An Empirical Examination of Global Software Piracy: Pricing and Policy Implications

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Abstract

Piracy threatens the very existence of the global software industry, and there is relatively little understanding of the impact of so called benefits of piracy, and the efficacy of legal strategies at a global level. Our research combines analytical approaches to studying piracy along with data from over 53 countries to empirically model global piracy behavior. Our analyses show that software piracy is not a price-dependent decision alone and is indeed expressed as a two-stage behavior as suggested by extant analytical models, where some consumers buy outright while some others first pirate and turn buyers. We develop a set of latent constructs from extant literature called consumers' moral and legal costs so as to capture the non-monetary costs of pirating as influenced by country-specific cultural and institutional factors. Our results suggest that while moral costs play a role in only preventing a consumer from pirating at all, legal costs manifest themselves in both stages where they not only play role in piracy prevention but they also can deter pirates from holding on to pirated copies. Further, contrary to popular arguments that piracy necessarily leads to future sales, the overall beneficial effects of software piracy, while indeed present, are quite limited across the software industry. We also demonstrate the superiority of country-specific pricing strategies while underscoring the importance of enforcement actions in mitigating piracy. We conclude that a focus on second-stage deterrence is superior to prevention strategies.

Keywords: piracy, digital goods, price discrimination, public policy

An Empirical Examination of Global Software Piracy: Implications for Pricing and Public Policy*

1 Introduction

"For almost fifteen years, the software industry has battled against software theft, recognizing that widespread piracy threatens the very existence of our industry. Despite these efforts, software piracy remains a serious problem throughout the world, accounting for one-quarter of the software used in the United States, and 40 percent of the software used worldwide. In parts of Asia and the former Soviet Republic, piracy rates approach 90 percent, virtually eliminating sales of legitimate software."

Source: Testimony of Richard C. LaMagna, Senior Manager, Worldwide Anti-Piracy Investigations, Microsoft Corporation, before the House Subcommittee on Courts, The Internet, and Intellectual Property on March 13, 2003.

Piracy is one of the most important factors threatening the software industry in its effort to create a global marketplace for its products. It is supposed that about 40 percent of all installed packaged software worldwide was pirated, causing $34 billion in global losses to the software industry. According to the Third Annual Business Software Alliance (BSA) and IDC Global Software study on global piracy, in 2005 for every two dollars' worth of PC software purchased legitimately, one dollar's worth was obtained illegally. In its effort to monitor and prevent piracy, the BSA and its various international affiliates keep track of piracy levels and monetary losses of software firms across the globe. While domestically BSA has pursued legal action against pirates through active enforcement of the Digital Millennium Copyright Act (DMCA), managing global piracy is more complex given the variance in legal situations, ethical attitudes toward piracy and affordability of the consumer base.

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Further complicating piracy-thwarting efforts is the popular belief in some quarters that piracy may even be beneficial (Haruvy, et al. 2004). This belief hinges on the potential externality benefits of piracy, where it is argued that some consumers pirate and get to know more about the product, thus eventually becoming buyers of legitimate copies. However, at a global level it is not clear as to which of these forces, e.g., legal measures, externality effects, or even country-specific elements, are at work and to what extent they influence piracy. An examination of these factors and their impact on sales and piracy is of importance to both vendors and regulators alike.

Piracy after all is not an isolated trait where consumers are necessarily pre-disposed toward pirating or buying and piracy is not truly costless to the consumer. Rather, consumers trade off buying (where costs are price-based) and piracy (where costs may be non-monetary like legal and/or moral costs) decisions. Understanding and calibrating how consumers make these complex tradeoffs is central to formulating effective public policies on piracy and managers' pricing decisions. An empirical explanation of piracy behavior in a global context is a *first* key contribution of our study.

From the firms' point of view, traditionally most software vendors charge uniform prices for their software across the globe. That intellectual property rights (IPR) firms act like monopolists is not surprising since they are often the sole owners of a good (Philips 1998). Until recently book publishers engaged in uniform global pricing. In order to combat intellectual property (IP) violation through photocopying, some publishers have engaged in price discrimination and/or offer lower print quality versions (e.g., Eastern Economy Edition from Prentice Hall) of its products in countries with higher rates of IP violation. More recently some software vendors have also begun to engage in price discrimination i.e., employ different prices for different countries. For example, in late 2004, Microsoft for the first time reconsidered its

global pricing strategy with the intention of lowering prices in countries like China and Brazil[1], while others like Oracle, Adobe and SAP continue to put out a global pricing list that is common across all countries in the globe. While intuition would suggest that a vendor charge a higher price in richer countries, piracy introduces significant complexity to this strategy. This is not only because piracy is a price-dependent concept, but also because the decision to pirate occurs in two stages (Chellappa and Shivendu 2005), where some consumers pirate software to merely "check it out" (Cheng, et al. 1997). Thus some pirates who subsequently update their value perception of the software may become buyers as well, thus leading to potential externality benefits of piracy.

There is, however, little empirical proof of the existence of any externality benefits at a global level, and on how piracy-protection measures and pricing play a role in managing these benefits. A *second* key contribution of our study is the development of a two-stage structural model to specifically delineate potential piracy benefits (if any) and capture the differential impact of non-monetary piracy costs during the two stages of piracy.

