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An Empirical Investigation Into the Effect of Music Downloading on the Consumer Expenditure of Recorded Music: A Time Series Approach

ABSTRACT. The downloading of music from the internet has been proliferating over the past three years. The recording industry believes that this phenomenon is responsible for the decline in recorded music sales since the year 2000, and to a certain extent this is supported by consumer surveys and previous studies that have used panel or cross-sectional data. In this analysis, an econometric, time-series model of consumer spending on tapes, LPs, and CDs is estimated which takes into account factors that are posited as effecting the consumption of recorded music, but not used in previous studies. The most significant finding is that music downloading, subsequent to 2000, affects consumer spending on tapes, LPs, and CDs through the price elasticity of demand. Falling DVD prices have also served to reduce the demand of recorded music during this same period.

The downloading of music from "peer-to-peer" file-sharing networks has increased dramatically since the advent of Napster in 1999. It was estimated that in 2003 three billion MP3 files were downloaded each month (Willcox, 2003). Coincidentally, sales of cassette tapes, LPs, and CDs have also "suffered" since 2000. We say "coincidentally," because the empirical evidence is sparse as to the cause and nature of these lagging sales. The Recording Industry Association of America (RIAA) believes that illegal downloads are the major reasons why, according to their stated statistics, the dollar value of music shipments of cassette tapes, LPs, and CDs, fell 4.5% in 2001 and 8.1% in 2002.[1]

However, if one uses a different data source and formula to calculate the growth rates, spending on tapes, LPs, and CDs by consumers declined in 2001 and 2002 by an average quarterly rate of 0.8% and 0.56%, respectively.[2]

The problem with this diverse information lies in the frequency and type of data that are used to compute the relevant statistics. In this paper, an economic analysis of recorded music consumption will be approached from an economic perspective by accomplishing two objectives. First, we use data from the U.S. Bureau of the Census, National Income and Product Accounts (NIPA), which is a non-industry and reputable source. Second, we will attempt to ascertain the factors that have been responsible for waning recorded music sales by positing and estimating an econometric demand model of consumer spending on tapes, LPs, and CDs using quarterly data from 1990 to 2004. Most of the data were downloaded from http://www.haverselect.com. Variable descriptions and the associated descriptive statistics may be found in the Appendix and in Table I, respectively.

EARLIER RESEARCH

There have been a number of issues raised and quite a bit of controversy generated over the past few years regarding the initiation of the peer-to-peer file-sharing networks. The recording industry is strident in its assertion that downloading copyrighted music is the main cause of declining recorded music sales, especially CDs. In a survey by Peter D. Hart Research Associates in May 2002 of 860 consumers who downloaded music in the last six months, 41% reported buying less music.[3] Moreover, the RIAA's Table of Yearend Statistics, 2002 indicates a 4.1% decline in the total dollar value of all formats from 2000 to 2001 and an 8.2% drop between 2001 and 2002.[4]

Zentner (2003) used two data sources, aggregate music sales by country between 1997 and 2002 and a European cross-section of

TABLE I
Descriptive Statistics (Not in Natural Logs)

	RTD (Mil$)	DPI (Bil$)	PRICE	PRICE_SOFT	PRICE_DVD
Mean	14862.32	6450.249	104.2614	283.4590	23.63
Median	16514.00	6251.900	105.6180	144.6980	24.20
Maximum	19551.00	7990.100	110.3330	885.5130	26.52
Minimum	7829.000	5306.600	97.10800	72.83700	20.41
Std. Dev.	3806.871	877.1197	4.026139	248.4308	1.87
Observations	59	59	59	59	59

Variables are explained in the Appendix.

15,000 people from October 2001, to examine the effect of music downloading on music sales. Using a panel dataset, he found that there is a large impact of piracy on music sales. Utilizing an instrumental variables approach on the cross-sectional data, Zentner (2003) also found that the downloading of MP3 files reduces the probability of buying music by 30%. Finding similar results, Peitz and Waelbroeck (2003) discovered that music downloading has resulted in a 10% decline in 2001 CD sales. They estimate an OLS regression for $n = 16$ countries over a two year period, 2000–2001, using the number of CDs sold as the dependent variable and GDP, MP3 downloads, broadband, and sale of CD players as the explanatory variables.

