Assessing the Impacts of Audio Home Copying Restrictions

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The ability of digital audio tape (DAT) technology to produce high quality duplicates of audio recordings presents a potential threat to the well-being of the recording industry. This potential threat has generated discussions about whether current copyright law adequately can protect the recording industry. One possible solution is to ban audio home copying. While an audio home copying ban most likely will result in increased industry revenue, jobs, and artists' royalties, there also will be a resulting loss in consumer welfare due to the elimination of the home taping option. This paper estimates econometric models of consumers' purchase/taping choice and uses these models as a basis for determining the consumer welfare loss incurred as a consequence of an audio home copying ban. The findings indicate that a ban will result in a substantial annual net monetary loss to society.

INTRODUCTION

Although the rapid development of technology undoubtedly has produced great overall benefits to society, some technological advances raise important moral and legal questions. Advances in medical technology, particularly those relating to fertilization and genetic engineering, are classic examples. The recent introduction and dissemination of digital audio recording technology are raising important questions about the suitability and intent of current copyright law in the music and recording industry.

This concern is motivated by the fact that digital audio tape (DAT) and the likely development of the recordable compact disc (CD) will give consumers the capability to produce near perfect reproductions of copyrighted recordings, the quality of which will not degrade as successive copies are made. This is a substantial improvement over existing analog technology that produces less than perfect copies that degrade rapidly as successive reproductions are made. The music industry has been quick to point out that such audio reproduction technology could seriously impact recording industry revenue, jobs, and artists' royalties and may be a violation of current copyright law.

In contrast, proponents of digital recording technology have argued that such technology does not constitute a copyright violation and that the whole notion of home copying of audio recordings may stimulate album sales by increasing listening exposure. Digital audio technology creates interesting questions from both economic impact and copyright law perspectives.

This paper provides a brief overview of copyright law as it relates to audio home copying and presents a comprehensive analysis of the potential economic impacts associated with revising copyright law to ban the practice of audio home copying. The analysis shows that recording industry revenues would increase about $1 billion annually if a ban of audio home copying were enacted. The annual welfare loss to consumers resulting from such a ban, however, is estimated to exceed $4 billion. With a potential deadweight loss to society of over $3 billion, the findings of this paper suggest that caution should be

exercised in any effort aimed at revising copyright law to address perceived threats from new audio technologies.

COPYRIGHT LAW AND AUDIO HOME COPYING

Few persons can argue against the need for copyright protection for authors of original work. This protection historically has taken the form of providing the copyright holder with exclusive use and the right to authorize use of the copyrighted work. Such use is defined to include reproduction, distribution, performance, and display. In the U.S. copyright protection was initiated by the first Congress in 1790 with the enactment of the Federal Copyright Act. In 1831 the 1790 statute was revised to include copyright protection to musical compositions. Although U.S. copyright law has undergone a number of revisions since 1831, its basic intent has remained unchanged: to provide a protective environment for the creativity of the author so that the entire public may benefit. This notion of public benefit often is overlook by advocates of strict copyright law that seek to provide near monopolistic powers to copyright holders.

To ensure that an acceptable public benefit is achieved, U.S. copyright law has been structured to allow some flexibility in the interpretation of copyright violation. One key factor in providing this flexibility is the concept of private use. The intent is to allow home copying of copyrighted material providing that such copies are not bought or sold. Language in the 1971 Sound Recordings Amendment to the U.S. copyright law indicates Congress's intent to include audio home copying as a permissible private use. The absence of such explicit language in the subsequent Copyright Act of 1976, however, reopened the matter to interpretation. The 1976 act does allow fair use copying (copying for purposes of research, teaching, news reporting, and criticism), but leaves strict interpretation of fair use in the hands of the courts. Thus, current copyright law with regard to audio home copying is ambiguous and open to interpretation by the courts.

The music industry considers the 1971 Sound Recordings Amendment to be irrelevant because the 1976 law did not define audio home copying as a private use. In contrast, proponents of digital audio technology contend that the 1976 legislation did not change the basic principle of the 1971 amendment which essentially permitted audio home copying.

Given the current status of copyright law with regard to audio home copying, several important questions need to be asked: Does digital audio technology necessitate a revision of the 1976 law to better define fair use, or can the interpretation of fair use be left in the hands of the courts? If copyright law remains unchanged in the presence of digital audio technology, what would be the likely impact on copyright holders and the general public benefit? Finally, if copyright protection is increased to prohibit audio home copying, what impacts will result?

Numerous important studies assessing the economics of copyright laws have been conducted. Novos and Waldman (1984) present a theoretical formulation to test the effects of increased copyright protection on social welfare. Their findings support the notion that increases in copyright protection can lead to net societal benefits due to its beneficial effects on productivity and creativity. Moreover, they find little evidence that restrictive copyrighting results in net societal losses due to the underutilization of the product. This finding contradicts claims made by many digital audio proponents. These proponents

insist that home copying stimulates recording sales and diversity of recording offerings, and product underutilization consequently is likely to result from any restrictions placed on audio home copying.