Empirical research on global piracy has generally attempted to explain country-specific piracy through linear regression models; initially it was suggested that piracy levels are lower in rich countries (Gopal and Sanders 2000, Shin, et al. 2004) and then cultural factors such as individualism/collectivism were shown to be important factors driving piracy (Husted 2000, Marron and Steel 2000, Moores and Dhaliwal 2004). Some researchers have also explored the impact of some law-related elements, such as membership in international intellectual property treaties (e.g., World Intellectual Property (WIPO); World Trade Organization (WTO); Universal Copyright Convention, etc.), duration of membership (Burke 1996, Papadopoulos

[1] "Microsoft rethinks unified pricing strategy: Company pondering different price points", by Joris Evers, IDG News Service, March 01, 2004. http://www.infoworld.com/article/04/03/01/HNrethinks_1.html

2003); the availability of copyright and patent protection in the national law (Van Kranenburg and Hogenbirk 2005); and legal remedies such as seizure and destruction of infringing copies and equipment (Andr´es 2006). However, note that previous studies *do not* necessarily consider *all* factors simultaneously when examining country-specific piracy either for reasons of limited interest or due to the high correlation amongst explanatory factors. Furthermore, the extant empirical literature has generally ignored a key element of piracy that analytical models consider to be the most important determinant of piracy, namely price (Chellappa and Shivendu 2003, Chen and Png 2003, Conner and Rumelt 1991, Sundararajan 2004). In this regard, a *third* key contribution of our research is construction of moral and legal cost indices from a variety of cultural and institutional factors and the incorporation of price along with other country-specific covariates in the empirical model.

For our investigation we use a longitudinal dataset of 53 countries over a period of 11 years (from 1994-2004) for which we have piracy information. Note that while prior research has used similar data, the econometric analysis has largely been cross-sectional. These studies have, therefore, not exploited the panel structure and do not account for seasonality/market maturation. Based on prior literature, we then identify sets of variables that are representative of piracy costs in a country and employ a factor analysis technique to create the latent constructs of moral and legal costs. We then propose a utility theory-driven structural demand model that affords empirical examination of global piracy through a two-stage nested consumers' decision tree, wherein some consumers make the decision to buy right away while others decide to buy after pirating. Note this structure also recognizes that the piracy costs may possibly have two roles: in the first stage they can prevent people from engaging in piracy, while in the second stage they can deter pirates from holding on to their pirated version. Our

combined, yet parsimonious, approach allows us to answer a number of interesting piracy-related questions leading to both pricing and policy recommendations.

Our analyses not only confirm the two-stage structure of piracy, but also reveal that consistent with prior analytical research, price is a statistically significant factor at both levels. On the other hand, the impact of moral and legal costs on piracy appears to be quite different and specific to each level. Our findings tell us that while moral costs are particularly important in determining whether or not a consumer will pirate at all, they do not influence the pirates' decision to buy, i.e., their decision to purchase/hold on to their pirated good post pirating. Legal costs, however, manifest both as prevention and post-piracy punishment factors, suggesting that there may be distinct effects of anti-piracy laws and fines versus subsequent enforcement follow-throughs.

Finally, our empirical results confirm the consumers' tradeoff between price and non-price factors (albeit differently at each level) from a utility point of view. However, since vendors cannot charge a different price to those who have pirated versus those who have not, and as data confirm significant variance in country-specific, non-price piracy costs, we extend our model to empirically compute optimal country-specific prices. Finally we conclude with specific policy recommendations that elaborate on the differential impact of legal costs on the consumers' piracy decisions.

The rest of the paper is organized as follows. In the second section, we explain the structural model of two-stage piracy behavior, followed by the empirical operationalization of the model as a nested discrete choice model. In the third section, we describe the data collection procedure, empirical analysis and results. We conclude the paper with a discussion of implications for global policy makers and software vendors, as well as directions for future work.

2 Structural model of two-stage piracy behavior

Theoretical models of piracy have generally been unconstrained by data requirements and are constructed at the granularity of a consumer's utility function. First, these models suggest that any impact of moral and legal costs is bounded by price, i.e., they are important only to the extent that the combined costs are less than the price of the software itself (Chellappa and Shivendu 2003, Conner and Rumelt 1991). Second, these models have shown that piracy is not a single-stage decision. Rather, consistent with theories of experience goods consumption, some consumers may initially pirate to experience the good and update their value perception of the product; post-sampling some of the pirates may turn buyers (Chellappa and Shivendu 2005, Givon, et al. 1995). This suggests that any externality benefits, if present, will manifest themselves in the second stage. While these analytical models provide rich insights into the underlying piracy behavior, it is empirical work on global piracy that has identified several market-level factors influencing piracy (Gopal and Sanders 2000, Marron and Steel 2000). So far, there has been no research (that we are aware of) that has reconciled the approaches of the two research streams. In this section we begin by presenting the analytical setup before deriving an empirically testable model.

Let a representative consumer of a country be defined by a value $v \in [\underline{v}, \overline{v}]$ for a software good such that this value is heterogeneous across countries and is distributed with cumulative density $K(v)$. Similarly, representative consumers in different countries suffer different moral $(m \in [\underline{m}, \overline{m}])$ and legal $\left(l \in \left[\underline{l}, \overline{l}\right]\right)$ costs with respective CDF's given by $m \sim G(m)$ and $l \sim H(l)$. A consumer will buy a product if and only if $u_b \geq 0$ (utility from buying – individual rationality (IR) constraint) and if $u_b \geq u_p$ (incentive compatibility (IC) constraint), where u_p is the utility from pirating and p is the price charged. In the two-stage model introduced by Chellappa and Shivendu (2005) as shown in Figure 1, consumers do not fully

incur the piracy costs in the first stage itself. Rather, since there is always the possibility of buying in the second stage, only those that keep a pirated copy incur the full costs of piracy. Let $\delta \in [0,1]$ be the transient parameter such that the consumer who pirates in the first stage incurs only a portion of the piracy costs $\delta(m+l)$, and suffers the rest $(1-\delta)(m+l)$ only if he decides to keep the pirated product. Furthermore, the pirates have now updated their value of the product from v to $\hat{v}(\hat{v} \sim J(\hat{v}))$, where $\hat{v} > v(\hat{v} < v)$ if the product was initially underestimated (overestimated). The pirates would, therefore, now reevaluate their piracy decision with the new value. Thus in the first stage, consumers will buy if and only if $v > p$ and $p < \delta(m+l) \Rightarrow \frac{p}{\delta} < m+l$ and in the second stage the pirates will buy if and only if $\hat{v} > p$ and $p < (1-\delta)(m+l) \Rightarrow \frac{p}{1-\delta} < m+l$.

