# The Effects of Audience Composition in the Dutch Radio Broadcasting Industry

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**PRELIMINARY**

**Abstract**

This paper empirically examines the effects of audience composition for the Dutch radio broadcasting industry. A two-sided empirical model is estimated which takes into account the demand from listeners as well as from advertisers. This paper follows a novel approach by specifying a nested logit model for listener demand in which markets are defined on the basis of sociodemographic characteristics such as gender and age. Moreover detailed firm-level information on advertising prices and quantities is available from a unique dataset. The results will indicate whether the demographic composition of a radio station's audience is more important than simply the magnitude of a radio station's audience. More specifically, this paper finds that audience composition is most important for different age groups and especially as the age gap widens. However the discounts and premiums on spot prices that advertisers receive do not depend on audience composition but on other radio station characteristics.

# 1 Introduction

In 2006, the average individual in The Netherlands spent 192 minutes listening to radio everyday and the advertising expenditures on radio were €485 million which is 5.8% of total media advertising.[1] These figures show that radio broadcasting stations not only provide entertainment to listeners but are also important channels for advertising companies to market their product to (potential) customers.

This paper empirically examines the effect of sociodemographic characteristics on the tune-in choices of listeners and the advertising prices of radio stations for the Dutch radio broadcasting industry. An empirical model of the radio industry is estimated using data on listener ratings data for several sociodemographically defined markets, advertising quantities and prices, and station characteristics. The paper uses a novel dataset including detailed firm-level information on advertising prices and advertising quantities. The sociodemographic characteristics that are used to define a market are mainly based on age. The estimates will indicate whether audience composition has an effect on the demand for radio broadcasting.

The two-sided nature is a key characteristic of radio broadcasting. Radio stations compete to attract listeners and then "sell" these listeners to advertisers. To be successful, a radio station needs to recruit both sides. The early theoretical treatments of media industries often assumed that the profitability of media firms depends on their capability to attract large audiences (Steiner, 1952; Spence & Owen, 1977). More recently, Anderson & Coate (2005) theoretically analyze how well commercial broadcasters provide programming to viewers or listeners and potential consumers to advertisers. In advertiser-supported media, suboptimal programming may occur if advertiser and listener preferences do not coincide. For example, Brown & Cavazos (2003) show that advertisers pay a premium for certain types of television programming. Furthermore, Tyler Mooney (2007) finds that the demographic composition of the listener audience is an important determinant of listener preferences and advertiser demand. The empirical results by Wilbur (2008) also suggest that advertiser preferences greatly influence network choices. These studies thus indicate that audience composition matters and not simply the magnitude of the audience.

The empirical model takes into account the two-sided nature of radio broadcasting by specifying a listeners demand function and an advertising demand function. Discrete choice models are widely used to describe the behavior of listeners (Berry, 1994; Rysman, 2004; Wilbur, 2008). The nested logit model is used to estimate the demand for listening (Berry & Waldfogel, 1999; Train, 2003). The advantage of the nested logit is that it does not exhibit the independence from irrelevant alternatives (IIA) property. The explanatory variables include advertising quantities, audience size, sociodemographic and station characteristics. The empirical specification for advertising demand closely follows Rysman (2004). Advertising demand is modeled through the aggregate demand for advertising on a given radio station. The inverse demand for advertising is estimated in which the advertising price is a function of audience size, listener demographics, and radio station characteristics. The sociodemographic characteristic age is used to define a market. This paper contributes to the empirical literature on media markets by considering demographic markets groups as opposed to geographically defined markets (Rysman, 2004; Argentesi & Filistrucchi, 2007). Moreover detailed firm-level information on advertising prices and advertising quantities are available from a unique dataset. Both demand functions will be estimated by two-stages least

[1] Commissariaat voor de Media, *Medialandschap in beeld: Concentratie en pluriformiteit van de Nederlandse Media 2006.*

squares because of the endogeneity of advertising quantities and audience sizes.

The estimation results will show the importance of the demographic composition of a radio station's audience. Radio stations broadcast certain types of programmes and music to attract listeners and in turn to be attractive advertisers. The main research questions are whether these sociodemographic characteristics are important in determining listener and advertiser choices and whether the preferences of listeners or advertisers matter more. The listener and advertising demand estimates will give insight into these issues. It is expected that radio stations target their programming to match the tastes of consumer with particular demographic characteristics that are valuable to advertisers. Other interesting findings will be whether listeners are averse to advertising and the degree of substitutability of radio stations from the perspective of the listeners.

The remainder of this paper is organized as follows. Section 2 gives a description of the radio broadcasting market in The Netherlands. The model for listener demand is presented in Section 3. Section 4 describes the data whereas the next section discusses the empirical specification and estimation methodology. In Section 6 the demand estimates are presented and Section 7 concludes.

## 2 The Dutch Radio Broadcasting Industry

In 1988 the first commercial radio stations were introduced in The Netherlands. Until then the public radio stations had a monopoly position in the radio broadcasting market. Although commercial radio stations were still not officially allowed, they used a foreign operating licence to broadcast in The Netherlands. In 1992 the first Dutch commercial radio broadcasting license was granted and during this year the number of commercial radio stations increased to nine.

In the nineties the number of commercial stations kept increasing which is mainly due to the increased availability of frequencies for radio broadcasting from temporary license auctions in 1994 and 1997. At the end of the nineties a few commercial radio stations succeeded in obtaining a considerable market position and therefore the public radio stations saw their market shares decline. The Herfindahl-Hirschmann index (HHI) for the national radio broadcasting market decreased from 0.9 to 0.25 in the nineties and is still around 0.25 implying that the radio broadcasting market is very concentrated.[2]

The current assignment of frequencies for radio broadcasting are licensed by a beauty contest held in 2003.[3] The Dutch government assigned a large number of FM and AM licenses for commercial radio for a period of eight years. There were nine national allotments of which five have specific format requirement[4] and four for unrestricted programming. Moreover, there were 26 regional allotments for commercial radio stations. Besides these commercial radio stations there are five national public radio stations and thirteen regional public radio stations. These radio stations did not have to take part in the beauty contest and obtained the allotment for free. However there are stricter rules that the public radio stations need to obey in terms of coverage, advertisement, and format requirements.