Theoretical work undertaken by Johnson (1985) establishes that the economic impact that unlimited copying has on social welfare is a function of the elasticity of supply of creative work, the value consumers place on variety, and the effect of copying on demand for originals and total consumption. Johnson's general formulation suggests that the copyright/societal welfare relationship depends heavily on supply and demand elasticities, and these can vary substantially by product and over time.

Liebowitz (1985) explores the notion that the availability of inexpensive copying devices may increase the demand for copyable originals and thus significantly alter the value of copyrighted goods (indirect appropriability). Liebowitz provides some empirical support for this notion by showing that the availability of photocopying technology has not had a detrimental effect on the publishing industry. Liebowitz's empirical findings cast some questions on the earlier theoretical findings of Novos and Waldman with respect to product underutilization.

Finally, the work of Besen and Kirby (1989) offers an important theoretical analysis that builds on earlier literature and addresses the important question of whether the demand for originals reflects the value placed on them only by direct purchasers (direct appropriability) or if the demand also is influenced positively by the value users place on copies (indirect appropriability). Their findings suggest that the effectiveness of copyright protection in improving net social welfare only can be evaluated if the extent of indirect appropriability can be quantified.

The long-term effects of appropriability on net social welfare (Novos and Waldman, 1984) are of primary concern in the digital audio tape issue. Those seeking additional copyright restrictions tend to downplay indirect appropriability, and those supporting DAT technology tend to overstate indirect appropriability. The existing literature and sales statistics are inconclusive with regard to appropriability. Beyond appropriability, however, there is another important, more tractable concern that largely has been overlooked in the literature on copyright law. This concern relates to the short-term losses in consumer welfare resulting from more restrictive copyright laws. Consumers of copyable materials have become accustomed to existing copyright law and have developed behavioral patterns that maximize their utility within this environment. Any restrictive change in copyright law will produce an immediate short-term loss in individual utility. While long-term benefits may result in individuals' utility as a result of the musical diversity and nurturing of talent that presumably is encouraged by strict copyright laws, the short-term losses in consumer welfare may produce political pressure that may force a copyright law revision before potential long-term benefits are realized.

In the economic literature several empirical methods have been applied to reach estimates of consumer welfare changes. Arguably, the most theoretically appealing method is that based on individual consumers' compensating variations. Using individual compensating variations to assess the consumer welfare impacts that would result from a revision of copyright law, this research attempts to determine how much consumers would have to be compensated after an audio home copying ban to feel as well off as before a ban. It fol-

lows that the monetary measure of this required compensation forms the basis of assessing the total loss in consumer welfare attributable to a home copying ban.

Small and Rosen (1981) previously formulated an estimate of consumer welfare using compensating variations and individual discrete choice models. Their formulation has been applied to assess a wide variety of welfare impacts, including the impacts of the voluntary export restrictions on Japanese vehicles in the 1980s (Mannering and Winston, 1987), mandatory automobile safety legislation (Winston and Mannering, 1984), and restricting freeway lanes to high occupancy vehicles (Small, 1983). This study applies Small and Rosen's procedure to assess the impacts of an audio home copying ban. To begin this application and recognize its potential limitations, the underlying audio format decision-making process must be understood.

AUDIO FORMAT DECISION-MAKING PROCESS

The magnitude of the impact of a home copying ban on consumer welfare is a direct outgrowth of the decision-making process by which consumers choose among audio formats (records, prerecorded tapes, made tapes, or compact discs) because this decision-making process ultimately determines the value that consumers place on having the made tape audio format choice available to them. The choice of a specific audio format involves related and time-variant decisions. These decisions can be classified according to musical type preferences, audio equipment, and specific purchase/taping choices.[1]

Musical type preferences, which are defined as choices among classical, country and western, soul, heavy metal, rock, and so on, evolve from cultural, social, and economic influences. These preferences play a key role in the choice of audio equipment and specific purchase/taping choices because certain types of music, such as classical music played on high quality compact discs, tend to benefit more from the use of high quality audio equipment and formats. In turn, consumers' musical type preferences are influenced by their existing stocks of audio equipment.

Apart from musical type preferences and socioeconomic factors, consumer expectations of the frequency and purpose of equipment use are important considerations in the choice of audio equipment. For example, high rates of usage for discriminating purposes are likely to direct users toward owning a quality compact disk player that offers superior sound and little format degradation (wear) associated with repeated use.