We can, therefore, write the demand in the first stage as

$$D_1(p \mid v,m,l) = N(1-K(p))R\left(\frac{p}{\delta}\right) \tag{1}$$

and during the second stage as (where R is the joint distribution of G and H)

$$D_2(p \mid \hat{v},m,l) = N(1-J(p))\left(R\left(\frac{p}{1-\delta}\right)\left(1-R\left(\frac{p}{\delta}\right)\right)\right) \tag{2}$$

Therefore the total price dependent demand from a two-stage model can be written as

$$\begin{aligned} D(p \mid v,\hat{v},m,l) &= D_1(p \mid v,m,l) + D_2(p \mid \hat{v},m,l) \\ &= N\left((1-K(p))R\left(\frac{p}{\delta}\right) + (1-J(p))\left(R\left(\frac{p}{1-\delta}\right)\left(1-R\left(\frac{p}{\delta}\right)\right)\right)\right) \end{aligned} \tag{3}$$

In order to set optimal prices, a vendor will have to maximize revenue, i.e. set $\frac{\partial}{\partial p}\pi = pD(p) = 0$. While optimal prices under some restrictive distributional assumptions have been derived elsewhere, we can easily see what they will be in terms of the distributions of values, legal and moral costs, and the transient parameter. However, in order to empirically estimate the optimal prices or the efficacy of discrimination strategies, we need to be able to

first operationalize the above decision structure and incorporate country-specific moral and legal costs (for the representative consumer) into such a model. In order to do so, we translate the above analytical setup to an equivalent two-stage nested discrete choice model.

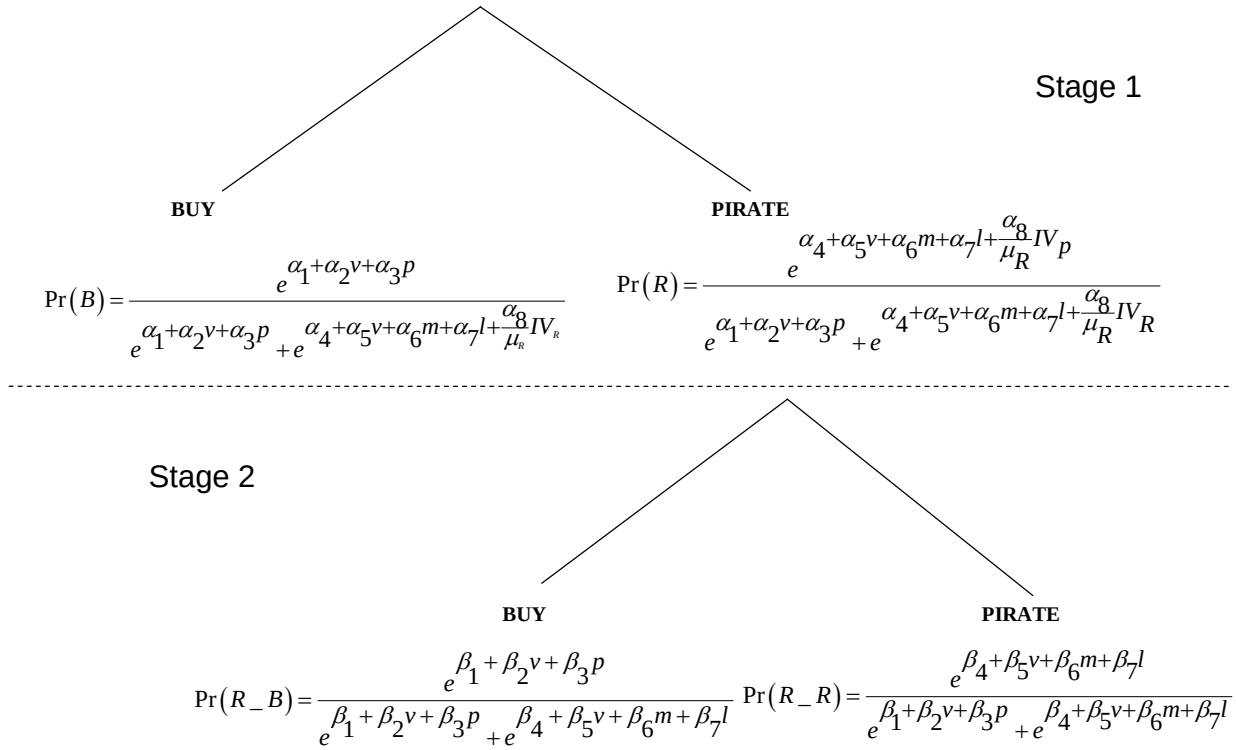
2.1 Econometric Model

Discrete choice models have been extensively used in marketing and economics to understand consumer decisions (Chintagunta 1993, Guadagni and Little 1983, Gupta 1988). An important feature of these models is that they allow for statistical calibration of the complex tradeoffs that consumers undertake while making discrete decisions like purchase/non-purchase of a good. For the most part, these models are consistent with utility maximization. Since the recovered demand model parameters are consumer-preference parameters and assumed to be invariant to structural changes, we can conduct 'what-if' counterfactuals to understand the economic implications of changes in one/more covariates. The parameters of these models are estimated using either micro-level observed choice data (individual/household level) or macro-level (aggregate) sales data.

Our theory suggests that at the first level consumers make one of two choices, buy outright or pirating. After having pirated, at the second level they choose between keeping the pirated copy and buying, where the consumers have new realized value for the product. Now suppose we are able to observe the total number of buyers and pirates, and we also know the costs and price associated with the product. Then we should be able to estimate the relative impacts of the various parameters on market demand.