We believe that there are problems with these and other previous studies that have attempted to assess the role of downloading music on recorded music sales (Hui & Png, 2003; Liebowitz, 2003). None of these studies used price as an explanatory variable. Liebowitz (2003) states that the prices of CDs have been constant over recent years, but the RIAA's own statistics show that CD prices have risen from $14.31 in 1998 to $17.09 in 2002 – an increase of 19.4% over the five-year period (Willcox, 2003). It is our contention that omitting price in a model predicting music sales would lead to serious misspecification error. Another source of misspecification error would be a failure to account for the price of substitutes and/or complements, e.g., the increasing competition resulting from DVDs and videogames. U.S. consumers spent $7 billion on computer games in 2002 and at least one third of all households have a DVD player. There is not much of a price difference between DVDs and CDs, therefore it is certainly plausible that consumers may prefer a newer format that offers not just music (DVD audio) but also video that can include many additional options. Finally, while the estimation of econometric models of cross-sectional and panel data is useful, it is also important to examine the empirical issues concerning music downloading utilizing data that are derived from time series, since many of the assertions made by the RIAA and the recording industry are based on statistics that are calculated using time series data.

MODEL SPECIFICATION

It is clear that no matter what data are used, recorded music sales have been falling since 2000. In Figure 1, consumer spending on tapes, LPs,

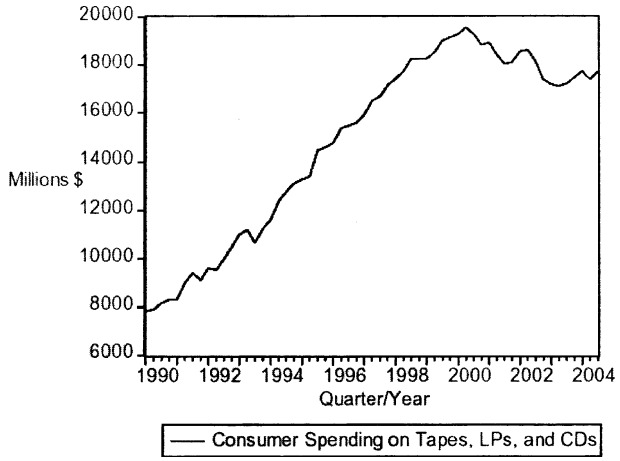

Figure 1. Consumer spending on tapes, LPs, and CDs.

and CDs (taken from the National Income and Product Accounts) is depicted. The change in trend after 2000 from positive to negative is clearly evident. A simple trend-growth model with a piecewise break at year 2000 is fit to the recorded music series (Table II). Prior to 2000, the growth in consumer spending on recorded music was 2.3%. However, after 2000, the growth rate was −1.1%. What is the cause of this decline? Indeed, part of this change in trend could be due to the proliferation of broadband usage which enabled the surge in music downloading since 2000. Over 10% of U.S. households subscribed to broadband in 2001 – in 2000 it was 5% (Vanston, 2002). An MP3 that is downloaded in 12 minutes with a standard dial-up connection would take 20 seconds with a household broadband connection (Zentner, 2003).

The advent of music downloading could have influenced the consumption of recorded music by changing the price elasticity of de-

TABLE II
Simple Trend-Growth Model

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
C	5.000757	0.083887	59.61278	0.0000
TIME	0.023226	0.000434	53.56407	0.0000
DOWN_MUSIC*(TIME-40)	−0.034598	0.001489	−23.22847	0.0000

Dependent Variable: RTD.
Sample (adjusted): 1990Q1–2004Q3.
Included observations: 59 after adjustments.

mand. For example, prior to 2000, the price index for tapes, LPs, and CDs was declining by an average annual rate of −0.35%, while subsequent to 2000, this growth turned positive: 0.37%. We could argue that if demand became more price elastic (or less price inelastic) after 2000, then this could be due to the substitute good, music downloading, becoming more profuse after 2000.[5] Thus, higher prices for CDs during this period would lead to a larger percentage decline in the quantity of recorded music purchased.