The last of the three decisions, purchase/taping choices, differs from the preceding two. Both musical type preferences and audio equipment choices are much longer-term decisions. The short-term nature of the purchase/taping choice, which includes both frequency (e.g., number of purchases and/or tapings per some time period) and choice of specific formats (e.g., record, prerecorded tapes, made tapes or CDs), makes it the obvious focal point for an assessment of the impacts of a ban on home taping because it will be the one audio-related decision that immediately and most significantly will be impacted by a ban. While the longer-term decisions of musical type and audio equipment influence the purchase/taping choice, other factors such as format price, availability and use of substi-

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[1] A purchase/taping choice is defined as a decision either to purchase a prerecorded format (record, prerecorded tape, or compact disc) or to make a tape as a substitute for such a purchase.

tute media,[2] consumers' socioeconomic conditions, consumers' tastes and preferences for specific formats, and consumers' expectations of purchase/taping usage[3] also exert important influence. In developing a defensible model of consumer welfare effects based on audio purchase/taping decisions, it is imperative that the econometric approach incorporate the factors that influence the choice process.

ECONOMETRIC FRAMEWORK

With the emphasis of this study on short-term effects, changes in consumer welfare can be computed by focusing on audio consumers' purchase/taping decisions. This assumes an analysis that is conditional on fixed consumers' musical type preferences and audio equipment stocks.

In considering this conditional purchase/taping decision, two types of audio consumer can be identified: those not having a CD player (who choose among record, prerecorded tape, and made tape option) and those owning a CD player (who have the additional CD format option). Distinguishing CD and non-CD owners is important because the additional format choice available to CD owners provides an inherent format flexibility not available to non-CD owners. With this separation of consumers, separate estimable discrete choice models of purchase/taping choice can be derived for CD player and non-CD player owners.

This research begins by defining an indirect utility function (i.e., prices and incomes as arguments) that describes the indirect utility that consumer k derives from a specific audio format purchase/taping choice:

(1) $U_k = F_k(k, p_{ki}/y_k, I_k, S_k, Z_k, \varepsilon_{ki})$

where:

U_k = The total indirect utility derived from the purchase/taping decision;

i = A particular format choice (e.g., records, prerecorded tapes, made tapes, or CDs);

p_{ki} = Purchase price of format i to consumer k;

y_k = Consumer k's household income;

I_k = Vector of consumer k's existing format inventories (number of long-playing [LP] records, tapes, and CDs);

S_k = Vector of the stock of existing audio equipment (e.g., turntable, tape deck in car, Walkman, etc.);

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[2] Media such as radio and television music videos can act as substitutes for purchase/taping choices. In addition, such media have a strong influence on musical type preferences and may increase the frequency of purchase/taping choices by acting as an advertising forum.

[3] As with audio equipment choice, high expectations of use are likely to influence the choice of purchase/taping format. For example, frequently used recordings may be more likely purchased in the CD format which is less susceptible to wear.

Z_k = Vector of consumer socioeconomic conditions and preferences that influence the choice of format; and

ε_{ki} = Random portion of utility that accounts for unobserved factors influencing consumers' audio choices.

Looking individually at the elements of equation (1), an increasing value of the term p_{ki}/y_k is expected to decrease the utility of format choice i. That is, increasing format price decreases the likelihood of a format being chosen, and the division of price by income reflects the hypothesis that wealthier consumers are less concerned with price. Consumers' format inventories (I_k) increase the utility of format selection because inventories reflect habitual behavior (i.e., they are an outgrowth of previous format choice). Similarly, existing stocks of audio equipment (S_k) capture habitual behavior and are expected to have a positive effect on format utility. For example, with all else equal, a person having an audio equipment stock that includes a car tape deck would extract more utility from the tape format than a person not owning a car tape deck. The socioeconomic and preference variables, Z_k, can capture cultural and musical preferences, among other factors, and their effect on different format alternatives can be positive or negative.

Equation (1) can be estimated with a random utility model. Depending on the distribution of ε_{ki}, a number of alternate probabilistic discrete choice random utility models can be derived. The two most popular formulations are the probit model, which is derived from the assumption that ε_{ki} is a normally distributed random variable, and the multinomial logit model, which is derived from the assumption that ε_{ki} is an independently identically distributed Gumbel variate (McFadden, 1981). The logit model has an important computational advantage over its probit counterpart, a closed-form likelihood function, which simplifies estimation. Moreover, the logit model is a more versatile model, as it has a well-behaved likelihood function that allows likelihood convergence to be achieved even when high multicollinearity exists among explanatory variables (Train, 1986). As a result, I selected it for this paper. The multinomial logit model is written as:

$$(2) \quad P_{ki} = \exp[V_{ki}]/\Sigma_j \exp(V_{kj}),$$

where:

P_{ki} = Probability of consumer k selecting format i;

V_{ki} = Mean indirect utility of format alternative i to consumer k (i.e., all elements of the random utility function except ε_{ki}; $V_{ki} = U_{ki} - \varepsilon_{ki}$); and

j = Set of available formats.

