Beyond the Spectrum Constraint: Concentration and Entry in the Broadcasting Industry

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Abstract

The broadcasting industry is still very concentrated all over the world, after 15 years in which new technologies and public policies allowed to overcome the constraint of limited availability of frequencies on the radio spectrum. We argue that the monopolistic competition set up, traditionally used to analyze the broadcasting industry, does not fit the empirical evidence. Instead we analyze the free entry equilibrium in a multistage game in which the decision on program quality (attractiveness) is crucial and the associated fixed costs are endogenously determined. We show that concentration might arise in the long run even in large markets despite entry is free.

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1 Introduction

Up to the Seventies, the broadcasting industry was dominated in each country by few national over-the-air networks: in most cases they were state-owned, with the notable exception of the United States. The uniform picture was that of a very concentrated industry all over the world. The traditional explanation referred to the so called *spectrum constraint*: the broadcast signals were delivered over-the-air from terrestrial transmitters for reception by individual homes. The frequencies available on the radio spectrum were limited, restricting the number of television channels that might be transmitted over-the-air. Therefore, the very high industry concentration was determined by a technological constraint.

During the last 15 years, alternative technological solutions have developed in order to overcome the spectrum constraint: cable and satellite broadcasting, often combined, have offered new entry opportunities in the industry, while the development of digital technologies in the over-the-air transmission will multiply in the early future the number of signals that can be delivered on the radio spectrum. In some countries, as the United States, Canada, Germany and Japan, a relevant percentage of households is cabled; in the UK and Japan direct satellite broadcasting services are well developed; in other cases scrambled over-the-air transmission allowed to introduce pay-TV services within the traditional broadcasting support.

The pattern of industrial structures is now much more diversified than two decades ago, and a very active role of private firms has emerged both in the traditional over-the-air transmission and in alternative broadcasting supports. In Europe and Japan private commercial broadcasters now compete on equal grounds with the long-standing state-owned networks. In the United States cable TVs have partially eroded the dominant position of the three commercial networks: the new scenario that tends to emerge is a dual market structure, with the major networks still maintaining a large share of the audience and the residual viewers spread over a huge number of small channels.

Another interesting piece of evidence that springs out of the US experience, where heterogeneous operators compete in the same market, refers to the different importance of the costs related to the production of programmes and the purchase of transmission rights. This component becomes extremely important for the more popular channels, covering up to 3/4 of the budget, while it is much less relevant for small operators.

The intense entry process of the last two decades has undoubtly led to a decrease in concentration. A crucial question, which is relevant also from a policy perspective [1], is whether this process will continue over time with a progressive fragmentation of the industry, or whether there exist reasons that will help a small number ot operators to maintain their market dominance. The aim of this paper is to offer new insight on the determinants of market structure in the long run in the broadcasting industry.

The way in which we model market competition is crucial to construct our predictions. The monopolistic competition and horizontal differentiation approach has been tradition-

[1] On public policy in the broadcasting industry see OECD (1993) and Motta and Polo (1997).

ally applied to the broadcasting industry: the associated view of the long run market structure would suggest a very fragmented industry with no dominant TV-channel. However, we argue that horizontal product differentiation captures only part of the story, and that the monopolistic competition model does not fit some of the evidence that *today* is characterizing the industry both in terms of market and cost structure. In particular, the patters of programming costs associated with the success of a TV-channel seems to suggest an important role of investments in the attractiveness of programmes. This important feature of the industry is better expressed in terms of vertical product differentiation.

A richer modelling of the broadcasting market requires therefore to combine horizontal and vertical differentiation, an approach that, to the best of our knowledge, has not been developed in the literature on this industry. The two main elements of our analysis are related to programming. The most relevant strategic tool in this perspective is identified in the design of the program schedules, by which (horizontally differentiated) TV-channels can improve their audience and consequently the willingness to pay of advertisers. However, improving the program schedule requires higher fixed costs, related to the production and/or acquisition of better (more popular) programs.

Our analysis is reminiscent of the endogenous sunk cost paradigm proposed by Sutton (1991) to explain patterns of persistent concentration in food and beveradge industries: successful, dominant firms have higher fixed costs, related to their effort to maintain and strengthen their market position; larger markets, ensuring higher gross profits to the dominant firms, determine an increase in their efforts for leadership but at the same time in the related fixed costs. The main result of this literature, known as the Finiteness Property, states that the number of firms does not depend on market size, but can be explained according to the distribution of the willingness to pay and the shape of the fixed costs associated to quality improvements[2].

In our setting, the number of firms sustainable in a free entry equilibrium becomes independent of the market size as the market becomes larger and larger, as occurs according to the Finiteness Property. Concentration in this limiting case is determined only by the degree of (horizontal) differentiation among TV-channels, a higher differentiation being consistent with a more fragmented structure[3] Hence, the free entry equilibrium may be consistent with a very fragmented structure if the TV-channels specialize in different programme types. But it also shares some features of the Finiteness Property: in particular, concentration might arise despite free entry as the long run equilibrium if TV firms choose relatively similar programme schedules, attracted by viewers' bias toward a limited number of program types.

The paper is organized as follows: section 2 presents some stylized facts on the broadcast industry in the main developed countries; in section 3 we set up a model with private, advertising financed, TV firms; the equilibrium is analyzed and discussed in

[2] See Shaked and Sutton (1982) and (1983) and Sutton (1991).

[3] This characterization of the equilibrium number of firms in terms of horizontal product differentiation seems new with respect to the existing literature on the Finiteness Property.

section 4. Section 5 concludes the paper.

2 Concentration in the broadcasting industry: some international evidence

Table 1 presents some data on market dimension and industry structure for the largest European countries - France, Germany, Italy, Spain and United Kingdom - the United States, Canada and Japan.

The first two rows show the potential dimension of the market in terms of viewers and advertising investment[4]. Three groups of countries can be identified according to both measures of market size: the largest - US and Japan - an intermediate group - Germany, UK, Italy and France - and two smaller countries - Spain and Canada. While considering only the main developed countries, our sample presents a very significant range of values, i.e. a range of very different market sizes.