From 2002 onwards the joint national market share has been higher for commercial radio sta-

[2]The HHI is calculated by $\sum(s_j^2)$ where $s_j$ is the listening share of radio station $j$. The HHI ranges from 0 to 1 where values close to zero indicate a competitive market and values close to 1 indicate a monopoly.

[3]Each firm that wanted to participate in the beauty contest needed to submit a business plan and a financial bid. A firm could score a '+' indicating above average or a '0' otherwise on its business plan. An allotment is assigned to a firm if he/she is the only firm with a '+' on the business plan. If more than one firm has an above average score the allotment is assigned to the firm with the highest financial bid.

[4]The format requirements are (1) not contemporary special music, (2) news/talk/information, (3) contemporary special music, (4) Dutch/European music, and (5) classical and/or jazz.

tions than for public radio stations as can be seen from Table 1. However regional public radio stations still have the highest market shares in many provinces, especially in the north-eastern part of The Netherlands. Table 1 also shows that in 2004, the year after the beauty contest, total listening time increased with 12 minutes compared with 2003. However in 2005 the total time spent listening to radio during a day decreased again and remained the same as in 2006. It seems that the increase in the number of stations in 2003 only had a temporary effect on listening time.

**Table 1. National market shares of radio stations**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| *Public radio* | *45.4* | *45.8* | *45.9* | *44.0* | *42.8* | *43.9* |
| - National | 31.1 | 31.2 | 31.4 | 29.4 | 28.3 | 29.5 |
| - Regional | 14.3 | 14.6 | 14.5 | 14.6 | 14.5 | 14.4 |
| *Commercial radio* | *47.1* | *48.5* | *48.0* | *49.6* | *50.4* | *49.8* |
| - National | 44.8 | 45.6 | 45.6 | 47.0 | 47.6 | 47.3 |
| - Regional | 2.3 | 2.9 | 2.4 | 2.6 | 2.8 | 2.5 |
| *Other*[5] | 7.5 | 5.7 | 6.1 | 6.4 | 6.8 | 6.3 |
| *Total listen time* | *189* | *188* | *187* | *199* | *192* | *192* |

Source: RAB/Intomart GfK (00-24 hour/population 10+)
& Mediaconcentratie in Beeld 2006

The total media expenditures for radio have increased with 65% in the period from 2001 to 2006.[6] Although the market shares are almost split evenly between commercial and public radio stations, media expenditures have been higher for commercial radio stations. The commercial share of media expenditures has been around 70% and the public share around 30% during the last years. It is not surprising that the public share of media expenditures is substantially lower because public radio stations have stricter requirements in their licenses than commercial radio stations with respect to the amount of advertising that is allowed.

The Dutch radio broadcasting market reached nearly 70% of the Dutch population above the age of 10 and on average an individual listens 192 minutes to radio every day in 2006. Morever 95.5% of the Dutch households has a radio and the average household had 2.4 radios. Listening to radio can be characterized as side-activity as 95% of the total listening time is spent while performing other activities.[7] The main activities during the time spend on listening to radio are working, household activities, and travelling by car.[8] Individuals listen to the radio mainly between 7am and 8pm with a peak around midday.

# 3 A discrete choice model of listener demand

This paper employs a discrete choice model for the listener demand which is widely used in the recent literature on applied economics to estimate the demand for differentiated products. (Nevo, 2000b; Ivaldi & Verboven, 2005). Discrete choice models assume that individuals choose either to

[6]Nielsen Media Research, Jaarboek Bruto Mediabestedingen 2006.
[7]http://www.tijdsbesteding.nl/hoelanghoevaak/vrijetijd/media/geluiddragers/algemeen/20061018.html
[8]Carat, *Mediafeitenboekje Nederland 2006*

listen to one of $J$ broadcasting stations, $j = 1, ..., J$, or choose the outside option $j = 0$, i.e. not to listen to radio at all. Following Berry (1994), the utility of listener $i$ from listening to radio station $j$ is given by[9]

$$u_{ij} = \delta_j + \epsilon_{ij} = x_j\beta + \xi_j + \epsilon_{ij} \tag{1}$$

where $\delta_j$ is the mean utility of radio station $j$ and is common to all consumers and $\epsilon_{ij}$ is the stochastic component of utility. The mean utility consists of observable characteristics, $x_j$, and of unobserved (by the researcher) product characteristics, $\xi_j$. The utility of the outside option, $j = 0$ is normalized to zero for all consumers. A consumer is assumed to choose to listen to the radio station that gives him or her the highest utility. That is, conditional on both the observed and unobserved (by the researcher) characteristics of the radio station, listener $i$ will choose to listen to radio station $j$ if and only if the utility obtained from radio station $j$ is greater than the utility that is obtained from listening to any other radio station that is available.

The assumption on the distribution of unobserved consumer heterogeneity has important implications for the substitution patterns. The next subsection describes the case of the nested logit model. A detailed discussion about the mixed logit or random-coefficients logit model can be found in Nevo (2000).