It can be shown that the natural log of a logit model's denominator, $\ln\Sigma_j \exp(V_{kj})$, is the expected maximum indirect utility from the choice process (McFadden, 1981). This term is referred to as the *logsum* or *inclusive value*. Small and Rosen (1981) show that the natural log of the denominator can be used as a basis to calculate changes in individual consumers' compensating variations and, subsequently, changes in overall consumer wel-

fare. Considering a consumer's indirect utility before and after the imposition of an audio taping ban, a consumer's compensting variation can be computed (Small and Rosen, 1981) as:

$$(3) \quad CV_k = [-1/\lambda_k][\ln\Sigma_j\exp(V_{kj})],_{V_k^o}^{V_k^f}$$

where:

CV_k = Compensating variation for consumer k;

λ_k = Marginal utility of income;

V_{kj} = Mean indirect utility;

j = Set of available format options;

V_k^o = Vector of all V_{kj} before a ban; and

V_k^f = Vector of all V_{kj} after a ban.

The right-hand term in brackets defines the expected maximum utility obtainable from the available format choices, the logsum. The difference in this expected maximum utility from before a ban to after a ban is multiplied by the inverse of the marginal utility of income (as indicated in equation (3)), which is the dollar value of a unit of marginal utility, to arrive at the compensating variation. Thus, equation (3) gives the difference in an individual's expected utility before and after a ban, and the marginal utility of income is used to convert this difference in utility (which is unitless) into a dollar amount.

To estimate a logit model as specified in equation (2) and subsequently arrive at an estimate of individual compensating variation, a functional form of the indirect utility must be provided. Specifying a functional form is necessary to estimate the logit model using maximum likelihood procedures. While nonlinear functional forms are always an option, linear forms are preferred on empirical grounds unless there are compelling theoretical reasons to suggest nonlinearities. Because no such theoretical evidence exists in this case, I specified the following linear function:

$$(4) \quad V_{ki} = \beta_{0i} + \beta_1(p_{ki}/y_k) + \beta_{2i}I_k + \beta_{3k}Z_k + \beta_{4i}S_k,$$

where:

β's = Coefficients estimable by standard maximum, likelihood methods (Train, 1986).

Once the coefficients of the indirect utility function are estimated, equation (3) can be applied to compute the changes in consumer welfare resulting from the imposition of an audio taping ban, with the marginal utility of income, λ_k, equalling the purchase price income coefficient (β_1) in equation (4) divided by household income (y_k).

Two additional issues must be addressed in applying equation (3) to estimate the total loss in consumer welfare resulting from a home copying ban: the determination of post-ban utilities, V_k^f, and the impact of purchase/taping frequency when aggregating individual consumer compensating variations. Traditionally, postpolicy utilities, V_k^f, are calculated by incorporating the changes produced by the policy (e.g., price) into the utility expression for the affected alternative(s). Because the home copying ban eliminates one alternative entirely, equation (3) must be rearranged appropriately. To start, note that equation (3) can be written as:

$$(5) \quad CV_k = [-1/\lambda_k][\ln\Sigma_j P_{kj}^o \exp(\Delta V_{kj})],$$

where:

P_{kj}^o = Initial probability of consumer k selecting format j; and

ΔV_{kj} = Change in utility resulting from a ban.

Because the removal of the made tape option is equivalent to setting $\Delta V_{kmt} = -\infty$ (where subscripting mt denotes the made tape option) and because the other options are assumed to be unaffected by a ban,[4] equation (5) becomes:

$$(6) \quad CV_k = [-1/\lambda_k][\ln(1-P_{kmt}^o)].$$

This equation provides the proper measure of consumers' compensating variation resulting from the elimination of the made tape option.

Because consumers with higher purchase/taping frequencies face welfare losses more often, the determination of a society average purchase/taping choice compensating variation must take this into account. Thus, in computing the average compensating variation per purchase/taping choice, individual compensating variations must be weighted by consumers' reported purchase/taping frequencies.

EMPIRICAL APPROACH AND LIMITATIONS

The focus on only the purchase/taping choice (as opposed to a complete model of choices including musical type preferences and audio equipment stocks as previously dis-

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[4] In this study, postban utilities do not include the utility effects of changes in format price that may result, nor do they include the utility effects of changes in musical type preferences, audio equipment stock, purchase/taping frequencies, or media use. Although the direction of bias resulting from the exclusion of such effects on format utilities is not clear, the fact that most excluded effects are longer term in nature suggests that the compensating variation figure that is obtained under these assumptions is a reasonably accurate portrayal of actual short-term impacts (e.g., first year after a ban).

cussed) is not without its costs in terms of potential effects on the the accuracy of subsequent copying ban welfare computations. Two general problems arise in this regard: those relating to model limitations and those relating to surveying procedures.

