve television scheduling decisions. We show that program quality is likely to have a direct effect on broadcasters' scheduling decisions, while it should also influence viewers' choices. Because program quality is unlikely to be fully observable by researchers developing these models, the possibility that they suffer from simultaneous equations bias looms large. As a result, there is a need to investigate the extent to which this is an issue (the work of Danaher and Mawhinney 2001 suggests it may well be a significant problem) and to develop an appropriate set of instruments to address the problem if necessary. A second promising area of empirical research is to develop a new empirical industrial organization model of the television industry to investigate a number of the testable hypotheses that emerge from our findings.

[19] A recent study by Danaher (2002) examines the issue of the use of a fixed access fee versus a usage fee in determining optimal profits for a subscription service, and may help shed some light on the most advantageous revenue model for subscription-based television services.

Acknowledgments

The authors gratefully thank the editor, the area editor, and two anonymous reviewers for their helpful comments.

Appendix

Market Equilibrium When $c = 2.7$

To show that $v^A = d^A = 1/4$, $v^B = 1/4$, and $d^B = 3/4$ represent equilibrium values when $c = 2.7$, we fix broadcaster B at $v^B = 1/4$ and $d^B = 3/4$, and show that broadcaster A does not have an incentive to unilaterally leave $v^A = d^A = 1/4$. A nearly identical approach can be used to show that broadcaster B has no incentive to unilaterally move when broadcaster A sets $v^A = d^A = 1/4$.

Broadcaster A has two options when leaving $v^A = d^A = 1/4$; it can either increase v^A by a positive amount ε and move to $d^A = 1/4 + \varepsilon$, or decrease v^A by ε, and move to $d^A = 1/4 - \varepsilon$. At their initial positions, the two broadcasters touch each other in the center with their respective hinterlands marginally covered, and both receiving half of all viewers. At this point broadcaster A's profits are $\pi^4 = 1/2 - 2.7(1/4)^2 = 0.332$. If broadcaster A increases quality, then the indifferent viewer locates at $x^+ = [(1/4+\varepsilon) - 1/4 + 1/4+\varepsilon+3/4]/2 = 1/2+\varepsilon$. Broadcaster A's rating then equals $1/2+\varepsilon$, and its profits are

$$\begin{aligned}\pi^{A+} &= 1/2+\varepsilon - 2.7(1/4+\varepsilon)^2\\ &= 0.332 - \varepsilon(0.35+2.7\varepsilon).\end{aligned}$$

Because $\varepsilon(0.35+2.7\varepsilon) > 0$ for $\varepsilon > 0$, $\pi^A > \pi^{A+}$, and broadcaster A has no incentive to increase its quality. On the other hand, if v^A is decreased by ε, then broadcaster A obtains a profit of

$$\begin{aligned}\pi^{A-} &= 2(1/4-\varepsilon) - 2.7(1/4-\varepsilon)^2\\ &= 0.332 - \varepsilon(0.65+2.7\varepsilon).\end{aligned}$$

Again $\pi^A > \pi^{A-}$, and broadcaster A will not decrease its quality either. Consequently, broadcaster A has no incentive to unilaterally move away from $v^A = d^A = 1/4$.

It can be shown that the profit function of broadcaster A at different locations and quality levels is strictly concave. Thus, based on the findings of Rosen (1965), the pure-strategy equilibrium $v^A = d^A = 1/4$, $v^B = 1/4$, and $d^B = 3/4$ is unique. □

Duopoly Competition When Viewers Are Myopic

The Optimal Second-Period Quality Levels Conditional on the First-Period Quality Levels[20]

The location of the indifferent viewer in the second period allows us to determine the equilibrium-quality levels in this period. As a result of the cost of switching channels (α), the location of the indifferent viewer in Period 2 ($\bar{x}_2$) for a given level v_2^A and v_2^B depends upon the levels of v_1^A and v_1^B, and thus the location of the indifferent viewer in Period 1 ($\bar{x}_1$). Specifically, three distinct cases exist: (1) the indifference point in Period 2 is to the right of the indifference point

[20] As discussed in §4.1, our analysis is based on values of α and c for which a pure-strategy equilibrium exists.

in Period 1 (i.e., $\bar{x}_2 > \bar{x}_1$); (2) the second-period indifference point is to the left of the indifference point in the first period (i.e., $\bar{x}_2 < \bar{x}_1$); and (3) the indifference points is in the same location in both periods (i.e., $\bar{x}_2 = \bar{x}_1$).