## 3.1 The nested logit model

In the nested logit model all radio stations are grouped into predetermined mutually exclusive groups or 'nests' and the random term, $\epsilon_{ij}$, is decomposed into an iid shock and a group-specific component. This decomposition allows the variance of the random terms in the utility function to be different across nests. The radio stations are grouped into $N + 1$ nests, $n = 0, 1, ..., N$. The outside good, $j = 0$, is assumed to be the only member of nestp 0. The utility of listener $i$ from listening to radio station $j$ in nest $n$ is:

$$u_{ij} = \delta_j + \zeta_{in} + (1 - \sigma)\epsilon_{ij} = x_j\beta + \xi_j + \zeta_{in} + (1 - \sigma)\epsilon_{ij} \tag{2}$$

where $\delta_j$ is the mean utility which is common to all listeners and $\epsilon_{ij}$ is iid with an extreme value distribution and represents the preference of listener $i$ for radio station $j$. The term $\zeta_{in}$ is common to all radio stations in a group of similar radio stations and represents the preference of listener $i$ for radio stations in nest $n$. Cardell (1997) shows that the distribution of $\zeta_{in}$ is the unique distribution such that if $\epsilon_{ij}$ is an extreme value random variable, then the term $\zeta_{in} + (1 - \sigma)\epsilon_{ij}$ also has an extreme value distribution. The parameter $\sigma$ lies between 0 and 1 and is a measure of correlation of listener utility across radio stations belonging to the same nest. If $\sigma = 1$ there is perfect within nest correlation of listener preferences and so the radio stations within this nest can be perceived as perfect substitutes. When $\sigma$ approaches 0, the within group correlation of utility also goes to 0 and the nested logit specification of utility becomes the standard logit utility specification given in equation (1).

The market share of radio station $j$ in nest $n$ can be expressed as the product of the probability of choosing radio station $j$ given that nest $n$ is chosen and the probability of choosing nest $n$. That is, $s_j = s_{j|n} \cdot s_n$ where $s_{j|n}$ is the within-nest market share and $s_g$ is the group share. This gives a

[9] In general, the utility of consumer $i$ from consuming good $j$ also depends on the price of the product. In the case of the radio broadcasting industry consumer prices are not relevant because consumers can freely listen to the radio. This can be seen as an implication of a two-sided market in which the radio stations generate revenue from advertisers.

market share of:

$$s_j = \frac{e^{\delta_j/(1-\sigma)}}{\sum_{j\in n} e^{\delta_j/(1-\sigma)}} \cdot \frac{[\sum_{j\in n} e^{\delta_j/(1-\sigma)}]^{1-\sigma}}{[1+\sum_{n=1}^{N}\sum_{j\in n} e^{\delta_j/(1-\sigma)}]^{1-\sigma}} \tag{3}$$

where the first term is the within-nest market share and the second term is the nest share. The nested logit specification allows for more flexible substitution patterns than the logit model because listener heterogeneity is correlated across radio stations. More specifically, the correlation between radio stations within a nest is higher than across nests. This can be shown by comparing the ratio of market shares for two radio stations that belong to the same nest and for two radio stations that do not belong the same nest. The ratio of market shares for radio station $j$ and $k$ that are not in the same nest, $j \in n$ and $k \in n+1$, is:

$$\frac{s_j}{s_k} = \frac{e^{\delta_j/(1-\sigma)} D_n^{-\sigma}}{e^{\delta_k/(1-\sigma)} D_{n+1}^{-\sigma}}$$

and the ratio of market shares for radio station $j$ and $k$ that are in the same nest, $j, k \in n$, is:

$$\frac{s_j}{s_k} = \frac{e^{\delta_j/(1-\sigma)}}{e^{\delta_k/(1-\sigma)}}$$

If radio station $j$ and radio station $k$ are not in the same nest, the ratio of market shares depends on the characteristics of all radio stations in the two nests containing radio station $j$ and $k$. However this ratio does not depend on any characteristics of the radio stations belonging to groups that do not contain radio station $j$ and $k$. This form of IIA can loosely be described as *independence from irrelevant nests* (IIN). If radio station $j$ and radio station $k$ are in the same nest, the ratio of market shares is independent of all other radio stations. This implies that there is proportionate substitution within a nest. Therefore IIA holds within nests but not across nests.

# 4 Data

The dataset comprises of information on market shares, advertising prices, advertising quantities, station characteristics and sociodemographic characteristics. The dataset covers 17 radiostations for several market for 23 time periods, that is from the first two-month period in 2005 until the last two-month period in 2006 (January-February, February-March, etc). A market is defined by sociodemographic characteristics of the Dutch population and are based on different age groups. The age groups are defined as 10-19, 20-34, 35-49, 50-64, and 65+ years of age. Not all radio stations for which listening ratings are reported are included in this study due to the lack of information on advertising data.

The listening measure is Intomart GfK's average quarter hour (AQH) rating which is the share of the population listening to radio for at least 8 minutes during a 15-minute time period. The ratings data are generated from listening diaries from rougly 10,000 participants. The participants record their quarter-hour listening behavior during one week. Intomart GfK releases ratings data on a monthly basis over a two-month period. These ratings data are available on several Dutch websites that focus on radio broadcasting issues. The data that are used in this study come from the website www.rab.fm. The listening figures are from Monday-Sunday, 7am to 7pm and are availabe for several sociodemographic groups of which different age groups are used in this study.

This data is enriched by information on advertising prices that come from the website www.radionieuws.nl

and from the individual websites of radio stations. The advertising price used in this study is the spotprice which is the advertising price for a 20-second advertisement. Information on advertising revenues is supplied by Nielsen Media Research who monitors and publishes advertising revenues of radio stations on a monthly basis. Advertising quantities are therefore calculated as the amount of advertising revenue divided by the spotprice.

The station characteristics that are available are costs and format and come from Agentschap Telecom which is the Radiocommunications Agency in the Netherlands and from the website www.rab.fm. The cost variable includes the costs that radio stations pay to Agentschap Telecom and depends on the number of towers and the amount of wattage.

Table 1 provides summary statistics for the main variables included in this study. The AQH-rating is the average number of listeners divided by the total population. The AQH-rating substantially differs across sociodemographic groups during an average 15-minute period.