Table 1: Concentration in the broadcasting industry 1992-93

	F	**D**	**I**	**E**	**UK**	**J**	**USA**	**CAN**
(1)	20448	31860	20304	11350	22088	42500	93053	9993
(2)	2674	3127	3882	2127	4247	14300	29375	1459
(3)	6.4	43.9	0	6.6	3.8	21.9	61.8	80.0
(4)	1.6	10	0	1.3	13.6	16.3	4.8	5.1
(5)	91	73	69	89	94	77	70	n.a.
(6)	80	60	93	78	83	40	39	n.a.

(1): TV households (x 1000); (2): TV ads expenditures (million \$); (3): Subscribers/Cabled households (%); (4): Satellite households/TV households (%); (5): Concentration ratio C_4 (audience by channel); (6): Concentration ratio C_2 (audience by group).

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Sources: TBI Yearbook 1994, The Media Map 1994

The penetration of distribution supports alternative to the over-the-air broadcasting one are shown in rows 3 and 4 for cable and satellite: although the picture is very different from country to country, in Germany, Japan, US and Canada cable TV services are chosen by a very large percentage of potential subscribers; direct satellite distribution is still relatively limited, probably due to the cost of the reception equipment for private viewers.

[4]These two variables are typically used to determine market size and the corresponding fees in international transmission rights contracts for television programs.

Finally, the last two rows show the concentration ratios for the industry in terms of audience [5] computed by taking the first four channels (row 5) and the first two firms (row 6). It is convenient to present both measures because the natural index for concentration - aggregate market share of the first *n firms* - is strongly influenced from country to country by the regulatory environment and the ceilings on ownership and multi-licences; on the other hand, the aggregate share of the first *n channels*, although not immune from regulatory influences, tends to reflect more closely the number of products sustainable in the market and therefore the economic tendency towards concentration.

Concentration by channel is extremely high in all countries, showing that a small number of programs is chosen by most viewers; moreover, even if a certain increase in concentration can be identified moving from larger to smaller countries, this pattern is not very pronounced[6]. Concentration by television group (firm) is particularly high in Europe, due to the role of public and private multichannel TV firms.

The changing environment of the broadcast industry can be further illustrated by referring to the United States case: until the late Seventies the three major commercial networks reached a 90 per cent viewing audience; the expansion of cable systems in the last fifteen years and the emergence of a fourth over-the-air national network[7] have partially eroded this dominant position. The over 100 cable system operators today in the market offer a very high number of channels to their subscribers in basic and premium packages[8], including the over-the-air networks program schedules. However, if we compute the audience of the cable systems net of the programs of the over-the-air networks, their importance is relatively limited [9], with an aggregate audience of around 25%, slightly above that of a single over the air network. The combined national advertising revenues - around $ 2.3 billion in 1994 - is far below the 10.9 $ billions of the four major networks [10].

The slight decrease in concentration experienced in the last decade in the major countries, taking the US as the leading case, suggests the emergence of a dual structure, where the major TV-broadcasters remain very few while many small operators fill the

[5] While audience is not the only relevant variable for industry analysis, it is probably the one which is less influenced by the different ways of financing of the broadcasting firms - public funds, advertising, subscription fees and several combination of these. Moreover, the audience distribution is the most important element of industry performance for public policy issues.

[6] Germany and Italy, which can be considered medium size markets, have a relatively low concentration ratio - in terms of the first four channels - as compared to the other European countries. The critical role of multichannel broadcasters in these two countries could explain this pattern.

[7] More recently two new over-the-air networks, United Paramount's UPN and Warner Bros' WB entered.

[8] The penetration ratio (subscribers/cable households) of basic packages in 1994 was 65.2% while that of premium services was 28.1%. The packages offered seem to be very similar: the 15 more popular programming services are offered by almost all the cable system operators - see FCC (1995), appendix H, tab.6.

[9] In cable homes around 2/3 of the viewing time is spent watching programs originating from the major over-the-air networks.

[10] On the situation in the US market see FCC (1995).

market niches. The main effect of entry in the broadcast industry seems a strong increase in the variety of programs *available* to the households, but not a corresponding diversification in the *actual choices* of the viewers.

A further piece of evidence which is useful in motivating our approach is related to the cost structure of TV firms. Although reliable and comparable data on costs are not available for TV firms across countries, some evidence from the US market suggests that the cost structure varies considerably across different types of TV operators. In particular, the share of costs for programming, including home production and purchase of transmission rights, seems crucially related to the success of the firm in terms of audience. In the US market, programming costs reached in 1993 74% of the balance sheet in a typical television network, 33% for cable system operators and only 23% for the local programming of television stations[11]. This ranking corresponds to the relative audience of these types of operators, very large for networks, lower for cable operators and local for TV stations. Hence, it seems that the share of programming costs increases sharply with the audience.

3 Advertising-financed TV channels: a model

The broadcasting industry has been traditionally considered a good example of monopolistic competition [12] or horizontal product differentiation of the Hotelling type: TV firms design their program schedule by choosing their variety, attracting the viewers according to their heterogeneous tastes and segmenting the market. Unfortunately, the stylized facts we briefly described, namely a very weak relation between market size and market concentration, and a strong correlation between fixed costs and firm's performance, do not match the basic predictions of those models[13]. Therefore we propose an alternative specification, by focussing on a different dimension in the competition for audience among TV firms, the perceived quality (popularity) of programs.

Modelling the TV sector requires to consider three classes of agents, the TV viewers, the advertisers and the TV firms. The first type of agents decide whether to watch a TV programme and which channel to patronize, determining the audience distribution. The willingness to pay of advertisers for advertising airtime increases with the audience. Finally, the TV firms influence the decisions of the other two groups in two ways: through the design of the program schedule, which attracts the viewers and determines the value of the advertising time; through the amount of advertising time within the programs broadcasted, which influences positively the revenues but discourages the viewers, reducing the value of the advertising slots.

[11] See Veronis et al. (1994). By local programming we refer to the program schedule of a local TV station when it does not broadcast programs of the affiliated network.

[12] See, for axample, Spence and Owen (1977).

[13] In horizontal differentiation models we expect a decrease in concentration (an increase in the number of firms) as the market size grows, and fixed costs unaffected by the variety chosen.