There are other factors, such as income and the prices of substitutes and complements, which may have had an effect on recorded music purchases. Consumers are purchasing more videogames and DVDs than ever before. One hypothesis is that the decline in recorded music purchases is a direct result of the growth in videogame and DVD sales since 2000.[6] Of course, this depends upon the nature of the substitute relationship that exists between videogames, DVDs, on one hand and recorded music purchases, on the other. We might expect both videogames and DVDs to be strong net substitutes for recorded music after 2000, that is, decreases in the price of a DVD or videogame would be associated with a decrease in recorded music purchases (*ceteris paribus*). It is important to note that using our data (see Appendix), the price of computer software and DVDs has declined by 2.0% and 1.4%, respectively, since 2000. In order to capture the nature of this relationship, we used the price index of computer software and the unit price of DVDs as predictors of real consumer spending on recorded music. The price index of software is used as a proxy for the price of videogames, since quarterly data on the latter are not available. Finally, we also included disposable personal income as an explanatory variable in order to capture changes in the economy.

In an attempt to incorporate all of the factors mentioned above, the following equation models personal consumption spending on cassette tapes, LPs, and CDs,

$$\begin{aligned} \mathrm{RTD}_t = {} & \beta_0 + \beta_1 \mathrm{TIME} + \beta_2 \mathrm{DPI}_t + \beta_3 \mathrm{PRICE}_t \\ & + \beta_4 \mathrm{PRICE\_SOFT}_t + \beta_5 \mathrm{PRICE\_DVD} \\ & + \beta_6 (\mathrm{TIME} - 40) \cdot \mathrm{D}_t + \beta_7 \mathrm{DPI}_t \cdot \mathrm{D}_t \\ & + \beta_8 \mathrm{PRICE}_t \cdot \mathrm{D}_t + \beta_9 \mathrm{PRICE\_SOFT}_t \cdot \mathrm{D}_t \\ & + \beta_{10} \mathrm{PRICE\_DVD}_t \cdot \mathrm{D}_t + \varepsilon_t, \end{aligned} \tag{1}$$

where

RTD_t	-log of consumer spending on cassette tapes, LPs, and CDs;
DPI_t	-log of disposable personal income;
$PRICE_t$	-log of chained price index of tapes, LPs, and CDs;
$PRICE\_SOFT_t$	-log of chained price index of software;
$PRICE\_DVD_t$	-per unit price of DVDs;
TIME	-time trend;
$D_t = 0$	when TIME < 40
$= 1$	when TIME ≥ 40 (2000Q1)

The variable D_t represents the period throughout which the downloading of music increased dramatically (2000Q1–2004Q3). In the interaction, (TIME − 40) · D_t, TIME = 40 corresponds to the first quarter of the year 2000 and the term in the equation $-40 \cdot \beta_6$ represents the necessary shift in the intercept term after 2000. PRICE_DVD was not logged since it contained zeroes. As mentioned previously, DPI_t, disposable personal income, is incorporated to capture changes in economic activity. RTD_t and DPI_t have been deflated by their appropriate chained price index, so they are expressed in ''real'' quantities.

If there is no structural change in the demand function after 2000, then we would fail to reject the null hypothesis,

$$H_0 : \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0.$$

Otherwise, we would have to inspect the nature and magnitude of the parameter shifts. Inspection of Figure 1 reveals that the type of downward adjustment that occurred in recorded music sales was a change from a positive trend before 2000 to a negative trend after 2000. This change is captured in Equation (1) by the interaction term, (TIME−40) · D_t, and the parameter, β_6, measures just how much less the slope of the trend line was after 2000, e.g.,

$$(2) \qquad \begin{aligned} &\beta_{\mathrm{TIME}<40} = \beta_1 \quad \text{when } D_t = 0, \\ &\beta_{\mathrm{TIME}\geq 40} = \beta_1 + \beta_6 \quad \text{when } D_t = 1. \end{aligned}$$