Table 1. Summary Statistics

| Variable | Mean | Median | Sd | Min | Max |
|---|---|---|---|---|---|
| AQH-rating | | | | | |
| All | 21.06 | 21.42 | 1.49 | 17.96 | 23.03 |
| 10-19 | 1.08 | 1.11 | 0.11 | 0.84 | 1.25 |
| 20-34 | 4.82 | 4.89 | 0.27 | 4.22 | 5.18 |
| 35-49 | 6.01 | 6.21 | 0.54 | 4.69 | 6.69 |
| 50-64 | 5.40 | 5.57 | 0.43 | 4.64 | 6.01 |
| 65+ | 3.76 | 3.74 | 0.23 | 3.40 | 4.08 |
| | | | | | |
| Spotprice | | | | | |
| Total | 376.76 | 280 | 319 | 40 | 1377 |
| - Commercial | 373.91 | 240 | 352.27 | 40 | 1377 |
| - Public | 381.99 | 457 | 246.76 | 60 | 928 |
| | | | | | |
| Ad quantity | | | | | |
| Total | 4668.48 | 4463.21 | 2726.42 | 232.83 | 12174.3 |
| - Commercial | 5304.69 | 5079.47 | 2789.94 | 1489.76 | 12174.36 |
| - Public | 3502.10 | 3593.61 | 2166.98 | 232.83 | 7181.29 |

The average spotprice is €376.76 and almost equal for commercial and public radio stations are. However, there is a large difference between the maximum prices of these two types of broadcasters. On the other hand, commercial radio stations broadcast many more advertising spots than public radio stations. Again the differences in minimum and maximum advertising spots is striking. Table 2 shows how population and income varies by sociodemographic group. Men have a higher income than women for all age categories. Moreover people aged 35-49 also have the highest income across gender.

Table 2. Population and income across sociodemographic groups (x1000)

| Group | Population | Income |
|---|---|---|
| All | 14,370 | 19,4 |
| | | |
| 10-19 | 1,887 | 1,25 |
| 20-34 | 3,326 | 21,26 |
| 35-49 | 3,857 | 30,08 |
| 50-64 | 3,039 | 28,86 |
| 65+ | 2,172 | 18,76 |

Table 3 reports listening data by radio station and age, gender, and age-gender combination. These data reveal substantial differences in preferences across sociodemographic groups. Appendix A shows the results of the two-sample T-test of AQH-rating for different sociodemographic groups. The test statistics that are marked by an asterisk indicate that the difference between the mean AQH-rating is significant. Teenagers mostly listen to Radio 538 and Q-Music and the popularity of these radio stations decline with age. On the other hand, people over 65 have a strong preference for ORN as 35.8% of the people in this age group tune in to these radio stations. [10] The listening choices of middle-aged people center around 6 radio stations which are Radio 538, Q-Music, Sky Radio 101FM, Radio 3FM, and Radio 2 of which the latter two are public radio stations. The table also shows that listening choices do not differ greatly across listeners of similar ages but these choices increasingly become different as the age gap widens. The listening preferences of men and women are quite similar. There are some notable exceptions when comparing men and women of different age groups. Radio 2 and Sky Radio 101FM are more popular among women whereas Radio 3FM and Radio Veronica are more popular among men.

The table in Appendix B shows the correlations between each sociodemographic group's listening choices, advertising revenue, spotprice, the quantity of ads, and gross rating points (GRP). The GRP are defined only for the relevant sociodemographic group. The correlations among the the age groups show the same pattern as described above.

[10] ORN refers to all regional public radio stations that together have national reach in The Netherlands.

**Table 3. Listening Patterns by Age and Gender (2006)**

| Radio station | all | 10-19 | 20-34 | 20-49 | 35-49 | 50-64 | 65+ | men | women | m2034 | m2049 | m3549 | w2034 | w2049 | w3549 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arrow Classic Rock | 1.55 | 1.82 | 1.18 | 1.99 | 2.62 | 1.42 | 0.35 | 2.02 | 1.02 | 1.37 | 2.48 | 3.33 | 0.95 | 1.39 | 1.71 |
| Arrow Jazz FM | 0.58 | 0.17 | 0.51 | 0.70 | 0.80 | 0.51 | 0.40 | 0.66 | 0.47 | 0.46 | 0.75 | 0.97 | 0.62 | 0.63 | 0.61 |
| Caz | 1.89 | 5.10 | 4.30 | 2.88 | 1.75 | 0.45 | 0.09 | 1.82 | 1.99 | 3.88 | 2.78 | 1.92 | 4.83 | 3.01 | 1.56 |
| Classic FM | 1.89 | 0.22 | 0.41 | 0.68 | 0.91 | 2.57 | 4.90 | 1.63 | 2.18 | 0.39 | 0.61 | 0.77 | 0.45 | 0.79 | 1.07 |
| E-power Radio | 2.50 | 3.26 | 4.39 | 3.61 | 2.98 | 1.33 | 0.73 | 2.90 | 2.04 | 4.82 | 4.07 | 3.45 | 3.80 | 3.00 | 2.37 |
| ORN | 14.72 | 3.71 | 2.84 | 4.35 | 5.51 | 23.43 | 35.80 | 13.04 | 16.64 | 2.85 | 3.50 | 4.04 | 2.83 | 5.39 | 7.44 |
| Q-Music | 5.87 | 14.32 | 10.74 | 8.78 | 7.21 | 2.04 | 0.23 | 5.33 | 6.50 | 8.40 | 7.60 | 6.95 | 13.69 | 10.31 | 7.59 |
| Radio 1 | 7.31 | 2.18 | 1.87 | 3.12 | 4.09 | 9.64 | 17.83 | 6.88 | 7.81 | 2.03 | 3.25 | 4.26 | 1.73 | 2.92 | 3.90 |
| Radio 10 Gold | 4.82 | 3.77 | 1.31 | 3.64 | 5.50 | 8.32 | 3.47 | 4.26 | 5.44 | 0.74 | 2.77 | 4.40 | 2.05 | 4.73 | 6.87 |
| Radio 2 | 10.98 | 5.45 | 3.15 | 8.28 | 12.40 | 16.77 | 12.18 | 9.96 | 12.20 | 2.69 | 6.91 | 10.31 | 3.73 | 10.06 | 15.12 |
| Radio 3FM | 7.70 | 7.53 | 16.89 | 12.88 | 9.66 | 2.08 | 0.82 | 9.66 | 5.39 | 20.20 | 15.83 | 12.34 | 12.68 | 9.10 | 6.25 |
| Radio 4 | 1.82 | 0.29 | 0.41 | 0.61 | 0.78 | 2.37 | 5.05 | 1.64 | 2.01 | 0.30 | 0.61 | 0.87 | 0.54 | 0.60 | 0.65 |
| Radio 5 | 1.03 | 0.23 | 0.12 | 0.27 | 0.37 | 1.19 | 3.37 | 0.73 | 1.40 | 0.10 | 0.21 | 0.28 | 0.13 | 0.35 | 0.50 |
| Radio 538 | 11.33 | 20.82 | 22.11 | 17.23 | 13.33 | 4.39 | 1.19 | 12.91 | 9.52 | 22.71 | 18.88 | 15.83 | 21.38 | 15.13 | 10.10 |
| Radio Veronica | 5.26 | 3.55 | 8.39 | 8.30 | 8.23 | 2.54 | 0.91 | 6.69 | 3.58 | 9.61 | 10.16 | 10.57 | 6.85 | 5.94 | 5.20 |
| Sky Radio 101 FM | 9.77 | 11.25 | 8.79 | 11.12 | 12.98 | 10.32 | 4.53 | 8.17 | 11.58 | 6.07 | 7.78 | 9.14 | 12.27 | 15.38 | 17.87 |
| Slam!FM | 1.44 | 5.95 | 3.22 | 1.95 | 0.94 | 0.30 | 0.00 | 1.76 | 1.02 | 3.69 | 2.24 | 1.06 | 2.61 | 1.60 | 0.78 |