In keeping with the tradition in econometric modeling, we redefine our aforementioned utility specification for buying and pirating to include the associated error terms that proxy for omitted variables. In the traditional logit choice model where a consumer is presented with choices i, j, and where the utility from choice i is given by $U_i = u_i + \varepsilon_i$ and j is given by $U_j = u_j + \varepsilon_j$, the

probability of choosing i is given by $\Pr(i) = \frac{e^{u_i}}{e^{u_i} + e^{u_j}}$. Similarly, the probability of choosing j is given by $\Pr(j) = \frac{e^{u_j}}{e^{u_i} + e^{u_j}}$. These choice probability expressions are derived by assuming that the ε's are independent and identically (*iid*) distributed with an extreme-value distribution (McFadden 1981).



$$\Pr(TOTAL\_BUY) = \Pr(B) + \Pr(R)\Pr(R\_B)$$

Figure 1: Choice model structure

We propose a nested logit choice model akin to Ben-Akiva and Lerman (1985) to capture the two-stage decision discussed in our theory section. We begin by discussing the second-stage of the model, which represents the choices faced by the consumer who has pirated in the first stage. Let p, v, m, l represent price, product value, moral and legal costs as before (measurement of these variables has been described in the next section). Some consumers may choose to buy

after having chosen to pirate earlier. For these buyers, the utility is given by $U_{R\_B} = u_{R\_B} + \varepsilon_{R\_B} = \beta_1 + \beta_2 v + \beta_3 p + \varepsilon_{R\_B}$. The utility for those who choose the option to retain the pirated good can be written as $U_{R\_R} = u_{R\_R} + \varepsilon_{R\_R} = \beta_4 + \beta_5 v + \beta_6 m + \beta_7 l + \varepsilon_{R\_R}$. Thus the choice probabilities from buying and pirating, conditional on having pirated in the first stage, are given by

$$\begin{aligned} \Pr(R\_B) &= \frac{\exp(\beta_1 + \beta_2 v + \beta_3 p)}{\exp(\beta_1 + \beta_2 v + \beta_3 p) + \exp(\beta_4 + \beta_5 v + \beta_6 m + \beta_7 l)} \\ \Pr(R\_R) &= \frac{\exp(\beta_4 + \beta_5 v + \beta_6 m + \beta_7 l)}{\exp(\beta_1 + \beta_2 v + \beta_3 p) + \exp(\beta_4 + \beta_5 v + \beta_6 m + \beta_7 l)} \end{aligned} \tag{4}$$

The inclusive value from pirating in the first stage is given by

$$IV_R = \frac{1}{\mu_R} \ln(\exp(\beta_1 + \beta_2 v + \beta_3 p) + \exp(\beta_4 + \beta_5 v + \beta_6 m + \beta_7 l)) \tag{5}$$

As explained in Ben-Akiva and Lerman (1985), the inclusive value in equation (5) is the maximum expected utility (EMU) from all underlying choices conditional on pirating in the first stage. Therefore, the first stage utilities are given by

$$\begin{aligned} U_B &= \alpha_1 + \alpha_2 v + \alpha_3 p + \varepsilon_B \Rightarrow u_B + \varepsilon_B \\ U_R &= \alpha_4 + \alpha_5 v + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R} IV_R + \varepsilon_R \Rightarrow u_R + \varepsilon_R \end{aligned} \tag{6}$$

Similar to equation (4), the unconditional first-stage choice probabilities of buying and pirating are given by

$$\Pr(B) = \frac{\exp(\alpha_1 + \alpha_2 v + \alpha_3 p)}{\exp(\alpha_1 + \alpha_2 v + \alpha_3 p) + \exp\left(\alpha_4 + \alpha_5 v + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R} IV_R\right)} \tag{7}$$

$$\begin{aligned} \Pr(R) &= \frac{\exp\left(\alpha_4 + \alpha_5 v + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R} IV_R\right)}{\exp(\alpha_1 + \alpha_2 v + \alpha_3 p) + \exp\left(\alpha_4 + \alpha_5 v + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R} IV_R\right)} \\ &\Rightarrow \frac{1}{1 + \exp[(\alpha_1 - \alpha_4) + (\alpha_2 - \alpha_5) v + \alpha_3 p - \alpha_6 m - \alpha_7 l - \frac{\alpha_8}{\mu_R} IV_R]} \end{aligned} \tag{8}$$

We transform equation (8) into a linear model as below

$$\ln\left(\frac{\Pr(R)}{1-\Pr(R)}\right) = (\alpha_4 - \alpha_1) + (\alpha_5 - \alpha_2)v - \alpha_3 p + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R}\ln\left(e^{\beta_1+\beta_2 v+\beta_3 p} + e^{\beta_4+\beta_5 v+\beta_6 m+\beta_7 l}\right) \quad (9)$$

Multiplying and dividing the last term in equation (9) by $e^{\beta_4+\beta_5 v}$ yields

$$\begin{aligned}\ln\left(\frac{\Pr(R)}{1-\Pr(R)}\right) = (\alpha_4 - \alpha_1) + (\alpha_5 - \alpha_2)v - \alpha_3 p + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R}(\beta_4 + \beta_5 v) \\ + \frac{\alpha_8}{\mu_R}\ln(\exp((\beta_1 - \beta_4) + (\beta_2 - \beta_5)v + \beta_3 p) + \exp(\beta_6 m + \beta_7 l))\end{aligned} \quad (10)$$

Simplifying equation (10) even further we have

$$\ln\left(\frac{\Pr(R)}{1-\Pr(R)}\right) = \gamma_1 + \gamma_2 v - \alpha_3 p + \alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R}\ln\left(e^{\beta_8+\beta_9 v+\beta_3 p} + e^{\beta_6 m+\beta_7 l}\right) \quad (11)$$

where

$$\gamma_1 = \alpha_4 - \alpha_1 + \frac{\alpha_8}{\mu_R}\beta_4; \quad \gamma_2 = \alpha_5 - \alpha_2 + \frac{\alpha_8}{\mu_R}\beta_5; \quad \beta_8 = \beta_1 - \beta_4; \quad \beta_9 = \beta_2 - \beta_5$$

The above implies that the total percentage of buyers needs to be derived by including those who bought right away and those who bought after pirating:

$$\Pr(TOTAL\_BUY) = \Pr(B) + \Pr(R)\Pr(R\_B) \quad (12)$$

As discussed earlier, δ captures the share of total piracy costs that is incurred by a consumer pirating in the first stage. For our proposed econometric model, δ is given by

$$\delta = \frac{\alpha_6 m + \alpha_7 l}{\alpha_6 m + \alpha_7 l + \frac{\alpha_8}{\mu_R}(\beta_6 m + \beta_7 l)} \quad (13)$$

In order provide empirical support for the two-stage demand model while being consistent with utility maximization, our results must yield statistically significant parameters $\gamma_1, \gamma_2, \alpha_3, \alpha_6, \alpha_7, \alpha_8, \beta_3, \beta_6, \beta_7, \beta_8, \beta_9, \mu_R$ and $\mu_R \in (0,1)$.