There are four remaining interactions in Equation (1), which are represented by the last four terms. They represent the interaction of each explanatory variable with the dummy variable, D_t, that

symbolizes the period of music downloading. These terms are included in order to determine whether there were any structural changes in the parameters of the explanatory variables over the period 2000–2004. For example, one of the explanations given earlier had to do with the effect of rising prices on music consumption. We would expect the relationship between price and quantity demanded to be inverse both before and after 2000. Of course, one of the empirical questions is what happened to the elasticity of demand, e.g.,

$$\begin{aligned} &\beta_{\mathrm{PRICE,TIME<40}} = \beta_3 \quad \text{when } \mathrm{D}_t = 0, \\ &\beta_{\mathrm{PRICE,TIME\geq 40}} = \beta_3 + \beta_8 \quad \text{when } \mathrm{D}_t = 1. \end{aligned} \tag{3}$$

Since it is assumed that $\beta_3 < 0$, if $\beta_8 < 0$, then demand is more elastic (or less inelastic) after 2000 due to the increased availability of the substitute good, downloaded music. We will discuss the remaining interaction terms in the empirical results section below.

Music downloads and file sharing may be one of the reasons why there are declining sales in the market for recorded music. Whether or not it is the predominant cause is an empirical question, an issue we will now consider.

ESTIMATION

The estimation of Equation (1) is more difficult than it seems because of two problems:

a. The postulation of the classical regression model requires that all variables be stationary, e.g., all are $I(0)$, or integrated of order zero,
b. The explanatory variables may not be exogenous variables and therefore may be correlated with the error term.

Problem (a) requires that all variables be cointegrated, or that a linear combination of them is stationary. If so, then Equation (1) may be referred to as the cointegrating relationship and the estimated parameters as the cointegrating vector. Ignoring the problems posed by (a) leads to what is known as a "spurious" regression (Granger & Newbold, 1974). A "spurious" regression will have t-statistics that are significant and high R squares, yet the relationships among the variables are meaningless.

The question is whether the variables, RTD_t, DPI_t, PRICE_t, $\mathrm{PRICE\_SOFT}_t$, and $\mathrm{PRICE\_DVD}_t$ are cointegrated in the presence of a break in trend, $\mathrm{TIME} \cdot \mathrm{D}_t$. Since it is known that the standard procedures for detecting cointegration are not appropriate in the presence of structural change (Saikkonen & Lutkepohl, 2000a), we will use a method that has been proposed by Saikkonen and Lutkepohl (2000b). These authors suggest to first estimate the deterministic components (dummy variable, trend), subtract them from the original series, and then utilize any of the multivariate, maximum likelihood tests for cointegration (Johansen, 1988; Stock & Watson, 1988).[7] Following this procedure, we created the "adjusted" series w_{1t} and $\vec{w}_{2t}$ prior to conducting the multivariate cointegration test,

$$\begin{aligned} w_{1t} &= \mathrm{RTD}_t - \hat{\beta}_0 - \hat{\beta}_1 \mathrm{TIME} \\ &\quad - \hat{\beta}_6(\mathrm{TIME} - 40) \cdot \mathrm{D}_t - \hat{\beta}_2' \mathrm{D}_t \bar{X}_t, \\ \bar{w}_{2t} &= \bar{X}_t - \hat{\mu}_0 - \hat{\mu}_1 \mathrm{TIME} - \hat{\kappa}(\mathrm{TIME} - 40) \cdot \mathrm{D}_t, \end{aligned} \tag{4}$$

where

$$\bar{X}_t' = (\mathrm{DPI}_t, \mathrm{PRICE}_t, \mathrm{PRICE\_SOFT}_t, \mathrm{PRICE\_DVD}_t),'$$

$\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_6$ are estimated parameters and $\hat{\beta}_2', \hat{\mu}_0, \hat{\mu}_1, \hat{\kappa}$ are all estimated parameter vectors. All five equations denoted in (4) above were estimated using OLS (Ordinary Least Squares).