This complex interaction will be analyzed in a multistage game according to the following timing of moves: the TV firms decide initially and simultaneously whether to enter or not the industry; then, being the number n of active firms public information, they choose the quality of their programs $\{q_i\}$; thirdly they select the amount of advertising slots $\{a_i\}$ given the quality of the programs, anticipating the effect of both the quality q_i and the advertising slots a_i on the audience A_i and therefore on the demand for advertising by the other firms in the economy. The latter choose the amount of advertising slots bought on the n TVs and finally the TV viewers watch their preferred (if any) programs.

According to backward induction, we consider initially the choice of the first two groups, the viewers and the advertisers, moving then to the more complex analysis of the strategies of the TV firms.

Viewers' choice: the audience function

The allocation of TV viewers among the n TV channels is summarized by an audience function which depends on the type of programs and on the amount of advertising slots broadcasted by the n TV firms. The viewers react positively to the quality of the programs and negatively to the amount of advertising slots; moreover, they consider the different TV channels as imperfect substitutes, with an own effect greater than the cross ones. We adopt the following linear specification

$$A_i = \delta \cdot \left[\alpha(n) + \beta(n) \left(\theta q_i - a_i \right) - \gamma(n) \sum_{j \neq i} \left(\theta q_j - a_j \right) \right] \tag{1}$$

with $\beta(n) \geq (n-1)\gamma(n) \geq 0$ and $\alpha \leq 1/n$; θ measures the marginal impact of program quality q_i, δ, a scale parameter, measures the size of the population of viewers; A_i is TV-channel i's audience, and a_i is the amount of advertising slots of TV-channel i. Notice that each channel competes with all the others on symmetric grounds, with no localized effect.

Contrary to the previous formal literature on the broadcasting industry, we consider the variety of TV-channels as an exogenous variable, and focus on the quality decisions of firms. We use the term quality as referred to the ability of any type of program to increase the audience; the complementary dimension of program's variety, which is implicitly given by the direct and cross effects $\beta(n)$ and $\gamma(n)$ in the audience function, pertains to the particular type of program broadcasted. Therefore we can have different varieties as sport or movies and, for each of them, a program which is able to attract a large or small portion of viewers, as the Superbowl vs. a minor league match or Jurassic Park vs. a dinosaurs B-movie with very poor special effects. Notice that even if several broadcasters offer similar programme schedules, they can still maintain some limited degree of (horizontal) differentiation through the design of the time schedule of programmes, i.e. avoiding to broadcast a movie at the same time of a rival.

Equation (1) can be obtained from different models of viewers' behaviour: an example derived from a viewers's discrete choice model is presented in the appendix We prefer, however, not to restrict ourselves to a specific model of viewers' choice, since our results can be proved for a wide class of *linear* functions that meet mild restrictions on the parameters. In general the parameters $\alpha(n)$, $\beta(n)$ and $\gamma(n)$ are related to the number of firms n, and can be specified in different ways according to different models of individual viewers' behaviour [14]. Some general restrictions can be set for this family of functions; the aggregate share of active viewers is $\sum A_i/\delta = n\alpha + (\beta - (n-1)\gamma)\sum(\theta q_i - a_i) \leq 1$. When the own effect is greater than the sum of the cross effects, i.e. $\beta \geq (n-1)\gamma$, $(\theta q_i - a_i) > 0$ implies $\alpha < 1/n$. Moreover, a more attractive programming makes some new viewers entering the market in addition to those who shift from the other channels, and total viewership increases [15]. Conversely, when $\sum A_i = \delta$ all the potential viewers watch a TV-channel[16], which implies $\beta = (n-1)\gamma$ and $\alpha = 1/n$, i.e. an increase in audience can be realized only by subtracting viewers from the other channels.

To simplify notation, we initially refer to those parameters simply as α, β and γ; their relation to the number of firms will be explicitly consider in the analysis of the entry stage, in which the number of firms will be determined.

Advertisers' choice: the demand for advertising time

The next step requires to derive the demand for advertising slots by the firms in the economy. Since our focus is on the TV sector we simplify this analysis, assuming strong symmetry conditions among non-TV firms that enable us to obtain simple aggregate relations. We require the demand for advertising to have three properties which seem empirically appealing: advertising has diminishing returns; it diminishes rival firms' demand; these strategic effects tend to decrease as the number of advertisers increases[17].

All these properties are satisfied by the following, admittedly simple, specification. The demand for the product sold by an advertiser k ($k = 1, .., K$), besides the usual price effect, is assumed to depend, through a multiplicative demand enhancing effect parameterized by $\psi \ll 1$, on the number of times the advertising message is viewed, that is on $\sum_i a_i^k \cdot A_i$, where a_i^k is the amount of advertising of firm k on TV i. Notice that advertising has a decreasing marginal effect on demand deriving from the induced

[14]Linear demand systems as the one adopted for the audience function can be obtained from three different models of individual behaviour: the representative agent, the address and the discrete choice approaches. The relations among these three models is further analyzed in Polo (1997).

[15]Alternatively, the total viewing time of the representative viewer increases, subtracting time to other leisure activities.

[16]Alternatively, the representative viewer spends all the leisure time watching TV programmes.

[17]Advertisers are implicitly assumed to operate in a monopolistically competitive market; therefore we consider advertising firms offering a generic consumer good which is an imperfect substitute of the products offered by the other advertisers, and which is potentially purchased by a typical viewer. We rule out for simplicity localized effects among advertisers, as those among producers of music equipment, whose advertising expenditures poorly influence the demand for food and beveradge, and which are particularly interested in the audience of music events and programmes.

reduction in the audience. The demand D^k of advertiser k is therefore:

$$D^k(p,a) = d^k(p) \cdot \psi \cdot \sum_{i=1}^{n} a_i^k A_i$$

where $d^k(p)$ shows the price effects at the individual level and ψ measures the impact of advertisings messages on individual demand[18]. The profit function of an advertiser is therefore:

$$\Pi^k = (p^k - c^k) \cdot d^k(p) \cdot \psi \cdot \sum_{i=1}^{n} a_i^k A_i - \sum_{i=1}^{n} p_i a_i^k$$

where p_i is the unit price of advertising on TV-channel i. From firm k's first order conditions it can be easily checked that the final product price p^k does not depend on the total amount of advertising a^k [19]; the optimal amount of advertising a_i^k on TV-channel i can be written as:

$$(p^k - c^k) d^k(p) \delta \psi \left\{ \alpha + \theta[\beta q_i - \gamma \sum_{j \neq i} q_j] - \beta[\sum_{l \neq k} a_i^l + 2a_i^k] + \gamma[\sum_{j \neq i} \sum_{l \neq k} (a_j^l + 2a_j^k)] \right\} = p_i$$