A key modeling limitation arises from the fact that there is no explicit account for longer-term choices. Without consideration of such choices, the effect of an audio home copying ban on consumers' choice of audio equipment and musical type preferences cannot be assessed.[5] Furthermore, one would have to estimate the shifts in format purchase prices that are likely to occur as a result of a home copying ban.[6] Thus, as the previous model formulation shows, the present analysis assumes that consumers' musical type preferences, audio equipment stocks, and format purchase prices remain constant in the face of a home copying ban. The effect of this assumption on welfare loss computations is ambiguous, primarily because industry pricing of formats and audio equipment following a ban is not predictable.

Another modeling concern arises from the relationship between the frequency of audio format purchase/taping choices and specific audio purchase/taping choices. This relationship results from the fact that frequency is related not only to factors such as socioeconomics, musical type preferences, and the availability and use of substitute media, but also to the utility derived from specific purchase/taping format choices. Consequently, frequency and individual purchase/taping choices should be modeled jointly, but such a joint model would require detailed information on a number of individual purchase/taping decisions—a requirement that cannot be met without extensive panel data (which are not currently available). In the absence of necessary data, I must assume how the frequency of purchase/taping decisions will be affected by an audio home copying ban.[7]

The second class of problems relates to surveying procedures. In focusing on specific purchase/taping decisions, it is necessary to use a surveying strategy that uncovers some past decision in which the consumer had to choose among records, prerecorded tapes, compact discs, and made tapes. A convenient approach is to ask consumers to recall their most recent listening experience and determine the musical selection/format that they listened to at that time, as well as length of time that they owned that specific musical selection/format. This uncovers a purchase/taping decision that was made when the format first was purchased or taped at home (as determined from the length of ownership

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[5] Intuitively, in the absence of the home taping option, consumers can be expected to adjust audio equipment stocks (e.g., redirect investment toward noncopying stocks) and musical type preference (e.g., they may be directed to musical types that typically are discounted in an effort to keep their audio budget constant).

[6] Estimation of such price shifts would require an equilibrium model that includes a model of industry pricing behavior as well as a complete model of consumer purchasing behavior (i.e., including long-term decisions relating to musical type preferences and audio equipment choices). Such a model could be used to predict equilibrium format prices following a ban. Unfortunately, the extensive data required to develop such an equilibrium model are not available for the audio market. See Berkovec (1985) or Mannering and Winston (1987) for examples of such models as applied to the automobile market.

[7] One would expect that a home copying ban would reduce the number of purchase/tapings (i.e., the frequency) made because the taping alternative would be eliminated. At least some additional purchases are likely to be generated, however, thus moving the total number of purchase/tapings closer to the levels before a ban.

response). Use of this approach to uncover a specific past purchase/taping decision creates two concerns. First, purchase/taping decisions that occurred many years ago are problematic because consumers may have had musical tastes and audio equipment stocks (both quantity and quality) that differ greatly from those reported at the time of the survey. To mitigate this, only purchase/taping decisions made during the year preceding data collection will be considered. The second concern relates to the fact that the most-recent-listening-experience approach is likely to uncover past purchase/taping decisions that resulted in format choices that tend to be used more heavily. To the extent that usage and format choices are related, some bias will be introduced in the estimation of specific purchase/taping format choice models and in subsequent welfare loss computations.[8]

With these limitations in mind, attention can be directed to the empirical estimation of the format-choice multinomial logit model (equation (2)) and compensating variation estimates (equation (6)). The logit model coefficients are estimated using a survey of audio consumers, and this survey is summarized below.

SURVEY RESULTS

A cross-sectional survey of audio consumers was conducted by Schulman, Ronca, and Bucuvalas, Inc. under contract to the Office of Technology Assessment, U.S. Congress (U.S. Congress, Office of Technology Assessment, 1989). Fifteen hundred and one respondents were interviewed by telephone in September and October 1988. The requirement that audio consumers' most recent listening experience be a musical selection/format that they had owned for one year or less reduces this sample to 517 respondents. Four hundred of the respondents do not own CD players and 117 own CD players. Because separate logit models are estimated for CD and non-CD owners, Table 1 presents summary statistics for each of these groups.

Table 1 presents the percentages of respondents choosing each audio format for the last listening experience. The table indicates that prerecorded tapes are the preferred format among non-CD owners, whereas compact discs are the preferred format among CD owners. The made tape option is the least preferred for non-CD owners, and records and made tape options are least preferred for CD owners.[9]

A comparison of CD and non-CD owner format inventories shows that CD owners have larger inventories, on average, of all formats and also have substantially higher purchase frequencies (as indicated by the reported number of purchases in the last month). This suggests, as expected, that respondents owning a CD player are more active audio consumers. The socioeconomic comparison of the two groups offers few surprises; CD

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[8] Elimination of such bias can be achieved by the application of standard econometric procedures relating to related discrete/continuous choice (Train, 1986). Unfortunately, a cross-sectional sample that is much more extensive than the one available for use in this study, in terms of frequency of use information, is needed to implement such econometric procedures. To estimate an related model of use and format choice, a diary-based survey of consumers' listening habits would be needed wherein consumers would note their audio listening behavior over a period of several weeks. The expense of conducting such as a survey is prohibitive.