The listening choices of the age group 10-19 are highly collinear with the choices of the age group 20-34 and 35-49 with a correlation of 0.80 and 0.71, respectively. The correlation is negative between the age group 10-19, 20-34, and 35-49 and the age group 50-64 and 65+. The listening choices of men and women are positively correlated for all age groups where the correlations are higher for men and women in the same age group. The correlations between age and the measures of advertising are highest for people between 10 and 50 years of age. In contrast, correlations between people over 50 years of age and the advertising measures are negative. Finally, the correlation for each sociodemographic group and its respective GRP is negative.

# 5 Empirical Specification

This section presents the model of demand for the radio broadcasting industry which takes into account the interaction between the two sides of the market. In particular, there are two demand specifications, one for the listener's side and one for the advertising side. The nested logit specification is used to estimate the listener demand function and an inverse advertising demand is specified for the advertisers' side of the market. The nested logit model is a popular choice in empirical research on differentiated products because it is computational simple. This computationally simplicitly, however, comes at a cost because it places somewhat restrictive assumptions on the substitution patterns. However the substitution patterns assumed in the nested logit model are far less restrictive than the substitution patterns assumed in the logit model.

## 5.1 Listener's demand

The nested logit model classifies the radio stations into $N$ nests and one additional neset for the outside option. Radio stations within the same nest are assumed to be closer substitutes than radio stations from different nests. In the case of the radio broadcasting market, it seems reasonable to assume that the outside option is represented by not listening to radio and constitutes one nest (not listening to radio) whereas the other nest consists of listening to radio. This structure assumes that the choice of a listener from a specific sociodemographic group is twofold. First, an individual decides whether or not to listen to radio, then he or she decides to which radio station to listen. This implies that listeners are more likely to switch to other radio stations than to turn off the radio.

Listeners are assumed to listen to one radio station that maximizes the utility of the listener. This is a reasonable assumption in the radio broadcasting market where listeners cannot listen to several radio stations simultaneously. The demand equation for listeners which is derived from the utility function given in equation (2) is the following:

$$\ln(s_{jgt}) - \ln(s_{0gt}) = \alpha^L \ln(A_{jt}) + \beta^L X_j + \gamma^L D_g + \theta_g^L D_g * X_j^f + \sigma \ln(s_{jgt|n}) + \epsilon_{jgt} \qquad (4)$$

where the subscript $j$ refers to a radio station with $j = 1, ..., J$, the subscript $g$ refers to a specific sociodemographic group, and the subscript $t$ refers to time. Following Nevo (2000), a market is defined as a group-two-monthly combination where a group is defined on the basis of age. In this specification the term $\alpha^L \ln(A_{jt}) + \beta^L X_j + \epsilon_{jgt}$ captures the mean utility of listening as opposed to not listening whereas $\sigma$ is the substitution parameter. The term $A_{jt}$ is the amount of advertising by radio station $j$ at time $t$. The elements in $X_{jt}$ are observed characteristics and include format dummy variables, a dummy for radio stations that do not broadcast on the FM-band, a dummy

for public radio stations, and a dummy for regional radio stations. The term $D_g$ includes group dummy variables and $D_g * X_j^f$ is an interaction effect between the format dummy variables and the group dummy variables. Finally, $\epsilon_{jgt}$ is a market-specific quality characteristic of radio station $j$ that is unobserved to the researcher.

The market share of radio station $j$ of group $g$ at time $t$ is denoted by $s_{jgt}$. The market shares are defined over the total potential market size, $M_t$. So if radio station $j$ has $q_{jgt}$ listeners in group $g$ then the market share for this radio station is $s_{jgt} = q_{jgt}/M_t$. The market share of the outside option is defined as the total market size minus the sum of the listeners of all radio stations relative to total market size, that is, $s_{0gt} = (M_t - \sum_{j=1}^{J} q_{jgt})/M_t$. The within-group market share of radio station $j$ in nest $n$ in group $g$ is defined as the number of listeners to radio station $j$ relative to the total number of listeners in nest $n$. So the within market share is equal to $s_{jgt|n} = q_{jgt}/\sum_{j=1}^{J} q_{jt}$.

The within group market shares ($s_{jgt|n}$) are by definition endogenous and need to be instrumented. It is common in the literature on discrete choice models of product differentiation to use the average of the characteristics of radio stations in the same market as instruments (Berry (1994); Nevo (2000)). This paper uses the average costs of competing radio stations as instruments. In addition, the size of the group population is included as an instrument. Both are appropriate instruments because they are both exogenous to the decision of a single radio station but are correlated with the within group market share.