We will now proceed to discuss our data and the estimation procedure, followed by a discussion of our empirical findings.

3 Data and analyses

Our annual time-series data span 11 years (1994-2004), and cover all the major continents. Akin to the BSA and IDC Global Software Piracy Study[2], representative countries from each continent are randomly sampled such that every region of piracy is represented. The resulting sample consists of 569 observations spanning 53 countries.

3.1 Price and v measures

For each country, piracy levels and corresponding monetary-loss data are acquired from public and private BSA reports. World Bank's World Development Indicators Database is used to generate a) number of personal computers in use for each country-year pair and b) country-specific value v (see Appendix C) .

Prices are obtained from the Producer Price Index (PPI) of pre-packaged software produced by the U.S. Bureau of Labor Statistics (BLS). Some other countries (e.g., Statistics Canada) created their own price index for pre-packaged software relying on the U.S. PPI Index (Barzyk 2003[3]). The PPI of pre-packaged software tracks average prices of domestically produced and consumed software. These are derived from the value of shipments of pre-packaged software as reported by producers for the economic census[4]. The Bureau of Labor reports PPI of pre-packaged software from 1997-2003. In order to adjust for price trending, we use data belonging to 1997 as the baseline data to derive our PPI index for years' 1994-1996 and

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[2] The BSA software piracy study lists 80 countries and seven regions, while the Hofstede sample consists of 50 countries and five regions, with 53 countries in common. http://www.bsa.org/globalstudy . Appendix C summarizes the methodology and process that are used to measure piracy rates by IDC and BSA.

[3] Fred Barzyk, "Price Index for Pre-packaged software", *18th Voorburg Group Meeting on Service Statistics*, Tokyo, 2003. The paper is available at http://www.stat.go.jp/English/info/meetings/voorburg/pdf/bar_prep.pdf

[4]Appendix D demonstrates how the Producer Pricing Index is created by the U.S. Departemnt of Labor. Detailed information about Producer Price Index is available on the Department of Labor website: http://www.bls.gov/ppi

2004. For example, PPI of pre-packaged software of Year 1994 is derived from $PPI_{1994} = \frac{Sales_{1994}}{Sales_{1997}} * PPI_{1997}$. Note that this price is uniform across countries but differs year-to-year, as software firms generally do not practice discriminatory pricing but do revise prices each year (Philips). While we are able to acquire measures for value (v) and price(p), country-specific moral costs (m) and legal costs (l) are multidimensional latent constructs (i.e. unobserved), hence need to be inferred from their underlying constituents. Next, we describe how these latent constructs are derived.

3.2 Constructing the latent constructs (moral and legal costs) from literature on piracy

Literature models moral and legal costs as non-monetary price-equivalent costs faced by a consumer during his decision to pirate. While moral costs or ethical propensity to pirate are suggested to be driven by the cultural background of a consumer (Gopal and Sanders 1998), legal costs or legal ramifications of pirating are suggested to be a result of institutional factors (Bagchi, et al. 2006).

Prior literature[5] finds that that some of the cultural indicator developed by Hofstede (1997) are highly influential in determining piracy (Gupta, et al. 2004, Husted 2000, Marron and Steel 2000, Shin, et al. 2004). It is suggested that consumers vary in their natural predisposition toward committing an immoral activity such as piracy depending upon the cultural background they come from. Hofstede (1997) suggests that there are four indicators that capture cultural differences across the globe -- namely power distance (PDI), collectivism (COL), masculinity (MAS), and uncertainty avoidance (UAI). Of these factors, Gopal and Sanders (2000) provide empirical support for collectivistic societies not valuing individuals' property rights and hence

[5] Appendix B summarizes the current empirical and analytical literature on all types of piracy. The focus of our study is not to generate new measures/scales to measure moral costs or legal costs. Instead, we rely on the extant literature which has identified underlying elements for each of these higher order constructs.

engaging in higher levels of piracy. Marron and Steel (2000), also find statistically significant correlation between collectivism and piracy level. While there is no empirical support that links MAS and UAI to piracy, Husted (2000) suggests that piracy is not only related to collectivism (COL) but also to power distance (PDI). He further suggests that the interaction between PDI and COL may need to be considered given the relatively high negative correlation (r=-0.67), thus potentially reducing the explanatory value of the individual factors. Hence we incorporate the interaction term as well in constructing out latent construct of moral cost.

Thus from a theoretical standpoint, moral cost is a multi-attribute latent construct, and in order to measure this latent construct, we employ a factor analysis procedure on the four cultural indices as well as the interaction between collectivism and power distance. Confirmatory factor analysis (CFA) on the data clearly shows that MAS and UAI do not load on the designated latent factor (completely standardized loading <0.70). Hence to refine the measurement model, we drop these two measurement items and repeat our analysis to build the latent construct of moral cost as the weighted linear combination of three items: COL, PDI and the interaction of the two (COLxPDI). Details on the factor loadings and the item-level correlations are presented in Table 1 below.