If $\bar{x}_2 > \bar{x}_1$, then broadcaster A gains additional ratings in Period 2 compared to Period 1, and we can solve for $\bar{x}_2$ using the equality

$$v_2^A - |\bar{x}_2 - d_2^A| - \alpha = v_2^B - |\bar{x}_2 - d_2^B|,$$

which leads to

$$\bar{x}_2 = v_2^A - v_2^B + \frac{1-\alpha}{2}.$$

As compared to $\bar{x}_1$, the presence of the lead-in effect reduces broadcaster A's potential gain in audience from quality improvement. Some viewers ($\alpha/2$) do not switch to A, but remain with B as a result of the lead-in effect. When $\bar{x}_2 < \bar{x}_1$ (causing broadcaster A to lose ratings), it is the case that $\bar{x}_2 = v_2^A - v_2^B + (1+\alpha)/2$. Thus, the lead-in effect mitigates the loss of broadcaster A's ratings by the amount $\alpha/2$ that would have occurred in the absence of this effect for a given level of v_2^A and v_2^B. Finally, there is no change in demand if $\bar{x}_2 = \bar{x}_1$.

To determine the actual quality decisions made by the two broadcasters for the three potential cases describing the relative locations of the indifferent viewer in the two time periods, we first examine the range of quality choices on the part of broadcaster A for a given level of v_2^B that makes it possible for a particular case to hold. Specifically, in order for $\bar{x}_2 < \bar{x}_1$, it must be the case that $v_2^A < v_2^B + \Delta v_1 - \alpha/2$, where $\Delta v_1 = v_1^A - v_1^B$. Similarly, for $\bar{x}_2 > \bar{x}_1$, then $v_2^A > v_2^B + \Delta v_1 + \alpha/2$. Finally, for $\bar{x}_2 = \bar{x}_1$, then $v_2^B + \Delta v_1 - \alpha/2 \le v_2^A \le v_2^B + \Delta v_1 + \alpha/2$. The values of v_2^B that allow each of the three cases to hold for a fixed level of v_2^A can be determined in a symmetric fashion.

In the first two cases (i.e., $\bar{x}_2 > \bar{x}_1$ and $\bar{x}_2 < \bar{x}_1$), a broadcaster's marginal revenue from quality changes equals one, which is the same as in the static model, but is lower than the marginal revenue from first-period quality changes because changes in the first period have consequences in both periods due to the lead-in effect. In the third case, the marginal revenue from quality changes in the second period equals zero. Given that the marginal revenue of quality is lower in Period 2 compared to Period 1, it is never optimal for broadcaster A to be in a situation where $\bar{x}_2 > \bar{x}_1$. Similarly, it will never be optimal for broadcaster B to be in a situation where $\bar{x}_2 < \bar{x}_1$. The interaction between the duopolists is such that they lower Period 2 quality levels with $\bar{x}_2 = \bar{x}_1$ at equilibrium.[21] Both broadcasters face a range of quality levels that will allow them to hold the indifference point fixed between the two periods. The lowest level of quality each broadcaster can choose to maintain the indifference point is

$$v_2^{A*} = \frac{\bar{x}_1}{2} = \frac{1}{4} + \frac{1}{2}\Delta v_1$$

and

$$v_2^{B*} = \frac{1-\bar{x}_1}{2} = \frac{1}{4} - \frac{1}{2}\Delta v_1.$$

This is an equilibrium if neither broadcaster has an incentive to unilaterally change its quality level from this point. We can determine whether broadcaster A has an incentive to unilaterally move by holding broadcaster B's quality level at v_2^{B*}, and then examining whether A can increase its profits by changing its quality level from v_2^{A*}. We can determine if broadcaster B has an incentive to unilaterally move its quality level from v_2^{B*} in an identical fashion.

When broadcaster A sets its quality level at $v_2^A = v_2^{A*}$, it earns a profit of

$$\pi_2^{A*} = \bar{x}_1 - c(v_2^{A*})^2 = \frac{1}{2} + \Delta v_1 - c\left(\frac{1}{4} + \frac{1}{2}\Delta v_1\right)^2.$$