[9] While records include long-playing (LP), extended-playing (EP), and 45s, LPs/EPs are far and away the most dominant choice among the majority of respondents. There seem to be a relatively small number of persons using 45s, but these individuals tend to be relatively frequent purchasers with large inventories.

**Table 1—Summary Statistics of Surveyed Audio Consumers
(Averages unless otherwise noted)**

	Non-CD Owners	CD Owners
Percent choosing long playing (LP) record format	17.0	10.26
Percent choosing prerecorded tape format	75.0	28.21
Percent choosing made tape format	8.0	10.26
Percent choosing compact disc (CD) format	-	51.27
Annual household income (dollars)	32,140	40,120
LP record inventories	43.2	60.5
Prerecorded tape inventories	26.1	34.4
Made tape inventories	14.7	29.1
CD inventories	-	27.6
Percent with car tape deck	74.3	86.3
Percent white/non-white	85/15	87/13
Percent male/female	38/62	58/42
Age (years)	34.6	30.5
Education (years)	12.6	12.7
Percent with full-time employment	49	61
Number of LP record, prerecorded tape, and CD purchases in the last month	0.21	1.57
Number of household members	3.18	3.18
Percent indicating sound quality is extremely important to listening	25.5	58.1

Data source: Survey commissioned by U.S. Congress, Office of Technology Assessment

owners are younger, more likely to have full-time employment, and more wealthy than their non-CD owning counterparts.

Given these general summary statistics, attention can be directed toward actual estimation of the format-choice logit model and changes in compensating variations.

LOGIT MODEL ESTIMATES

Multinomial logit estimates of the purchase taping choice (i.e., equation (2)) are presented in Tables 2 and 3 for consumers not having a CD player and those having a CD player, respectively.[10] The overall statistical fit of both models indicates that they are significant at over the 99.99 percent confidence level.

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[10] As mentioned above, the fact that these purchase/taping models are not considered jointly with the choice of purchase/taping frequency is a possible source of coefficient estimation bias. Although impossible to prove empirically, this potential bias would tend to be mitigated by two factors. First, CD and non-CD owners are distinguished by the frequency of purchase/tapings (Table 1). Therefore, the separate

Most coefficient estimates are statistically significant, as indicated by t-statistics, and are consistent with their hypothesized effect on utility, as discussed in the presentation of the indirect utility function (equation (1)) in the non-CD model (Table 2). The constant term estimates indicate a mean preference for prerecorded tapes (although this preference is not statistically significant relative to records) and against made tapes relative to the record format option.[11] The negative relative preference for made tapes apparently captures the inconvenience of choosing such a format in terms of the time investment required to tape.[12]

The variable of purchase price divided by household income, as expected, has a highly significant negative effect on the probability of selecting a format.[13] This finding underscores the importance of price in format selection.

The total inventory variable (quantity of all formats currently owned) has a positive and significant effect on the made tape format choice. This result reflects the fact that audio consumers with high purchase frequencies tend to have high usage rates of the made tape option.[14]

The car tape deck indicator variable has the expected sign, with those consumers owning a car tape deck more likely to select tape formats. Race is found to be a significant factor, with whites more likely to choose tape options.

Finally, the sound quality indicator variable shows that consumers that list sound quality as extremely important are less inclined to select the prerecorded tape option. This lends some support to the popular notion that prerecorded tapes offer inferior sound quality when compared to records or even some made tapes.

The coefficient estimates for the CD-owner model (Table 3) are similar to those estimated for the non-CD owner model. The constant terms of this model indicate mean preferences for both prerecorded tape and CD options relative to records and a negative relative preference for the made tape option, but the made tape and CD preferences are not highly statistically significant. The price/income variable is properly signed, as is the

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models of these two groups account, to some extent, for possible taste differences resulting from frequency of choice. Second, the inclusion of inventory variables, which are highly correlated with purchase/taping frequency, captures some effect of the relationship between specific choices and frequency.

[11] Because multinomial logit models are based on differences in utility between alternatives, constant terms only can be estimated for N - 1 alternatives, where N is the total number of alternatives (three in the non-CD model case and four in the CD model case). In this case the record format constant is set implicitly equal to zero.

[12] For those individuals selecting the made tape option, data were collected on the time required to make the tape. Attempts to incorporate this variable in the model were not successful, however, because there were just nine observations with complete data on the time required for taping.

[13] Format price is assumed to be borne totally by the purchaser. Groups of purchasers may have informal agreements in which individuals take turns purchasing prerecorded originals and allow others in the group to copy them. This phenomenon would reduce format price, increase the logit price coefficient, increase the marginal utility of income, and result in an overestimation of the compensating variation (equation (5)). The data indicate that only 17 percent of the made tapes were made from originals not owned by the person taping. Thus, this effect would not have a significant impact on the forthcoming compensating variation estimates, although some caution is warranted when looking at subsequent welfare estimates.