The amount of advertising, $A_{jgt}$, is also expected to be correlated with $\epsilon_{jgt}$. If for some exogenous reason many people listen to radio it is also expected that this has a positive impact on advertising because advertisements become more effective as they reach more people. The average time spent listening (TSL) of other radio stations is used as an instrument for the amount of advertising. If listeners listen longer to a radio station they are also more likely to be exposed to advertisements. The listener demand function given in equation (4) is estimated by two-stage least squares (2SLS).

## 5.2 Advertising demand

A radio station produces revenue by 'selling' its listeners to advertisers. The approach by Rysman (2004) is followed in which the advertising price increases in market shares because this provides a better fit with the data as can be seen from Table 2. The inverse advertising demand curve is specified as:

$$p_{jt} = A_{jt}^{\alpha^A} s_{jgt}^{\delta} \pi_{jgt}$$

where $A_{jt}$ is the amount of advertising by radio station $j$ at time $t$, $s_{jgt}$ is the market share of radio station $j$ of group $g$ at time $t$, and $\pi_{jgt}$ is the profit of advertisers from the number of times a person is confronted with an advertisement. The parameter $\alpha^A$ is expected to be positive to allow the advertising price to increase with listening shares. In practice, the inverse advertising demand curve is specified as a log-linear function:

$$\ln p_{jt} = \alpha^A \ln(A_{jt}) + \delta \ln(s_{jgt}) + \beta^A X_j + \gamma^A P_g + \theta_g^A P_g * X_j^f + \nu_{jgt} \tag{5}$$

In this specification the term $\ln \pi_{jgt}$ is captured by a linear function of observable variables and an unobservable term $\nu_{jgt}$. The term $P_g$ is the proportion of listeners within age group $g$. The advertising price that is used in this paper differs from the specification of Berry & Waldfogel (1999). Berry & Waldfogel (1999) define the advertising price as the annual advertising revenue

per listener. They construct this measure for advertising price based on total revenue figures for each market and therefore calculate a market price for advertising. In contrast, this paper has a unique price for each radio station because our dataset has detailed firm-level information on advertising prices.

Since advertising prices depend on quantities and thus on market shares, the term $\ln(s_{jgt})$ is expected to be correlated with the term $\nu_{jgt}$. The amount of advertising, $A_{jt}$, is also instrumented for because if for some unobservable reason advertiser's willingness to pay would be high the amount of advertising is also expected to be high. Therefore instruments are used for the market share and the amount of advertising of radio station $j$ and include the average costs and average time spent listening to competing radio stations. Again 2SLS is used to estimate equation (5).

# 6 Results

This section presents parameter estimates from the model and discusses the implication of these estimates. Table 4 shows the estimation results for the listen demand equation and ad price equation for both the sociodemographic groups based on age (age groups 10-19, 20-34, 35-49, 50-64, and 65+).

The parameter estimates for the listener demand function for the different age groups without interaction effects are given in the first column of Table 4. Radio stations that do not broadcast over the FM-band have lower listening shares whereas public radio stations have a higher listening share. The hits format dummy is positively significant suggesting that listeners prefer to listen hits compared to pop formats. On the other hand, the format dummies news and classic are significantly negative indicating that the excluded pop format is a more popular choice. The group dummies are all positive and significant implying that listeners in the age groups 20-34, 35-49, 50-64, and 65+ listen more to radio than the

The amount of advertising is positive implying that listeners do not dislike advertising. There are two possible explanations for this positive effect. First, radio stations might strategically set their advertising slots. Radio stations often have similar advertising slots around the hourly broadcasting of the news. Therefore, switching from radio stations will often lead to exposure to advertisments broadcasted by other radio stations. Secondly, switching between radio stations is not as likely as in other media channels. Radio listening is performed as a side activity while watching television and reading magazines is a main activity. Finally, the coefficient of the within-nest listening share is .898 indicating that there is business-stealing among radio stations.

The parameters of the listener demand function including interaction effects is given in the third column of Table 4. There are some differences compared to the previous specification. First, the regional dummy becomes significant and the format dummy for hits becomes negative. Moreover, the age group 50-64 turns insignificant while the age group 65+ becomes negative. The interaction effects indicate that the listeners in the age group 20-34 tend to listen more to pop music than listeners in the age group 10-19. For the other age groups, 35-49, 50-64, and 65+, the results show that these listeners listen less to pop than do listeners in the age group 10-19.

For both equations the Anderson canonical correlations likelihood-ratio test rejects the null hypothesis of underidentification at the 5% level while the Hansen J test does not reject the null hypothesis of valid instruments.

The parameters of the ad demand function for the different age groups without interactions is given in the second column of Table 4. This specification only includes 391 observations because

each radio station only charges a singly price. Advertisers receive a discount on public and regional radio stations and radio stations broadcasting classical music. Advertisers pay a premium for radio stations broadcasting on the FM-band, broadcasting news, and attracting listeners from the age group 20-34. This might be due to a smaller overall reach across different listenplaces. Radio stations that broadcast on the FM-band can be received in the car and at work whereas radio stations that broadcast via other channels such as cable can only be easily received at home. Radio stations that can be received on several listenplaces are able to charge a premium to advertisers.