Piracy research also suggests that a second component of piracy costs arises from a consumers' expectation of getting caught and the punitive damage he might suffer in that case (Chellappa and Shivendu 2003, Globerman 1988). Extant empirical work on global piracy suggests that drivers of legal barriers to piracy stem from a country's institutional infrastructure (Andr´es 2006, Van Kranenburg and Hogenbirk 2005). Some have constructed indices that specifically examine aspects of legal protection of patent rights, coverage, and participation in international patent agreements (Burke 1996, Park and Ginarte 1997) while other investigate the provisions for loss protection (Van Kranenburg and Hogenbirk 2005). A shortcoming of

using these measures alone is that while they capture punitive aspects of protection (through laws) if caught, they do not address the reality of a country's actual enforcement of these laws, which would influence a consumer's expectation of getting caught (Andr´es 2006, Samuelson 1999). Independently however, some literature (Ronkainen and Guerrero-Cusumano 2001) has used the *Corruption Perceptions Index* (compiled annually by Transparency International) as a proxy measure of the law enforcement of IPR. Corruption is a manifestation of a lack of respect of a firm or a citizen for the rules which govern their businesses (Kaufmannet al. 2003). Prior empirical studies have suggested that corruption in the law-enforcement systems (e.g., customs, police, judiciary, etc.) will result in low level of detection of piracy crime (Bagchi et al. 2006; Papadopoulos 2003) and hence, reduce the effectiveness of IP law enforcement. Given that both the laws relating to IPR and their enforcement are relevant to consumers' attitudes toward piracy, it is critical to include a measure of both in identifying a consumer's legal cost of pirating (Ostergard 2000, Samuelson 1999). Thus, the eventual legal cost faced by a consumer is a multi-attribute latent construct and we develop this measure by first considering all of the drivers examined earlier.

We obtain a number of country-specific indicators of legal costs from the World Bank[6]. We first identified multiple sources of this measure, including *Rule of Law Index* and *Control of Corruption Index* from governance research, *Property Right Indicator* from the Index of Economic Freedom, and *Number of International Intellectual Property Agreements* (*IP Agreements*) from the World Intellectual Property Organization (WIPO). World Bank releases reports on the aggregate governance research indicators bi-annually from 1996 to 2004. First, the *Rule of Law Index* is a composite measure and includes several indicators, including

[6] www.worldbank.org/wbi/governance/govdata/

perceptions of the incidence of crime, the effectiveness and predictability of the judiciary and the enforceability of contracts. It is a proxy for the extent to which agents have confidence in and abide by the rule of society, and is understood to be indicative of the success of a society in developing an environment in which fair and predictable rules form the basis for economic and social interactions and the extent to which property rights are protected (Cass 2003). The other indicator, *Control of Corruption Index*, measures perceptions of corruption and represents control of governance failure. It also assesses the likelihood that private property will be expropriated and analyzes the independence of the judiciary, the existence of corruption within the judiciary and the ability of individuals and businesses to enforce contracts. It represents the degree to which a country's laws protect private property rights and the degree to which its government enforces those laws. *Property Right Indicator* examines the degree to which a country's laws protect private property by enforcing the laws and how safe private property is from expropriation. This indicator is compiled from several items such as legally granted and protected private property, commercial code defining contracts, etc. Please see Appendix A for further details.

Table 1: Scale Reliability for Latent Constructs - Legal and Moral Costs

Legal Costs						
Items	*Factor Loading*	*Item Correlation*				
1. Corruption Control	-0.98	1.00				
2. Rule law	-0.98	0.96	1.00			
3. IP Agreement	-0.12	0.12	0.12	1.00		
4. IP right protection	-0.10	0.09	0.10	0.02	1.00	
Moral Costs						
Items	*Factor Loading*	*Item Correlation*				
1. Power Distance	-0.89	1.00				
2. Collectivism	-0.91	0.67	1.00			
3. Masculine	0.00	0.11	-0.09	1.00		
4. Uncertainty Avoidance	-0.21	0.19	0.32	0.06	1.00	
5. Collectivism x Power Distance	-0.99	0.89	0.91	0.00	0.21	1.00

Note: Bolded correlations are significant at $p < 0.05$. Maximum likelihood factor extraction method was used for both latent constructs. Four items of legal costs explain 48.86% of variance, Eigenvalue = 1.95. Five items of moral costs explain 53.11% of variance, Eigenvalue = 2.65

Our exploratory factor analysis reveals that *Property Right Indicator* and *Number of International Intellectual Property Agreements* (*IP Agreements*) are not significantly loaded on the latent construct, and hence we drop these items to create the final factor score. The adequacy of each multi-item scale in capturing the latent factors was assessed by checking internal consistency reliability and convergent validity. We can see from Table 2 that the values of Cronbach's Alpha for both constructs are well above the suggested threshold of 0.70. In addition, the standardized factor loadings for all items are above the suggested cut off of 0.60 (Hatcher 1994), with a minimum factor loading of 0.91 with strong evidence of convergent validity. The latent construct *moral cost* is in the range of -2.07 to 1.35, and *legal cost* is between -1.75 to 1.68. All the details have been provided in Table 2 below.

Table 2: Confirmatory Factor Analysis for Latent Constructs

Confirmatory Factor Analysis Results				
Construct	*Indicator Variable*	*Standardized Loading*	*Communality Estimate*	*Composite Reliability (Cronbach Alpha)*
Moral Cost			2.65	0.93
	Collectivism	0.92	0.84	
	Power Distance	0.91	0.83	
	Collectivism x Power Distance	0.99	0.99	
Legal Cost			1.96	0.98
	Rule of Law	0.99	0.98	
	Control of Corruption	0.99	0.98	
Note: only five items were retained and 4 items were removed during confirmatory factor analysis.				