[14] From an econometric point of view, this inventory variable can be considered exogenous because it represents an accumulation of past decisions and is not affected significantly by the individual choice decision being modeled.

Table 2—Multinomial Logit Estimation Results for Audio Format Choice (Individuals not having a CD player in home or car, t-statistics in parentheses)

Variable	Estimated Coefficient
Constant for prerecorded tapes	0.366 (1.0297)
Constant for made tapes	-2.92** (-5.638)
Format purchase price (in dollars) divided by annual household income (in thousands of dollars)	-2.327** (-3.471)
Total record and tape inventory, defined for made tape option only	0.0059** (1.76)
Car tape deck indicator defined for tape options (1 if have car tape deck, 0 otherwise)	0.7427** (2.59)
Race indicator defined for tape options (1 if white, 0 otherwise)	0.905** (2.80)
Sound quality indicator variable defined for prerecorded tape option only (1 if sound quality extremely important, 0 otherwise)	-0.449** (-1.724)
Number of observations	400
Log-likelihood at zero	-439.44
Log-likelihood at convergence	-272.37

* Significant at the .10 level (one-tailed t-test)
** Significant at the .05 level (one-tailed t-test)

Data source: Survey commissioned by U.S. Congress, Office of Technology Assessment

sound quality indicator variable. Race is again a significant factor, this time with whites more likely to choose the CD format.

The classical music indicator variable shows that individuals preferring classical music tend to select the CD format option, which provides some empirical evidence on the theoretical linkage between musical tastes and format choice. Finally, the full-time employment indicator suggests that individuals with full-time employment have a preference for the made tape format. This result may capture the practice of custom taping (i.e., mixing selections from numerous albums) for the purpose of using a made tape in a car tape deck on the trip to work.[15]

WELFARE COMPUTATIONS

Changes in consumer welfare are estimated using individual compensating variations that are computed by applying equation (6). Using logit model estimates and applying equation (6) to each individual in the sample of CD and non-CD owners yields a

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[15] It should be noted that both non-CD and CD models were tested for the independence of irrelevant alternative (IIA) logit specification problem using the test developed by Small and Hsaio (1985). The validity of the logit structure could not be rejected, indicating acceptability of the chosen specification.

Table 3—Multinomial Logit Estimation Results for Audio-Format Choice (Individuals having a CD player in home or car, t-statistics in parentheses)

Variable	Estimated Coefficient
Constant for prerecorded tapes	1.335** (3.28)
Constant for made tapes	-1.012* (-1.37)
Constant for compact discs	0.728 (1.096)
Format purchase price (in dollars) divided by annual household income (in thousands of dollars)	-1.618** (-2.00)
Sound quality indicator variable defined for prerecorded tape option only (1 if sound quality extremely important, 0 otherwise)	-0.582* (-1.37)
Race indicator defined for compact disc option (1 if white, 0 otherwise)	1.211** (1.91)
Classical music indicator defined for compact disc option only (1 if listen to classical music, 0 otherwise)	0.933* (1.42)
Full-time employment indicator defined for made tape option only (1 if employed full time, 0 otherwise)	1.166* (1.54)
Number of observations	117
Log-likelihood at zero	-162.20
Log-likelihood at convergence	-129.29

* Significant at the .10 level (one-tailed t-test)
** Significant at the .05 level (one-tailed t-test)

Data source: Survey commissioned by U.S. Congress, Office of Technology Assessment

frequency-weighted average compensating variation of $1.62 (i.e., weighted by the individual's stated frequency of purchase, which gives more weight to the compensating variations of frequent purchasers). Thus, for each purchase/taping decision, the imposition of a home copying ban results in an average consumer welfare loss of $1.62.

Consider an average consumer making ten purchase/tapings. With an average purchase/taping frequency-weighted probability of selecting the made tape option of 15.8 percent,[16] the average consumer can be expected to make 1.58 tapes per ten purchase/tapings; that is, the consumer would have to be paid $16.20 to be as well off after a ban as before for the ten purchase/tapings. This implies that each time the average consumer decides to tape, a compensation of $10.25 is required ($16.20/1.58). This is a reasonable value given the 1987-1988 prices of records, prerecorded tapes, and CDs and the unique characteristics of made tapes (such as potentially superior sound quality relative

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[16] This value is higher than the unweighted percentage choosing the made tape option as indicated in Table 1. This reflects the fact that consumers with higher probabilities of choosing the made tape option also have higher purchase/taping frequencies.

to prerecorded tapes, the ability to customize by selecting only desirable songs for taping, and the option to tape more than one artist).