It can deviate from v_2^{A*} by either decreasing or increasing v_2^A. If it reduces its quality level (i.e., $v_2^A < v_2^{A*}$), the markets of the two broadcasters will separate and broadcaster A is a local monopoly. Thus, its profit will be

$$\pi_2^{A-} = 2v_2^A - c(v_2^A)^2,$$

and results in a profit change that equals $\Delta\pi_2^{A-} = \pi_2^{A*} - \pi_2^{A-} = 1/2 + \Delta v_1 - c(1/4 + \Delta v_1/2)^2 - 2v_2^A + c(v_2^A)^2$. Solving for $\Delta\pi_2^{A-} = 0$ leads to two roots for v_2^A,

$$v_2^A[1] = \frac{4 + \sqrt{16 - 8c - 4c^2\Delta v_1 - 4c^2(\Delta v_1)^2 - 16c\Delta v_1 - c^2}}{4c}$$

and

$$v_2^A[2] = \frac{4 - \sqrt{16 - 8c - 4c^2\Delta v_1 - 4c^2(\Delta v_1)^2 - 16c\Delta v_1 - c^2}}{4c}.$$

Through some algebraic manipulation, it can be shown that $v_2^{A*} < v_2^A[2]$, and therefore any v_2^A less than v_2^{A*} will result in $\Delta\pi_2^{A-} > 0$. Thus, broadcaster A will not unilaterally lower its quality below v_2^{A*}.

If broadcaster A increases v_2^A to a level higher than v_2^{A*}, two separate cases can occur. In the first case, if v_2^A is greater than v_2^{A*}, but less than $v_2^{A*} + \alpha/2$, its demand does not change as a result of the lead-in effect. Therefore, small increases are not profitable. In the second case (i.e., v_2^A is set greater than $v_2^{A*} + \alpha/2$), broadcaster A will capture additional demand from broadcaster B, but with a fixed percentage of viewers remaining with B due to the lead-in effect. Broadcaster A's profits in this case are equal to

$$\begin{aligned}\pi_2^{A+} &= v_2^A - v_2^{B*} + \frac{1-\alpha}{2} - c(v_2^A)^2 \\ &= v_2^A + \frac{1}{4} - \frac{\alpha}{2} + \frac{1}{2}\Delta v_1 - c(v_2^A)^2.\end{aligned}$$

Again, solving $\Delta\pi_2^{A+} = \pi_2^{A*} - \pi_2^{A+}$ leads to two roots for v_2^A. It is then possible to show that $v_2^{A*} + \alpha/2$ is greater than the larger root. Therefore, any v_2^A greater than $v_2^{A*} + \alpha/2$

[21] The tendency for each broadcaster to decrease quality while keeping $\bar{x}_2 = \bar{x}_1$ can also be derived from the quality reaction functions, which are $v_2^{A*}(v_2^B) = v_2^B + \Delta v_1 - \alpha/2$ and $v_2^{B*}(v_2^A) = v_2^A - \Delta v_1 - \alpha/2$. When plotted in two dimensions with v_2^A on the vertical axis and v_2^B on the horizontal axis, the reaction sequence will be such that quality levels keep decreasing because the curve $v_2^{B*}(v_2^A)$ is always α higher than $v_2^{A*}(v_2^B)$

will result in $\Delta\pi_2^{A+} > 0$. Consequently, broadcaster A has no incentive to unilaterally move from v_2^{A*}. $\square$

The Unconditional First- and Second-Period Quality Levels

Having determined the second-period quality level choices as functions of first-period quality levels, we can write each broadcasters' two-period profit equation as a function of the first-period quality levels. Doing this for broadcaster A leads to the two-period profit equation

$$\begin{aligned}\Sigma\pi^A &= \pi_1^A + \pi_2^A \\ &= \left(\frac{1}{2} + v_1^A - v_1^B\right) - c(v_1^A)^2 + \left(\frac{1}{2} + v_1^A - v_1^B\right) \\ &\quad - c\left(\frac{1}{4} + \frac{1}{2}v_1^A - \frac{1}{2}v_1^B\right)^2.\end{aligned}$$

Based on the first-order condition for profit maximization ($\partial\Sigma\pi^A/\partial v_1^A = 0$), broadcaster A's reaction function is given by

$$v_1^{A*}(v_1^B) = \frac{8 - c + 2cv_1^B}{10c}.$$

Broadcaster B's reaction function, $v_1^{B*}(v_1^A)$, can be determined in a symmetric fashion. If a pure-strategy Nash equilibrium exists (and the market is fully covered in equilibrium), the equilibrium quality levels in Period 1 (and thus the Period 2 equilibrium quality levels) can be found by equating the two broadcasters' reaction functions. Doing this results in the sequential equilibrium

$$v_1^{A*} = v_1^{B*} = \frac{1}{c} - \frac{1}{8}, \quad v_2^{A*} = v_2^{B*} = \frac{1}{4}. \quad \square$$

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