In order to obtain a manageable expression of the demand for advertising slots we assume symmetric advertisers, i.e. $c^k = c$ and $d^k(p) = d(p)$ (implying $p^k = p$). In the symmetric equilibrium of the advertising game among the K firms, then, $a_i^k = a_i^l = a_i/K$, i.e. we observe the same amount of advertising across the K advertisers on each individual TV-channel, although not necessarily across each TV-channel. From the first order conditions we can write:

$$(p - c) \cdot d(p) \delta \psi \left\{ \alpha + \theta[\beta q_i - \gamma \sum_{j \neq i} q_j] - \beta \frac{K+1}{K} a_i + \gamma \frac{K+1}{K} \sum_{j \neq i} a_j \right\} = p_i$$

Hence, being K very large, we can approximate the demand for advertising slots by

$$p_i = S \cdot \left[\alpha + \beta(\theta q_i - a_i) - \gamma \sum_{j \neq i} (\theta q_j - a_j) \right] \tag{2}$$

where $S = \delta \cdot \psi \cdot (p - c) d(p)$ is a scale parameter that measures the economic (profit) dimension of the economy for an advertiser: it can increase because the number of consumers increases (δ), because the advertising messages are more effective in stimulating purchases (ψ) or because the profit that can be extracted from a single consumer is greater. Different values of S can therefore be interpreted as due to different market

[18] This parameter would be important in evaluating advertising on different media - as TV-channels, radio or newspapers - as well as in comparing of TVs financed through advertising vs. subscription fees.

[19] This is because we assume that advertising has only a scale effect upon demand.

sizes, different media and advertising techniques and different phases of the business cycle.

It is worth noting that, although the demand for slots might seem very similar to the audience function, there exists a fundamental difference between the two: while the TV viewers look at the channels as substitutes, in the demand for advertising slots the quantities advertised on the n TV-channels enter as complements: if a_j increases, j's audience falls while i's audience increases: the willingness to pay for a spot in i's programs increases as well, i.e. i's demand for slots shifts to the right.

TV firms

We consider now the profit function of the TV firms. In the TV business, most of the costs do not depend on the number of viewers that watch the programs, and are therefore fixed, while the costs of broadcasting the programs (including the advertising messages) to an additional viewer are negligible. The nature of fixed and variable costs is therefore very similar to a public good case.

Within the fixed costs, we can distinguish between two broad subsets: a first class is basically determined by technological or institutional reasons, as the cost of the cable or transmitters network and that of the broadcasting equipment, or the cost of a licence. Those fixed costs, that we label as σ, are *exogenous* with respect to market size and do not depend on the nature of market competition.

The second class of costs refers to programming and includes production costs and the purchase of transmission rights: those costs are very sensitive to market size and the degree of competition, due to technical and, more substantially, quasi-rent reasons. A very popular program costs more because the cost of the scarse input needed (talent) is pushed up by competition among TV-channels. Those fixed costs F are *endogenous* and will be assumed to be increasing and convex in the level of quality of the programmes, i.e. $F = F(q_i)$, $F' > 0$ and $F'' > 0$. As will be clear later on, in our model the simplest specification consistent with a finite level of quality in equilibrium is a cubic function, i.e. $F(q_i) = q_i^3/3$.

Finally, we shall assume constant (zero) marginal costs. The current profits of TV i can be written as

$$\Pi_i = S\left[\alpha + \beta(\theta q_i - a_i) - \gamma \sum_{j \neq i}(\theta q_j - a_j)\right] a_i - \sigma - q_i^3/3 \qquad (3)$$

4 Equilibrium

We are now able to analyze the broadcasters decisions. In the third stage, the TV firms choose simultaneously the amount of advertising slots. Standard computations allow to establish the following result.

Lemma 1 *In the third stage of the game there exists a unique (subgame perfect) equilibrium in advertising time characterized by*

$$\hat{a}_i = \frac{(2\beta+\gamma)\alpha + \theta\left[\left(2\beta^2 - (n-2)\beta\gamma - (n-1)\gamma^2\right) q_i - \beta\gamma \sum_{j\neq i} q_j\right]}{(2\beta+\gamma)(2\beta-(n-1)\gamma)} \tag{4}$$

Substituting the equilibrium expression in the demand function, it is easy to check that

$$p_i = S\left[\alpha + \beta(\theta q_i - \hat{a}_i) - \gamma \sum_{j\neq i}(\theta q_j - \hat{a}_j)\right] = \beta S \hat{a}_i$$

In the second stage of the game the TV firms choose the quality of their programs. The net profits of a TV firm can be written as

$$\Pi_i = \beta \cdot S \cdot \hat{a}_i^2 - \sigma - \frac{1}{3} q_i^3 \tag{5}$$

The equilibrium level of qualities is described in the following proposition. We identify the conditions that ensure existence and uniqueness, and we shall check that they are met in the free entry equilibrium of the overall game.