Descriptive Statistics							
Items	*Mean (Std. Dev)*	*Min*	*Max*	*Item Correlations*			
1. Rule of law	0.76 (0.96)	-1.1	2.36				
2. Corruption Control	0.75 (1.08)	-1.15	2.58	0.96			
3. Collectivism	54.38 (25.22)	9.00	94.00	-0.74	-0.73		
4. Power Distance	57.26 (22.38)	11.00	104.00	-0.68	-0.71	0.67	
5. Collectivism x Power Distance	3492.72 (2429.07)	360	8930	-0.76	-0.76	0.91	0.89

3.2 Estimation results

The parameters of equation (11) are estimated using the aforementioned data. We restate this below

$$\Pr(TOTAL\_BUY)_{i,t} = \Pr(B)_{i,t} + \Pr(R)_{i,t}\Pr(R\_B)_{i,t}$$

where

$$\ln\left(\frac{\Pr(R)_{i,t}}{1-\Pr(R)_{i,t}}\right) = \gamma_1 + \gamma_2 v_{i,t} - \alpha_3 p_{i,t} + \alpha_6 m_{i,t} + \alpha_7 l_{i,t} + \frac{\alpha_8}{\mu_R}\ln\left(e^{\beta_8+\beta_9 v_{i,t}+\beta_3 p_{i,t}} + e^{\beta_6 m_{i,t}+\beta_7 l_{i,t}}\right) \quad (14)$$

Since the IV coefficient μ_R cannot be separately identified, it is recovered by repeated iterations with different starting points and the estimate with lowest SSE is chosen.

Note that piracy data is available only at the country level but over multiple time periods and referenced by subscripts i (country) and t (time-period) for econometric estimation. In other words the consumer described in the choice-model is a representative consumer for each country. Further, while only the choice of pirating is observed, literature in marketing provides techniques for econometric estimation of nested demand models where market structure can be inferred from observed choices (Chintagunta 1993, Guadagni and Little 1983, Gupta 1988). For example, using nested logit-like specifications, scholars in marketing have assessed if observed choices imply that consumers choose size first and then the brand or the vice-versa. While these two decisions happen sequentially and the order is unobserved to the econometrician, by testing alternative model specifications and by using objective model selection criteria, researchers identify which decision process better explains observed choices. Similarly, in this study while the sequence of a representative consumer's choice is unobserved to us, using observed data and recovered demand parameters we can construct this consumer's decision process. A further advantage with modeling the piracy decision-process is that only one of the branches needs to be extended to the second stage, i.e., while consumers may pirate and then buy, there is no need to consider buying and then pirating since the consumer already owns the product.

Table 3: Descriptive Statistics

Variable	Description	Mean (Std. Dev)	Min	Max	1	2	3	4
Ln(Pirate)	Ln (PiracyLevel/(1-PiracyLevel))	-0.43 (1.02)	-3.89	1.32				
Legal	Construct built on two indices: Rule of Law and Control of Corruptions from Governance Index	2.00 (0.99)	0.25	3.68	0.71			
Moral	Construct built on Hofstede's power distance (PDI), collectivism, and interaction between PDI and collectivism	3.00 (0.99)	0.93	4.35	0.68	0.78		
Price	Producer price index from Bureau of Labor	111.95 (22.5)	96.9	163.39	-0.33	0.01	0.01	
Value	Country's total software market revenue divided by its number of personal computers in use	94.29 (59.61)	6.82	460.26	-0.03	0.12	0.11	0.37
N=569 (excluding 14 observations with missing values)								

3.3 Discussion of results

We estimate two sets of models. Model 1, is the model detailed in section 2.1. Model 2, introduces the non-linear effect of price in both stages of the demand model. Our empirical analyses offer support for our proposed two-stage demand model. While Model 2 marginally outperforms Model 1 on the adjusted R-square and log-likelihood criteria, Model 1 outperforms Model 2 on the nested model-selection BIC criterion i.e. when we correct for additional parameters needed to be estimated. Hence we report the results for both the models in Table 4, however limit the discussion of our analysis to our results for Model 1 alone. We begin by discussing the parameters of the first stage and end this section with discussion on the second-stage parameters and controls for seasonality/time trends.

1. First-Stage Demand Model

Legal and moral costs have statistically significant effects in the first-stage consumer decision to buy or pirate. The moral cost parameter (-.36) and legal cost parameter (-.42) suggest that these costs serve as good deterrents to first-stage piracy. Price is also very important in consumers' decision to pirate or purchase legally (.04). γ_1 and γ_2 together capture

the differences in innate preference for the good, between those who pirate and those who buy. $\gamma_2 = 0$ implies that $\alpha_5 - \alpha_2 + \frac{\alpha_8}{\mu_R}\beta_5 = 0$. This, however, does not imply that buyers or those who pirate do not differ in their marginal utility from the value of the good v, i.e. $\alpha_5 - \alpha_2$ may or may not be equal to 0. $\alpha_5 - \alpha_2$ will only be 0 if $\frac{\alpha_8}{\mu_R}\beta_5 = 0$ and $\alpha_5 - \alpha_2 + \frac{\alpha_8}{\mu_R}\beta_5 = 0$, i.e. either $\beta_5 = 0$ and/or $\alpha_8 = 0$ since μ_R cannot be zero if the proposed demand model is consistent with utility maximization. Similarly, $\gamma_1 = 1.22$ implies that $\alpha_4 - \alpha_1 + \frac{\alpha_8}{\mu_R}\beta_4 = 1.22$. This difference may stem from the contribution of a second-stage component $\frac{\alpha_8}{\mu_R}\beta_4$ or innate difference between α_4 and α_1. In order to evaluate differences in valuation or innate preference between buyers and those who pirate, we need to examine the results of the second-stage demand model.

2. Second-Stage Demand Model

Unlike the first-stage model where both legal and moral costs have statistically significant effects on consumers' decisions to buy or pirate, in the second stage, only legal costs affect consumers' decisions to hold on to the pirated copy or purchase legally. This is a very important and insightful result, as it suggests the need to explore different public policy controls for first-stage piracy deterrence and post-piracy punishment. As far as we know, this study is the first one to empirically demonstrate this need, and implications of this finding are discussed later.