**Table 4. Results from the nested logit model - 2SLS**

| Variable | $\ln(\frac{s_{jgt}}{s_{0gt}})$ | $\ln(p_{jt})$ | $\ln(\frac{s_{jgt}}{s_{0gt}})$ | $\ln(p_{jt})$ |
|---|---|---|---|---|
| Constant | -6.496 | 3.116 | -7.011 | 1.861 |
| | (.115)*** | (1.02)*** | (.175)*** | (1.362) |
| No FM | -0.039 | -0.311 | -0.063 | -0.225 |
| | (.017)** | (.069)*** | (.024)*** | (.092)** |
| Public | 0.069 | -0.133 | 0.14 | -0.042 |
| | (.012)*** | ( .055)** | (.018)*** | (.080) |
| Regional | 0.022 | -0.100 | 0.057 | -0.208 |
| | (.014) | (.057)* | (.017)*** | (.132) |
| Hits | 0.052 | -0.009 | -0.083 | 0.227 |
| | (.011)*** | (.112) | (.023)*** | ( .127)* |
| News | -0.044 | 0.671 | -0.381 | -4.053 |
| | (.015)*** | (.264)** | (.038)*** | (4.766) |
| Classic | -0.083 | -0.921 | -0.37 | -4.331 |
| | (.012)*** | (.036)*** | (.032)*** | ( 1.932)* |
| 20-34 | 0.119 | 1.471 | 0.321 | 1.396 |
| | (.011)*** | ( .875)* | (.026)*** | (1.370) |
| 35-49 | 0.165 | 1.115 | 0.254 | 1.152 |
| | (.012)*** | (.781) | (.024)*** | (1.656)*** |
| 50-64 | 0.136 | 1.458 | 0.003 | 3.940 |
| | (.012)*** | (.957) | (.018) | (2.078)** |
| 65+ | 0.068 | -0.690 | -0.229 | -2.246 |
| | ( .012)*** | ( .971) | (.023)*** | (1.528) |
| Advertising | 0.047 | 0.059 | 0.102 | 0.207 |
| | (.013)*** | (.081) | (.019)*** | (.065)*** |
| $\ln s_{jgt\|n}$ | 0.898 | | 0.809 | |
| | (.005)*** | | (.013)*** | |
| $\ln s_{jgt}$ | | 0.787 | | 0.689 |
| | | (.092)*** | | (.129)*** |
| 20-34*Hits | | | -0.135 | 1.295 |
| | | | (.026)*** | (.752)* |
| 20-34*News | | | -0.106 | 3.597 |
| | | | (.036)*** | (5.009) |
| 20-34*Classic | | | -0.131 | 4.331 |
| | | | (.026)*** | (2.151)** |
| 35-49*Hits | | | 0.164 | -1.076 |
| | | | (.027)*** | (.913) |
| 35-49*News | | | 0.136 | 3.149 |
| | | | (.037)*** | (5.060) |
| 35-49*Classic | | | 0.089 | 4.550 |
| | | | (.028)*** | (2.377)* |
| 50-64*Hits | | | 0.439 | -2.362 |
| | | | (.042)*** | ( 1.222)* |
| 50-64*News | | | 0.573 | 3.596 |
| | | | (.053)*** | ( 5.095) |
| 50-64*Classic | | | 0.446 | 2.343 |
| | | | (.046)*** | (2.663) |
| 65+*Hits | | | 0.46 | 2.104 |
| | | | (.047)*** | (1.992) |
| 65+*News | | | 0.873 | 6.218 |
| | | | (.07)*** | (5.094)*** |
| 65+*Classic | | | 0.678 | 6.191 |
| | | | (.066)*** | ( 2.158)** |
| Hansen J Test | 1.642 | na | 1.208 | na |
| p-value | 0.200 | | 0.272 | |
| LM statistic | 247.080 | 22.520 | 187.996 | 23.821 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |

*** Significant at the 1% confidence level

The number of observations is 1872

The specification for ad demand with interaction effects is shown in the fourth column of Table 4. An interesting finding is that radio stations with high listening shares in the age group of 35-49 and 50-64 charge higher spot prices. These age groups are also the groups with the highest income (see Table 2). Only two of the format dummies are significant which are the dummy for radio stations broadcasting mainly hits and radio stations that focus on classical music. The format hits is positive while the format classical is negative. Both are negative suggesting that advertisers receive a discount for these formats. The interaction effects show that the interactions of 20-34 with hits and classic, of 35-49 and classic, and of 65+ and news and classic are significantly positive. The only significantly negative interaction effect is 50-64 with hits. The quantity of advertisement is also positively related with spot prices. Finally, audience size has an impact on the spot price. This indicates that the quantity of listeneres also matters.

For both equations the Anderson canonical correlations likelihood-ratio test rejects the null hypothesis of underidentification at the 5% level. The Hansen J test cannot be performed because the equation is exactly identified.

# 7 Conclusion

The main question of this paper is whether audience composition is an important aspect in the Dutch radio broadcasting industry. A two-sided model of listener demand for radio stations and advertiser demand for audience is estimated to quantify this effect. Moreover a market is defined on the basis of sociodemographic characteristics. We find that listeners from different age groups have dissimilar preferences for radio formats especially as the age gap widens. Moreover listeners within in a given age group perceive radio stations as strong substitutes. A remarkable but consistent finding is that listeners do not dislike advertisement. A possible explanation for this effects is either the simultaneous timing of advertising slots or that listening to radio is mainly performed as a side activity.

On the advertising side we find that advertisers pay a premium for radio stations that attract many listeners from the age groups 35-49 and 50-64. On the other hand, radio stations that do no broadcast on the FM-band charge a discount probably due to their smaller coverage across different listenplaces such as the car and at work where these radio stations are more difficult to receive. Only two formats have a significant effect on advertising prices for the markets based on age groups which are the regional format and news format for which advertisers receive a discount. Summarizing, audience composition is most important for different age groups and especially as the age gap widens. Furthermore, advertisers receive discounts and premiums but this does not depend on the audience composition.

There are several interesting directions for future research. A model can be estimated for different geographic markets which includes information about audience composition. However, due to the lack of data for the Dutch radio broadcasting of detailed ratings data this is at the moment not possible. A possible solution is to combine national and regional ratings data and assuming distributions for sociodemograpic characteristics. Furthermore, the choices of advertisers can be more explicitly modeled by taking into account the individual decisions of advertisers. Finally, an interesting extension to this paper is to specify and estimate the supply side of the radio broadcasting industry which also takes into account the presence of public radio stations since they constitute almost half of total listening. Counterfactual experiments can then be used to see whether there is still a rationale for public radio stations. Moreover the possible effects of the introduction of digital radio can be analyzed because digital radio will be introduced in the near future in The Netherlands.