Proposition 2 *If* $(2\beta+\gamma)\sqrt{\theta^2 H^2(\beta-(n-1)\gamma)^2 + 4\alpha H} - \theta H(n-1)\beta\gamma > 0$ *there exists a symmetric (subgame perfect) equilibrium in qualities characterized by*

$$\hat{q} = \frac{\theta H(\beta-(n-1)\gamma) + \sqrt{\theta^2 H^2(\beta-(n-1)\gamma)^2 + 4\alpha H}}{2} \tag{6}$$

where $H = \frac{2\beta S\theta\left(2\beta^2-(n-2)\beta\gamma-(n-1)\gamma^2\right)}{(2\beta+\gamma)(2\beta-(n-1)\gamma)^2}$. *If* $(2\beta+\gamma)\sqrt{\theta^2 H^2(\beta-(n-1)\gamma)^2 + 4\alpha H} - 2\theta H(n-1)\beta\gamma \geq 0$ *the equilibrium is unique.*

Proof: By deriving the profit function we get the first order condition

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{H}{2\beta+\gamma}\left[(2\beta+\gamma)\alpha + \theta(2\beta^2-(n-2)\beta\gamma-(n-1)\gamma^2)q_i - \theta\beta\gamma\sum_{j\neq i} q_j\right] - q_i^2 = 0 \tag{7}$$

which, in a candidate symmetric equilibrium, can be rewritten as $\alpha H + \theta H(\beta-(n-1)\gamma)q - q^2 = 0$. Solving for q gives the expression above. The second order conditions require

$$\frac{\partial^2 \Pi_i}{\partial q_i^2} = \frac{\theta H}{2\beta + \gamma} \left(2\beta^2 - (n-2)\beta\gamma - (n-1)\gamma^2 \right) - 2q_i < 0 \tag{8}$$

Evaluated at the equilibrium point, after rearranging, (8) gives the first condition above, which sets a constraint in the $(n, S, \theta, \alpha, \beta, \gamma)$ space. We shall check once solved for the equilibrium number of firms if the concavity conditions hold.

Finally, uniqueness can be established by noting that equation (7) is a quadratic function in q_i; treating q_{-i} all together, since $\partial^2\Pi_i/\partial q_i \partial q_j < 0$ and $\partial^2\Pi_i/\partial q_i^2 < 0$ for a maximum, the best reply function is decreasing. Using the contraction mapping argument the condition for uniqueness can be rewritten as $\mid \partial^2\Pi_i/\partial q_i^2 \mid \geq \sum_j \mid \partial^2\Pi_i/\partial q_i \partial q_j \mid$. Substituting and rearranging we obtain the second condition above.

□

It is worth noting that, for any given level of n, the equilibrium quality and advertising levels are increasing in the size of the market S. Since $\beta > (n-1)\gamma$ when the market is not covered, an increase in the size of the market, allowing to finance better programs, determines an expansion in the individual and overall audience in equilibrium. This process continues until all the market is covered[20], or, equivalently, until market size reaches a level $\overline{S}$. Fron that level on, no further expansion in aggregate audience is possible: the parameters of the audience function become $\beta = (n-1)\gamma$ and $\alpha = 1/n$[21]. It is easy to check that all the equilibrium expressions obtained so far remain valid, with the additional restriction on the parameter values described above.

We can now consider the entry decisions of the firms in the first stage game and the long run equilibrium structure of the market.

To simplify the analysis, we treat n as a continuous variable. The profits evaluated at the subgame perfect equilibrium in $\hat{a}$ and $\hat{q}$ are

$$\Pi = \beta S \frac{[\alpha + \theta(\beta - (n-1)\gamma)\hat{q}]^2}{[2\beta - (n-1)\gamma]^2} - \sigma - (1/3)\hat{q}^3 \tag{9}$$

We proceed in the analysis as follows: first of all we prove in the following proposition that the concavity and uniqueness conditions hold in a free entry equilibrium. Then we characterize the equilibrium number of firms as the market size increases, focussing on the asymptotic market structure, and showing its relationship to the degree of substitutability among channels.

Proposition 3 *In a free entry equilibrium the conditions for concavity and uniqueness specified in Proposition 2 hold.*

[20] This occurs when all the potential viewers watch a TV channel and/or all the viewers spend all the leisure time watching television.

[21] This change in parameters is not determined by a shift in tastes, but simply by the fact that the viewers' choice problems shifts from an internal to a corner solution.

Proof: The first order conditions (FOC) in the quality stage, evaluated at the symmetric equilibrium, can be written as $\alpha + \theta(\beta - (n-1)\gamma)\hat{q} = \hat{q}^2/H$. Set initially $\sigma = 0$ and evaluate the free entry condition (FEC):

$$[\alpha + \theta(\beta - (n-1)\gamma)\hat{q}]^2 = \frac{(2\beta - (n-1)\gamma)^2}{3\beta S}\hat{q}^3$$

Substituting the FOC in the FEC we obtain, after rearranging,

$$\hat{q} = \frac{H^2\,(2\beta - (n-1)\gamma)^2}{3\beta S} = \frac{2\theta H\,(2\beta^2 - (n-2)\beta\gamma - (n-1)\gamma^2)}{3(2\beta + \gamma}$$

Equating it to the expression of the symmetric equilibrium qualities (6) we obtain, after rearranging

$$\frac{3(2\beta+\gamma)\sqrt{\cdot} - \theta H\,(2\beta^2 + (2n-1)\beta\gamma - (n-1)\gamma^2)}{6(2\beta+\gamma)} = 0 \tag{10}$$

where $\sqrt{\cdot} = \sqrt{\theta^2 H^2(\beta-(n-1)\gamma)^2 + 4\alpha H}$. Hence in a free entry equilibrium $(2\beta + \gamma)\sqrt{\cdot} = (\theta H/3)(2\beta^2 + (2n-1)\beta\gamma - (n-1)\gamma^2)$. Substituting in the condition for uniqueness specified in Proposition 2 we obtain $(\theta H/3)(2\beta^2 + \beta\gamma - (n-1)\gamma^2)$ which always holds for $\beta \geq (n-1)\gamma$. Finally, if the uniqueness condition holds, the concavity condition holds as well. It is easy to check that if the exogenous sunk costs are positive, i.e. $\sigma > 0$, the same results hold good. $\square$

Once established that the free entry symmetric equilibrium exists and is unique, we can characterize the number of firms sustainable in the market. Looking at the expression of the zero profit condition (9), it turns out that the number of firms n should depend on $(\alpha, \beta, \gamma, \theta, S, \sigma)$, a rather long list to expect a clearcut result. However, when market sizes become large, the zero profit condition is governed by the behaviour of the higher degree terms. Moreover, the zero profit locus becomes asymptotically independent of S, what is usually associated with the Finiteness Property. Finally, we shall prove that this limiting number of firms is entirely explained by a combination of parameters β and γ of the audience function which can be interpreted as the degree of substitutability among channels.