Using $\bar{w}_t' = (w_{1t}, \bar{w}_{2t})'$ from the above estimated model, $\bar{w}_t$ is a VAR(2) with ECM representation,

$$\Delta \bar{w}_t' = \Pi \bar{w}_{t-1} + \Delta \bar{w}_{t-1,1} + \bar{\vartheta}_t, \tag{5}$$

and the Johansen procedure (Johansen, 1988) is used to test for the rank of Π and thus the presence and order of cointegration among the variables.[8]

The results of the maximum eigenvalue cointegration test are in Table III. We reject the null hypothesis of no cointegration in favor of the alternative of exactly one cointegrating vector. Thus, we can safely assume that our results are not spurious and proceed to estimate Equation (1) taking into account the endogeneity issues raised in problem (b) above.

If any of the explanatory variables are correlated with the error term in Equation (1), then it is well known that OLS estimators are both biased and inconsistent. In this case, the fully modified least squares procedure (Phillips & Hansen, 1990) should be used to adjust

TABLE III
Johansen Cointegration Test: Max-Eigenvalue

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max–Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.472549	35.82311	30.43961	0.0097
At most 1	0.333109	22.68716	24.15921	0.0781
At most 2	0.264327	17.19033	17.79730	0.0615
At most 3	0.085939	5.032038	11.22480	0.4728
At most 4	0.028763	1.634334	4.129906	0.2361

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.
*Denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon, Haug, and Michelis (1999) *p*-values.

for endogeneity by including both leads and lags of the first differences of each explanatory variable in Equation (1). Essentially, this would "purge" the potential correlation between any of the explanatory variables and the error term in the equation by controlling for innovations in the explanatory variables. In order to examine the endogeneity issue and concomitantly whether we should include the leads and lags in Equation (1), the following null hypothesis was tested,

$$H_0 : \bar{\gamma}_1 = \bar{\gamma}_2 = \bar{\gamma}_3 = 0,$$

where

$$\begin{aligned} RTD_t = {} & \beta_0 + \beta_1 \mathrm{TIME} + \beta_2 \mathrm{DPI}_t + \beta_3 \mathrm{PRICE}_t \\ & + \beta_4 \mathrm{PRICE\_SOFT}_t + \beta_5 \mathrm{PRICE\_DVD} \\ & + \beta_6 (\mathrm{TIME} - 40) \cdot \mathrm{D}_t + \beta_7 \mathrm{DPI}_t \cdot \mathrm{D}_t \\ & + \beta_8 \mathrm{PRICE}_t\_\mathrm{D}_t + \beta_9 \mathrm{PRICE\_SOFT}_t \cdot \mathrm{D}_t \\ & + \beta_{10} \mathrm{PRICE\_DVD}_t \cdot \mathrm{D}_t + \vec{\gamma}'_1 \Delta \vec{X}_{t+1} \\ & + \vec{\gamma}'_2 \Delta \vec{X}_t + \vec{\gamma}'_3 \Delta \vec{x}_{t-1} + \rho \varepsilon_{t-1} + v_t, \end{aligned} \tag{6}$$

and, as before, $\bar{X}'_t = (\mathrm{DPI}_t, \mathrm{PRICE}_t, \mathrm{PRICE\_SOFT}_t, \mathrm{PRICE\_DVD}_t)'$. The next to the last term, $\rho\varepsilon_{t\text{-}1}$, is included to control for serial correlation. We found that we could not reject this null hypothesis, so we estimated Equation (6) without the last three terms, $\Delta\bar{X}_{t+1}, \Delta\bar{X}_t, \Delta\bar{X}_{t-1}$. The results of this test and the regression estimates are found in Table IV.

TABLE IV
Regression Model

Variable	Coefficient	Std. Error	*z*-Statistic	Prob.
C	13.31244	2.260127	5.890132	0.0000*
TIME	0.022524	0.003124	7.210982	0.0000*
LOG_DPI	0.591679	0.305287	1.938107	0.0526***
LOG_PRICE	−0.638012	0.229656	−2.778115	0.0055*
PRICE_SOFT	0.000168	7.68E−05	−2.189870	0.0285**
PRICE_DVD	1.52E−05	0.000252	0.060170	0.9520
DOWN_MUSIC*(TIME−40)	−0.014797	0.005542	−2.670026	0.0076*
DOWN_MUSIC*LOG_DPI	0.326594	0.131816	2.477649	0.0132**
DOWN_MUSIC*LOG_PRICE	−0.759862	0.260814	−2.913427	0.0036*
DOWN_MUSIC*PRICE_SOFT	0.000470	0.003360	0.139917	0.8887
DOWN_MUSIC*PRICE_DVD	0.020830	0.010032	2.076227	0.0379**
AR(1)	0.568426	0.114039	4.984492	0.0000*
R-squared	0.995784	*F*-statistic	661.2613	
Adjusted *R*-squared	0.994278	Prob (*F*-statistic)	0.000000	
S.E. of regression	0.021154			
Durbin–Watson stat	2.108511			