In 1987, the year most compatible with the mid-year 1988 survey of audio consumers used to estimate the logit models and compensating variations,[17] industry shipments of records, prerecorded tapes, and CDs reached an annual rate of 637 million album equivalents (Recording Industry Association of America, 1988).[18] Sales of blank audio cassettes were roughly 388 million units in 1987 (International Tape/Disc Association, 1988).

Surveys have found that around 84 percent of the blank tapes purchased are used to record music (Audits and Surveys, 1983), giving a total of 326 million blank tapes used for music taping purposes. In the sample of 1501 audio consumers, 20.4 percent of all tapings use nonblank used tapes (i.e., taping over previously taped music); an average of 1.63 album equivalents are recorded on every tape. Thus, 409.54 million tapes (blank and nonblank) were used to record 667.55 million (409.54 x 1.63) album equivalents in 1987. The sample of 1501 audio consumers also indicated that for every ten albums taped, a net of almost four would have been purchased if taping were not available (a net of 38 percent of taped albums are would-be purchases).[19] Using this figure, the abolition of taping would increase purchases by 253.7 million album equivalents annually. Industry revenues gained from a taping ban are computed using purchase-frequency-weighted, postban, logit-model-predicted format choice probabilities to arrive at an average price paid per album equivalent of $7.80.[20] This results in an industry revenue gain of $1.98 billion (253.7 x 7.80).[21] Because 326 million fewer blank tapes would be sold annually at an average price of $2.45 per unit,[22] however, a $798.7 million revenue loss would be incurred by the blank tape industry. This leaves a net industry revenue gain of $1.18 billion annually.[23]

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[17] The 1988 survey considers purchase/taping choices up to one year before the survey date. Thus, purchase/taping choices are being captured back to 1987.

[18] Five singles (45s, cassette singles) are equivalent to one album.

[19] Respondents indicated that nearly five of ten taped albums are would-be purchases, but that one of these five would displace another purchase, leaving the net effect at almost four. This finding is roughly equivalent to the 40 percent would-be purchases figure reported by Warner Communications, Inc. (1982).

[20] The selling price of formats is derived from 1987 statistics (Recording Industry Association of America, 1988) by assuming that albums sell at an average of 10 percent below reported list prices. Also, it should be noted that the predicted postban shift in market shares among formats is small and results solely from frequency weighting. This is an outgrowth of the logit model structure which imposes the restriction of uniform cross-elasticities.

[21] In terms of profit, exact figures are understandably difficult to determine. Using U.S. Congress, Office of Technology Assessment (1989) estimates, however, the $7.80 should translate into a wholesale price of roughly $5.00, with $1.00 earmarked for artist royalties, $0.55 for music publisher and songwriters, and $1.25 for manufacturing and packaging, with roughly $2.20 for recording industry profits. Simple computations similar to the industry revenue computation shown in the text can be undertaken with these values to determine rough estimates of a ban's impact on profits, royalties, etc.

[22] The unit tape price is determined using the 1984 figure of $2.24 (Greenspan, 1986) and adjusting it to a 1987 equivalent by assuming a 3 percent annual tape-price inflation.

[23] The use of 38 percent of taped albums as would-be purchases is conservative because this value is obtained from only those individuals indicating that they could purchase the same material (as was taped) in a prerecorded format. This is a reasonable value because prerecorded formats act as substitutes even if the material is not exactly the same (e.g., a single song missing from an album, etc.). If only exact

Consumer welfare losses can be based on the 409.54 million blank and nonblank tapes that no longer will be used for the made tape option. Consumer welfare losses are estimated to be $4.2 billion (409.54 x $10.25). Because these consumer welfare losses exceed projected revenues, the estimated loss to society of an audio home copying ban will be approximately $3.02 billion per year (4.2 - 1.18).[24] Thus, although audio home taping is costing the industry billions in lost revenues, an audio taping ban would be even more costly to consumers and result in net annual losses to society.

CONCLUDING REMARKS

Although the current ambiguity of copyright law with respect to audio home copying may need to be rectified in light of the proliferation of digital audio recording technology, this paper shows that caution should be exercised in any copyright law revision. A copyright law revision that effectively bans audio home copying will result in increased industry revenue, job opportunities, and artists' royalties, but the short-term effects of such a policy are catastrophic. Audio consumers will pay a high price resulting in a substantial net loss to society. The longer-term consequences of a ban are unclear, as issues relating to direct and indirect appropriability, investments of increased industry revenue, format price changes, new technologies, and shifting consumer tastes may lead to net benefits or even greater net losses over a period of years.

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substitution is considered, a mere 21 percent of taped albums would be purchased. This translates into a net annual industry revenue gain of $294.7 million as opposed to $1.18 billion.

[24] To provide some perspective of the magnitude of this loss, a zero deadweight loss to society implies an average consumer compensation of only $2.88 (as opposed to the estimated $10.25) to forego a made tape choice.

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