Proposition 4 *When $S \to \infty$ the equilibrium number of firms in a free entry equilibrium $\hat{n}_\infty$ does not depend on S.*

Proof: Remember that $\hat{q} = \hat{q}(S)$ and H is linear in S; when S becomes very large, $\hat{q}$ becomes almost linear in S, since the highest degree of S in $\hat{q}$ is 1, i.e.

$$\hat{q}(S) \simeq \theta(\beta - (n-1)\gamma)H \tag{11}$$

In this limiting case the zero profit condition is governed by two terms of the third degree in S

$$\Pi \simeq \frac{[\theta(\beta-(n-1)\gamma)]^2}{[2\beta-(n-1)\gamma]^2}\beta S[\hat{q}(S)]^2 - (1/3)[\hat{q}(S)]^3 = 0 \tag{12}$$

Substituting the simplified expression of the equilibrium quality (11) in the simplified expression of the zero profit condition (12), the θ and S terms cancel out. The free entry condition reduces, after rearranging, to $\Pi \geq 0$ if $2\beta^2 - (4n-5)\beta\gamma - (n-1)\gamma^2 \geq 0$, which is a function of β and γ only. $\hat{n}_\infty$, the free entry equilibrium number of firms when $S \to \infty$, solves this expression as an equality. □

The proposition above shows that the zero profit locus in the (S, n) space is asymptotically horizontal; its behaviour for small market size depends on the relative importance of the demand intercept α, which enables more firms to coexist given their captive market share, and of the exogenous sunk costs σ, which make it more difficult to survive in a fragmented market. Hence, the zero profit locus when $\sigma = 0$ gives the upper bound on the number of firms sustainable in the market. Moreover, the intercept α tends initially to determine a negative relationship between the number of firms and market size, the opposite being true for the effect of the fixed entry costs σ. Figure 1 shows the two different cases: the downward sloping line[22] corresponds to the zero profit locus when $\sigma = 0$, i.e. the case in which only α matters, while the upward sloping lines might be the zero profit loci when the exogenous sunk cost σ are positive. Hence, the downward sloping curve gives the highest number of firms for given market size which are sustainable in a free entry equilibrium. It is immediate to notice that all the curves tend asymptotically to squeeze around the value $\hat{n}_\infty$.

The equilibrium industry structure as determined by the zero profit condition is strongly influenced by the competition for audience among TV firms, which is primarily realized through an increase in the quality of programs. If the market size S increases, current profits tend to increase: they are reduced, restoring the zero profit condition, not through further entry but through an increase in the quality of programs and in the corresponding fixed outlays. This result reminds the Finiteness Property that characterizes natural oligopolies[23] in which competition in quality is crucial. Notice that the negative relation between market size and the number of firms that can initially emerge clearly shows the increasing importance of the fixed endogenous outlays for programming that are pushed up as the market grows: for small market size, programme quality and the associated fixed costs are negligible, while when the market becomes larger and larger quality and costs increase even faster, inducing an increase in concentration.

We are now interested in determining the equilibrium number of firms when market size becomes larger and larger. Since the entire map of isoprofit curves lies around the asymptotic horizontal line that identifies the limiting number of firms sustainable when

[22] The plot is drawn using the discrete choice specification of the audience function presented in the appendix.

[23] See, for instance, Shaked and Sutton (1983).

the market becomes very large, $\hat{n}_\infty$, we focus on the determinants of that value, i.e. on the position of this flat line.

As shown above, in the limiting case of S very large, the zero profit condition is defined in the (β, γ, n) space: the equilibrium number of firms $\hat{n}_\infty$, therefore, is expected to depend on the degree of substitutability among TV channels, i.e. on the features of horizontal product differentiation. It must be reminded that the parameters of the audience function depend in general on the number of firms, i.e. $\beta = \beta(n)$ and $\gamma = \gamma(n)$ [24]. Sufficient conditions for characterizing the free entry equilibrium can be given by using the expression

$$d(\beta, \gamma, n) = \frac{\beta(n)}{(n-1)\gamma(n)} \tag{13}$$

which is the ratio of the own effect and the sum of the cross effects in the audience function and in the demand for advertising time; $d(\cdot)$ generalizes to the n products case the usual index of product substitutability in linear demand models[25]. This index $d(\cdot)$ depends on the particular functions $\beta(n)$ and $\gamma(n)$, which derive from different micro models of viewers' behaviour, and, through those expressions, on n. Therefore it can vary because the functions $\beta(n)$ and $\gamma(n)$ change for any value of n, what we define a variation in the *degree of differentiation*; alternatively, $d(\cdot)$ changes when n varies given the functions $\beta(\cdot)$ and $\gamma(\cdot)$: we shall refer to this second source of variation as the *pattern of differentiation*. Figure 2 shows two examples in which the pattern of differentiation is decreasing, the former implying a higher degree of differentiation than the latter: the curves are decreasing[26], showing that the pattern of differentiation is consistent with a negative relation between the number of TV channels and their differentiation; moreover, for each n one curve is always above the other, since its degree of differentiation is higher.

Figure 1 and 2 about here

The following proposition establishes a sufficient condition for the equilibrium number of firms being increasing in the degree of differentiation without restricting us to a specific expression of $\beta(n)$ and $\gamma(n)$, i.e. to a specific micro model of viewers' choice.

Proposition 5 *If the pattern of differentiation $d(\cdot)$ for given functions $\beta(n)$ and $\gamma(n)$ is non increasing in n, the maximum number of firms sustainable in a free entry equilibrium when S becomes very large, $\hat{n}_\infty$, is increasing in the degree of differentiation $d(\beta(\cdot), \gamma(\cdot))$. If a sufficient degree of differentiation is feasible such that* $\lim_{n\to\infty} d(\cdot) = 2$*, then $\hat{n}_\infty \to \infty$, while if* $\lim_{n\to\infty} d(\cdot) < 2$*, then $\hat{n}_\infty$ is finite.*

[24] We omitted in the equilibrium analysis so far to write down explicitly this functional relation to save notation, since the number of firms was given in the second and third stage of the game.

[25] Notice that $d(\cdot)$ is strictly related to the importance of the expansion effect with respect to the displacement effect: with no entry of new viewers $d(\cdot) = 1$, while with no displacement effect $d(\cdot) \to \infty$.