H_0: $\vec{\gamma}_1 = \vec{\gamma}_2 = \vec{\gamma}_3 = 0$; *F*-statistic = 1.0026; Prob (*F*-statistic) = 0.4675.
H_0: $\beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$; *F*-statistic = 2.4711; Prob (*F*-statistic) = 0.0456**.

Dependent Variable: RTD (Consumer Spending on Records, Tapes, and CDs).
Sample (adjusted): 1990Q2–2004Q3.
Included observations: 58 after adjustments.

*Statistically significant at .01 level.
**Statistically significant at .05 level.
***Statistically significant at .10 level.

EMPIRICAL RESULTS

It is clear that there has been structural change in the demand for recorded music subsequent to the year 2000. Our testing has prompted us to reject the null hypothesis of no structural change (see Table IV).

Prior to 2000, the coefficient on TIME indicates a 2.25% growth rate in the consumption of recorded music. This is not different from the results of the simple trend-growth model (2.32%, Table II). However, after 2000 and controlling for the other factors that influence the demand for recorded music, the growth is 0.77% – which is different from the rate estimated using the simple trend-growth model found in Table II (−1.14%).[9] In other words, the *adjusted* growth in the consumption of recorded music is actually larger than it would be

in the absence of the other variables that influence demand, such as income and the prices of substitute and/or complementary goods. As mentioned previously, this time trend could be representative of the proliferation of broadband usage, or it could be capturing the effects of other omitted explanatory variables that change over time. Notwithstanding this, it is clear from these results that, *ceteris paribus*, the consumption of recorded music has actually increased rather modestly since 2000.[10]

Since the actual growth in the demand for recorded music is negative, the question remains as to what has contributed to this decline. As discussed previously, the latent variables contributing to the trend did not force a negative growth rate, *ceteris paribus*, so it must be that music downloading and some of the remaining explanatory variables in the model have all contributed to the decline. We find that the advent of music file sharing after 2000 has reduced the demand for recorded music through its influence on price elasticity (see Table V). Prior to 2000, the price elasticity of demand for recorded music was inelastic: −0.64%. However, since the downloading of music is a substitute for recorded music, this price elasticity after 2000 yielded an elastic response: −1.4%. Thus, due to the increased availability of the substitute good, downloaded MP3 files, a 1% increase in the price of recorded music after 2000 was associated with a more than proportionate 1.4% decline in the quantity purchased – decreasing consumption and sales.

Although music downloading has reduced recorded music consumption after 2000, our results also indicate that DVDs are a strong substitute for tapes, LPs, and CDs. A 1% decline in the price of DVDs is associated with a 2.08% decline in the demand for recorded music. As can be seen in Table V, this elasticity coefficient is the

TABLE V
Elasticity Coefficients

Variable	Prior to 2000	After 2000
TIME	2.2524%	0.7727%
DPI	0.5917%	0.9183%
PRICE	−0.6380%	−1.3978%
PRICE_SOFT*	0.0168%	0.0638%
PRICE_DVD	0.0015%	2.0845%

*Difference between coefficients not statistically significant.

largest after 2000. However, the price of software after 2000 is no more a substitute for recorded music as it was prior to 2000 – the coefficient on the interaction term is statistically insignificant (Table IV). This unexpected result may be due to the fact that we are using the price of computer software as a proxy for the price of videogames.[11]

CONCLUSION

It is a plausible tenet that both the advent of music downloading and lower DVD prices both served to reduce the consumption of tapes, LPs, and CDs after the year 2000. As mentioned previously, consumer purchases of DVDs and videogames have really "taken off" since 2000. In a similar vein, the price of CDs, tapes, etc., is also an important determinant of what consumers will spend on these music formats. Prior to 2000, it has the largest effect with an elasticity coefficient of −0.64% and it has the second largest effect with an elasticity of −1.4% after 2000. It does appear that more of the substitute good, downloaded music, has reduced spending on recorded music more than proportionately after 2000 by changing the "slope"of the demand curve.