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**Appendix A - Two Sample T-test(2006)**

| Group | 10-19 | 20-34 | 20-49 | 35-49 | 50-64 | 65+ | men | women | m2034 | m2049 | m3549 | w2034 | w2049 | w3549 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all | **8.02*** | 0.23 | -0.11 | -0.47 | -1.49 | -1.38 | -1.12 | 1.19 | -1.37 | -1.85 | **-2.24*** | **2.18*** | 1.87 | 1.42 |
| 10-19 | | **-6.11*** | **-7.39*** | **-7.94*** | **-6.80*** | **-5.42*** | **-8.87*** | **-6.65*** | **-6.66*** | **-8.06*** | **-8.99*** | **-4.98*** | **-5.96*** | **-6.01*** |
| 20-34 | | | -0.31 | -0.61 | -1.67 | -1.74 | -1.14 | 0.74 | -1.55 | -1.90 | **-2.20*** | 1.58 | 1.27 | 0.95 |
| 20-49 | | | | -0.32 | -1.48 | -1.56 | -0.90 | 1.15 | -1.35 | -1.73 | **-2.04*** | 2.05* | 1.73 | 1.37 |
| 35-49 | | | | | -1.20 | -1.31 | -0.58 | 1.50 | -1.07 | -1.44 | -1.75 | **2.40*** | **2.09*** | 1.71 |
| 50-64 | | | | | | -0.19 | 0.62 | **2.27*** | 0.11 | -0.14 | -0.36 | **2.97*** | **2.73*** | **2.43*** |
| 65+ | | | | | | | 0.68 | **2.01*** | 0.26 | 0.05 | -0.13 | **2.59*** | **2.38*** | **2.15*** |
| men | | | | | | | | **2.12*** | -0.56 | -0.91 | -1.21 | **3.02*** | **2.72*** | **2.33*** |
| women | | | | | | | | | **2.15*** | **2.69*** | **3.10*** | 0.98 | 0.62 | 0.25 |
| m2034 | | | | | | | | | | -0.25 | -0.48 | **2.85*** | **2.61*** | **2.31*** |
| m2049 | | | | | | | | | | | -0.24 | **3.46*** | **3.21*** | **2.86*** |
| m3549 | | | | | | | | | | | | **3.89*** | **3.64*** | **3.27*** |
| w2034 | | | | | | | | | | | | | -0.39 | -0.71 |
| w2049 | | | | | | | | | | | | | | -0.35 |
| w3549 | | | | | | | | | | | | | | |

* denotes signifance at the 5% level

The two sample T-test is based on AQH-rating

**Appendix B - Correlations(2006)**

| Group | 10-19 | 20-34 | 20-49 | 35-49 | 50-64 | 65+ | men | women | m2034 | m2049 | m3549 | w2034 | w2049 | w3549 | adrevenue | spotprice | qads | GRP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all | 0.38 | 0.24 | 0.42 | 0.57 | 0.77 | 0.66 | 0.94 | 0.95 | 0.21 | 0.28 | 0.37 | 0.31 | 0.55 | 0.61 | 0.44 | 0.51 | 0.35 | -0.36 |
| 10-19 | | 0.80 | 0.84 | 0.71 | -0.17 | -0.31 | 0.50 | 0.25 | 0.69 | 0.73 | 0.70 | 0.91 | 0.84 | 0.49 | 0.85 | 0.83 | 0.72 | -0.45 |
| 20-34 | | | 0.93 | 0.63 | -.42 | -0.43 | 0.50 | -0.01 | 0.98 | 0.97 | 0.85 | 0.95 | 0.70 | 0.20 | 0.81 | 0.82 | 0.67 | -0.61 |
| 20-49 | | | | 0.87 | -0.21 | -0.37 | 0.62 | 0.20 | 0.88 | 0.95 | 0.95 | 0.94 | 0.88 | 0.52 | 0.88 | 0.91 | 0.75 | -0.34 |
| 35-49 | | | | | 0.13 | -0.20 | 0.64 | 0.46 | 0.54 | 0.71 | 0.86 | 0.71 | 0.94 | 0.84 | 0.77 | 0.83 | 0.69 | -0.07 |
| 50-64 | | | | | | 0.88 | 0.55 | 0.89 | -0.44 | -0.36 | -0.21 | -0.33 | 0.07 | 0.45 | -0.12 | -0.06 | -0.14 | -0.65 |
| 65+ | | | | | | | 0.49 | 0.75 | -0.41 | -0.42 | -0.38 | -0.42 | -0.22 | 0.05 | -0.26 | -0.22 | -0.23 | -0.52 |
| men | | | | | | | | 0.79 | 0.49 | 0.55 | 0.59 | 0.50 | 0.60 | 0.49 | 0.58 | 0.66 | 0.45 | -0.09 |
| women | | | | | | | | | -0.08 | 0.01 | 0.14 | 0.11 | 0.50 | 0.66 | 0.28 | 0.33 | 0.23 | -0.62 |
| m2034 | | | | | | | | | | 0.97 | 0.83 | 0.88 | 0.57 | 0.07 | 0.73 | 0.75 | 0.59 | -0.54 |
| m2049 | | | | | | | | | | | 0.94 | 0.89 | 0.69 | 0.24 | 0.79 | 0.83 | 0.65 | -0.47 |
| m3549 | | | | | | | | | | | | 0.82 | 0.77 | 0.46 | 0.80 | 0.86 | 0.67 | -0.14 |
| w2034 | | | | | | | | | | | | | 0.83 | 0.38 | 0.87 | 0.87 | 0.75 | -0.61 |
| w2049 | | | | | | | | | | | | | | 0.83 | 0.83 | 0.85 | 0.74 | -0.41 |
| w3549 | | | | | | | | | | | | | | | 0.51 | 0.54 | 0.49 | -0.46 |

GRP refers to Gross Rating points and are defined for only the relevant sociodemographic group