[26] The two curves are obtained from the discrete choice specification of viewers' behaviour discussed in the appendix, by choosing different values of the parameter f.

Proof: The free entry condition in the limiting case $S \to \infty$ reduces to $2\beta^2 - (4n - 5)\beta\gamma - (n-1)\gamma^2 \geq 0$. Dividing by $(n-1)^2\gamma^2$ it can be rewritten as

$$2d(\cdot)^2 - \frac{4n-5}{n-1}d(\cdot) - \frac{1}{n-1} \geq 0 \tag{14}$$

Totally differentiating this expression we obtain

$$\frac{dn}{dd} = \frac{4(d-1)(n-1)^2 + (n-1)}{(d-1) - [4(d-1)(n-1)^2 + (n-1)]\partial d/\partial n} \tag{15}$$

which is positive if $\partial d/\partial n < 0$, being $d \geq 1$ by assumption. Taking the limit of the free entry condition as n tends to ∞ we obtain $2d(d-2) \geq 0$. Since d increases, for any n, as the degree of differentiation increases, the condition above determines the degree of differentiation sufficient to induce the entry of an infinite number of firms. If $d < 2$ as $n \to \infty$ the profits would be negative and the entry process ends up with a finite number of firms. □

Proposition 5 shows that the industry might be highly concentrated despite free entry even for very large market size. But it also establishes that the market, whatever its size, is not necessarily concentrated if there exists a sufficient degree of differentiation. For example, higher differentiation, by reducing the extent to which viewers switch from one channel to another, also reduces the incentive to invest in quality; quality and advertising would decrease in equilibrium, and so would advertising revenues and programming costs. In turn, lower fixed outlays would allow more firms to enter the industry. The sufficient condition for this result requires that the pattern of (horizontal) differentiation is non increasing in the number of firms. This amounts to saying that the degree of substitution among products does not decrease as the number of products rises. Such a condition is very natural in the literature of (horizontal) product differentiation.

With reference to the oligopoly theory literature, proposition 5 suggests a trade off between differentiation by variety and by quality: if the former is poor (d low) the latter is very effective, while a higher degree of (horizontal) differentiation among channels decreases the equilibrium quality of the programs. This kind of trade-off emerges also in models of differentiated *duopolies* in which firms have to choose both their variety and quality[27]: in these models, if the fundamentals allow a significant horizontal differentiation the equilibrium configuration entails divergent varieties and similar (low) quality, while if the scope for horizontal differentiation is limited similar varieties and different qualities are selected in equilibrium. Entry and the equilibrium with n firms, however, are not addressed in these papers.

In our setting, the market structure arising at the long run equilibrium depends crucially on the degree of horizontal product differentiation, which we treat as exogenous. This result calls for some comments.

[27] See Neven and Thisse (1988) and Ireland (1987). See also Irmen and Thisse (1996) for a situation where two firms decide on n characteristics.

If we extended the model such as it stands and allowed for an additional stage of the game where firms decide upon some variable which decreases the degree of substitution, they would exploit this possibility as much as the cost of such a strategy permits[28]. In turn, if the scope for horizontal differentiation would be sufficiently high, this would imply that the number of firms which could coexist in the industry becomes large.

Horizontal differentiation in the broadcasting industry offers a rich set of opportunities, because the programme schedule can contain different types of programmes and, for each variety, a characterization different from that of the other channels. However, the possibility of increasing product differentiation depends on the distribution of consumers' preferences for the different types of programmes. Consider a situation in which consumers' preferences are biased towards only a small subset of program types, as for instance sport events and movies. Even if TV firms tried to characterize their programme schedules with respect to the rival channels, the scope for differentiation would be limited if the programme schedules were mainly designed for these large potential audiences. The endogenous increase in programme quality and programming costs would be the result: few TV firms providing the popular types of programmes would have large market shares, whereas a large number of TV channels providing programmes devoted to minorities would have a small share of the audience.

These features might explain why few TV firms are still dominant in all countries, and might allow for a dual market structure to arise as an equilibrium where few TV firms offer relatively similar and popular programmes and have most of the market while a large number of more specialized (or local) TV channels cover programme types patronized only by minorities.

However, we feel that to deal with such extensions we would need a model where viewers' preferences for different varieties of programs are accounted for in a more sophisticated way than our model allows to do. Our main objective in this paper was to enphasize the importance of the quality choice of TV channels and its possible implications upon the structure of the market. A model which combines in a careful way the endogenous sunk cost paradigm we propose with the horizontal product differentiation approach traditionally suggested by the previous literature on the TV industry is beyond of the scope of this paper and is left for future research.

5 Conclusions

Traditionally the monopolistic competition paradigm, focussed on the design of the variety of program schedules, has been considered as the appropriate framework to analyze the broadcasting industry. However, the persistence of concentration which can be ob-

[28]For instance, if we specify the audience function according to the discrete choice model of viewers' behaviour described in the appendix and we assume that firms are able to determine, through the variety of their programme schedule, the percentage of idiosyncratic viewers who like their channel, we would obtain that firms choose a corner solution, i.e., they choose the maximum differentiation allowed. This corner solution reminds the maximum differentiation result of the Hotelling type literature.

served in larger and smaller countries can not be explained within that paradigm. In this paper we have developed a model of the broadcasting industry which suggests that the persistence of a high degree of concentration might arise in the industry even in the absence of the spectrum constraint or any other factor which prevents entry.

Our central assumption is that competition among broadcasters is on the perceived quality of the programs, i.e. on their ability, for given variety, to capture a high audience. Since a more popular program also tends to cost more, due to technological and quasi-rent arguments, the broadcast industry seems to be a good example of the endogenous sunk cost paradigm as proposed in Sutton (1991).

We model the interaction among viewers, advertisers and TV firms that characterizes the broadcast industry, proving that the maximum number of firms sustainable is independent of market size as this latter becomes larger and larger. We also show that the minimum degree of concentration depends on the degree of (horizontal) substitutability among TV channels. This is a somehow new result in the natural oligopoly literature.

Our results seem relevant in addressing regulatory issues. Public policy in the broadcast industry has been traditionally designed to promote variety of programmes and to foster pluralism of views. Our result that persistent concentration might arise despite the possibility of free entry and the absence of any technological or institutional contraint suggests that public policies in the broadcasting industry might still be needed in the future.