The empirical evidence presented in this paper supports the assertion that the proliferation of peer-to-peer file sharing networks since 2000 has led to a *significant* decline in music format sales. However, it is important to note that music downloading was not the only cause of this decline – the price of DVDs had the largest elasticity coefficient in absolute value after 2000 (2.08%, Table V).

It can also be inferred from our results that enhanced copyright restrictions placed on consumers who make use of these networks to "share" music would reduce the price elasticity of demand for recorded music-making it easier for suppliers to increase prices and thus sales. However, the proliferation of *legal* music downloading services should tend to temper these price increases. Suppliers would not be able to raise the price of a CD much beyond that charged by iTunes or Napster and expect to increase revenue.[12] Consumers would benefit, since they would not only face price stability, but also an enhanced market for all music formats that was more attuned to tastes and preferences, e.g., the flexibility to *legally* download the music of their choice.

APPENDIX: DATA SOURCES

All data were downloaded from http://www.haverselect.com except for PRICE_DVD

RTD	Consumer Spending on Cassette Tapes, LPs, and CDs (Millions of Chained 2000 $)
DPI	Disposable Personal Income (Billions of Chained 2000 $)
PRICE	Chained Price Index of Cassette Tapes, LPs, and CDs (Index, 2000 = 100)
PRICE_SOFT	Chained Price Index of Software (Index, 2000 $)
PRICE_DVD	Average Price of DVDs (Per Unit Price, $, Recording Industry Association of America)

NOTES

[1] RIAA, *2002 Yearend Statistics*, http://www.riaa.com/news/marketingdata/pdf/year_end_2002.pdf.

[2] U.S. Bureau of the Census, *National Income and Product Accounts, Personal Consumption Expenditures by Type of Expenditure*, http://www.haver.com. We calculate growth rates as a one period percent change and then average them over the four quarters to get the average annual rate.

[3] Peter D. Hart and Associates, *Survey for RIAA*, May 2002.

[4] See Note 1.

[5] We would like to thank one of the referees for pointing this out.

[6] Between 2000 and 2004, DVD and software sales have increased 10.4% and 2.9%, respectively.

[7] Each variable was first tested for a unit root using Perron's (1989) test of structural change. Results will be made available upon request from the authors.

[8] VAR is *Vector Autoregressive Model* and ECM is *Error Correction Model*. The lag order ($p = 2$) is chosen optimally in the econometric software program, EViews 5.1.

[9] As a reminder, $\hat{\beta}_{\text{TIME}\geq 40} = \hat{\beta}_1 + \hat{\beta}_6$.

[10] The coefficients of the logged variables are interpreted as elasticities, e.g., a one percent change in "X" is associated with a $\hat{\beta}_j$ percent increase in "Y." The coefficients of the non-logged variables, such as the time trend and PRICE_DVD must first be converted using the formula: $100(e^{\left(\hat{\beta}_j - \frac{\text{Var}(\hat{\beta}_j)}{2}\right)} - 1)$ before they may be interpreted as the percent change in "Y" for a unit change in "Y" (Halvorsen & Palmquist, 1980; Kennedy, 1981).

[11] It should be noted that videogame sales and quantity data were available, but only annually from the Interactive Digital Software Association. In order to see whether the results would change substantially, the above regression was estimated using the price of videogames imputed from annual to quarterly values. The estimated coefficients and their associated statistical inferences did not change substantially. The elasticity coefficient for the price of videogames was negative (a complement), but statistically insignificant. Results will be made available upon request from the authors.

[12] In actuality, since most users of these services download individual song tracks rather than the entire CD of an artist, the price we are referring to here is really *per track*.

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