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Appendix: the audience function from a discrete choice model of viewers' behaviour

We briefly sketch how to derive a system of audience functions for the n channels from a discrete choice model of viewer's behaviour. Obviously this is not the only way to offer a micro-foundation to the audience function, and alternative specifications can be obtained from the representative consumer and the address approaches of product differentiation: the former, however, offers poor insights on the parameters' restrictions when dealing with a n products model, while the latter becomes relatively messy when allowing for a change in the total numer of active consumers (total demand for the n products), as admitted in our model [29]

The utility of a viewer watching a programme with quality q_i and advertising time a_i is

[29] The literature on dicrete choice models of product differentiation has almost neglected the linear demand model, although most of the applications in oligopoly theory still use this friendly specification; moreover, it is usually claimed that it is not possible to generalize the linear two-products model to the n goods case. See for example Anderson, De Palma and Thisse (1991) p.120. In this appendix we show, with reference to the audience function, how pairwise comparisons of n products allow to solve the problem. See also, for linear demand systems, Polo (1996).

$$U_i = \theta q_i - a_i + \epsilon_i = s_i + \epsilon_i \tag{16}$$

for $i = 1, .., n$, where s_i is the (deterministic) net surplus from the program and ϵ_i is a random i.i.d. term with zero mean and finite variance, drawn from a common distribution, representing viewers' heterogeneity on a horizontal differentiation dimension. The outside utility is $U_0 = s_0 + \epsilon_0$.

There exist $n(n+1)/2$ types of viewers $t_{i,j}$ for $i, j = 0, 1, .., n$ and $i \neq j$: a $t_{i,j}$ viewer decides her choice by comparing programme i and j only. For instance, a $t_{1,2}$ viewer chooses between programme 1 and 2, while the subset $t_{0,n}$ identifies the viewers who choose between programme n and the outside option. Viewers' heterogeneity is therefore referred to the pair of alternatives they consider and to the random components ϵ in the preferences on each of the two alternatives considered.

It is convenient to define, respectively, types $t_{0,i}$ and $t_{i,j}$, $i, j = 1, .., n$, $i \neq j$, as *idiosyncratic* and *addicted* viewers: the former watch (at most) their preferred channel, while the latter watch in any case a programme, chosen between their two elected channels. We have therefore n subsets of idiosyncratic viewers and $n(n-1)/2$ subsets of addicted ones.

A viewer of any type knows the realizations of the random terms ϵ which characterize her preferences. An outside observer knows only the distribution of the difference in the random terms, which is uniformly distributed on the support $[-L, L]$, with mean $\mu_x = 0$, variance $\sigma_x^2 = L^2/3$, density $f(x) = 1/(2L)$ and cumulative density $F(x) = 1/2 + x/(2L)$.

There exists a large number δ of viewers; the share of each of the idiosyncratic types $t_{i,0}$ is $f/(n(n+1))$, $f \in [0, n+1]$, while the share of each of the addicted types $t_{i,j}$ is $2(n+1-f)/(n(n+1)(n-1))$. Notice that if $f = 2$ we are in symmetric case, in which all the viewers types are equally important, while if $f = 0$ ($f = n+1$) only addicted (idiosyncratic) viewers are represented. Finally, the aggregate size of all the idiosyncratic types is $f/(n+1)$ while that of the addicted types is $(n+1-f)/(n+1)$.

A $t_{i,j}$ viewer, $j = 0, .., n$, $j \neq i$ patronizes programme i if $U_i \geq U_j$. The probability that i is chosen by a $t_{i,j}$ viewer is therefore $F(s_i - s_j)$ or

$$Pr_{i,j}(i) = \begin{cases} 0 & if \;\; s_i - s_j < -L \\ \frac{1}{2} + \frac{(s_i - s_j)}{2L} & if \;\; -L \leq s_i - s_j \leq L \\ 1 & if \;\; s_i - s_j > L \end{cases} \tag{17}$$

Aggregating individual choices over viewers' types we obtain the linear audience function.

$$A_i = \delta \left\{ \frac{f}{n(n+1)} Pr_{i,0}(i) + \frac{2(n+1-f)}{(n+1)n(n-1)} \sum_{j=1, j \neq i}^{n} Pr_{i,j}(i) \right\} \tag{18}$$

Substituting the corresponding expressions[30] we obtain:

$$A_i = \delta \left\{ \alpha(n) + \beta(n) \left(\theta q_i - a_i\right) - \gamma(n) \sum_{j \neq i} (\theta q_j - a_j) \right\} \tag{19}$$

[30] We explicitly represent the aggregate audience when $Pr_{i,j}(i) \in (0, 1)$ for all the viewers' types; the extension to the corner solutions is trivial.

where

$$\alpha = \frac{2n+2-f-nfs_0w}{2n(n+1)}$$
$$\beta = \frac{(2n+2-f)w}{2n(n+1)}$$
$$\gamma = \frac{(n+1-f)w}{(n+1)n(n-1)}$$

and where $w = 1/L$. Two parameters are related to the degree of horizontal differentiation among channels. The first parameter is w, which is inversely related to the degree of (horizontal) heterogeneity in tastes at the individual level: a higher w implies that the variance in the random component ϵ decreases, and determines a more elastic individual and aggregate schedule. The second relevant parameter is f, which measures the relative importance of idiosyncratic viewers in the population: a higher f implies that when programme i becomes more attractive (a higher s_i), the increase in audience is determined relatively more by the entry of new (idiosyncratic) viewers - *expansion effect* and relative less by the shift of (addicted) consumers from other goods - *displacement effect*. The degree of differentiation among channel i and the remaining $(n-1)$ channels, $d_n = \beta/(n-1)\gamma$, is

$$d_n(f) = \frac{2n+2-f}{2n+2-2f} \tag{20}$$

For given f, the degree of (horizontal) differentiation is decreasing in n; moreover, it is equal to 1 when $f = 0$ (no audience expansion effect) and tends to ∞ when $f \to n+1$ (no displacement effect), i.e. when there is no competition among channels. Finally, it is worth noting that w does not influence the degree of differentiation at the aggregate level.