$\beta_8 = \beta_1 - \beta_4$=18.17 and $\beta_9 = \beta_2 - \beta_5 = 0.64$ imply that holding piracy costs and price of the good fixed, consumers who buy in the second stage have a higher innate preference for the digital good (i.e. $\beta_8 > 0$) as well as a higher valuation (i.e. $\beta_9 > 0$) for it, compared to those who continue to hold on to their pirated copy. Hence, if via sampling through piracy, consumers feel like the revealed value of the good outweighs the costs of piracy and price, then consumers will more likely purchase the good post pirating. Identification restrictions, limit our ability to assess

if consumers who pirate in the first stage actually update their valuation and innate preference for the good in the second stage i.e. $\alpha_4 < \beta_4$ and/or $\alpha_5 < \beta_5$.

Table 4: Demand Model Results

Variables	Model 1 (Std. Error)	Model 2 (Std. Error)
Stage 1 – Demand Parameters		
$\gamma_1 = \alpha_4 - \alpha_1 + \frac{\alpha_8}{\mu_p}\beta_4$	1.22** (0.54)	1.82 (1.18)
$\gamma_2 = \alpha_5 - \alpha_2 + \frac{\alpha_8}{\mu_p}\beta_5$	0.00 (0.00)	-0.04 (0.03)
α_6 (moral cost)	-0.36*** (0.04)	-0.32*** (0.05)
α_7 (legal cost)	-0.42*** (0.05)	-0.42*** (0.05)
α_3 (price)$^+$	0.04*** (0.01)	0.95 (0.67)
α_9 (price*price)		1.31** (0.41)
Stage 2 – Demand Parameters		
$\beta_8 = \beta_1 - \beta_4$	18.17* (13.27)	-25.09*** (6.51)
$\beta_9 = \beta_2 - \beta_5$	0.64*** (0.27)	3.05* (1.76)
β_6 (moral cost)	5.64 (4.83)	4.84 (2.46)
β_7 (legal cost)	-6.01** (3.71)	-2.58** (2.05)
β_3 (price)	-0.26*** (0.10)	-1.53 (0.72)
β_{10} (price*price)		-1.31*** (0.44)
Seasonality Parameters		
Year 1995	-0.06 (0.10)	-0.02 (0.03)
Year 1996	-0.49*** (0.09)	-0.09** (0.03)
Year 1997	-0.31*** (0.10)	-0.15*** (0.03)
Year 1998	0.35*** (0.10)	-0.19*** (0.03)
Year 1999	0.18 (0.10)	-0.24*** (0.03)
Year 2000	0.04 (0.11)	-0.27*** (0.04)
Year 2001	-0.14 (0.11)	-0.30*** (0.04)

Year 2002	-0.14 (0.10)	-0.34*** (0.04)
Year 2003	-0.02 (0.14)	-0.33*** (0.04)
Year 2004	-0.01 (0.11)	-0.29*** (0.04)
μ_p ++	0.1	0.1
n	569	569
Adj. R^2	0.70	0.72
Log-Likelihood	-447.17	-424.67

Significance: *** p <0.001, ** p <0.01, * p <0.05
+ Price variable negative
++ Calculated numerically by minimizing SSE
Note: we also test the effect of interaction of Legal Cost and Moral Cost. It is not significant.

Price is also very important in consumers' decisions to pirate or purchase legally (-.26). Where all else is equal, higher prices lead a consumer to consider the piracy option instead of the purchase option in stage 2. Combining results from the first stage and second stage suggest that there is statistically significant interplay between price and piracy levels. Further, varying levels of moral costs and legal costs across countries also warrants that firms and policy makers work in concert while formulating their strategies. Failure to do so limits firms' ability to extract profits and public policy officials' ability to control piracy. In order to control for seasonality effects, we also include time dummies for each year. The adjusted R-square of our proposed demand model is .70, showing fairly high descriptive power.

4 Global Policy and Pricing Strategies

Our model and empirical estimates provide certain important insights into policy and pricing strategies in a global context. In this section we shall first examine optimal global pricing strategies that vendors should adopt, followed by a discussion on the implication of preventive versus post-piracy punitive actions to thwart piracy.

4.1 Optimal global pricing strategies

"How much does a Big Mac cost in India versus in New York versus in Taipei, and how do you map a similar Big Mac index to software? It's a very difficult problem. We do know that we need to work with these governments so we do have software and the right offerings priced in a way that's relevant to them and their consumers and their constituencies."

-- Martin Taylor, Microsoft's general manager of platform strategy

That price in itself is significant at both stages is not surprising, however, that still leaves the vendor with the question of how to set optimal prices. For example, while ideally the vendor would like to set two prices one for pirates and one for buyers (or prices differently at the two levels), price itself is endogenous to the decision to buy/pirate. Further, it is practically impossible to set two different prices for these two consumer segments. On the other hand, the heterogeneities in the piracy cost indices make evident that it is prudent to develop a discriminatory strategy of pricing. Increasingly firms have begun to recognize this, e.g., Microsoft has decided to deviate from its "one-rate policy" in dealing with certain countries (Fried 2004). In order to develop the optimal country-specific pricing, we examine the total profit from both stages as follows

$$\frac{\partial \pi}{\partial p} = \frac{\partial}{\partial p}[(\Pr(B) + \Pr(R)\Pr(R\_B)) * M] = 0 \tag{15}$$

M is the market size of a country, and from equations 4, 7 and 8, we can compute the probabilities by plugging in the appropriate estimates (the derivations and details are available from the authors). The results of this price discrimination strategy are clearly superior to the profits from uniform global pricing, while taking into account both the piracy costs as well as the two-stage behavior.

The importance of pricing cannot be overemphasized given the two-stage behavior. If prices are low, then more people buy outright, increasing the share of legitimate sales but eroding unit margins. However, if prices are high, then more people pirate in the first stage. The latter may even be good under some circumstances, such as if it helps consumers update

their valuation of the product. Thus while a firm may not want to necessarily encourage piracy, some situations may warrant managing piracy as reflected in the piracy costs in a country. Clearly, piracy costs are meaningful only to the extent that they are comparable with both prices and generic product valuation v, and when we compare the optimal prices to the product valuation, we see a distinct pattern emerging (see Figure 2).

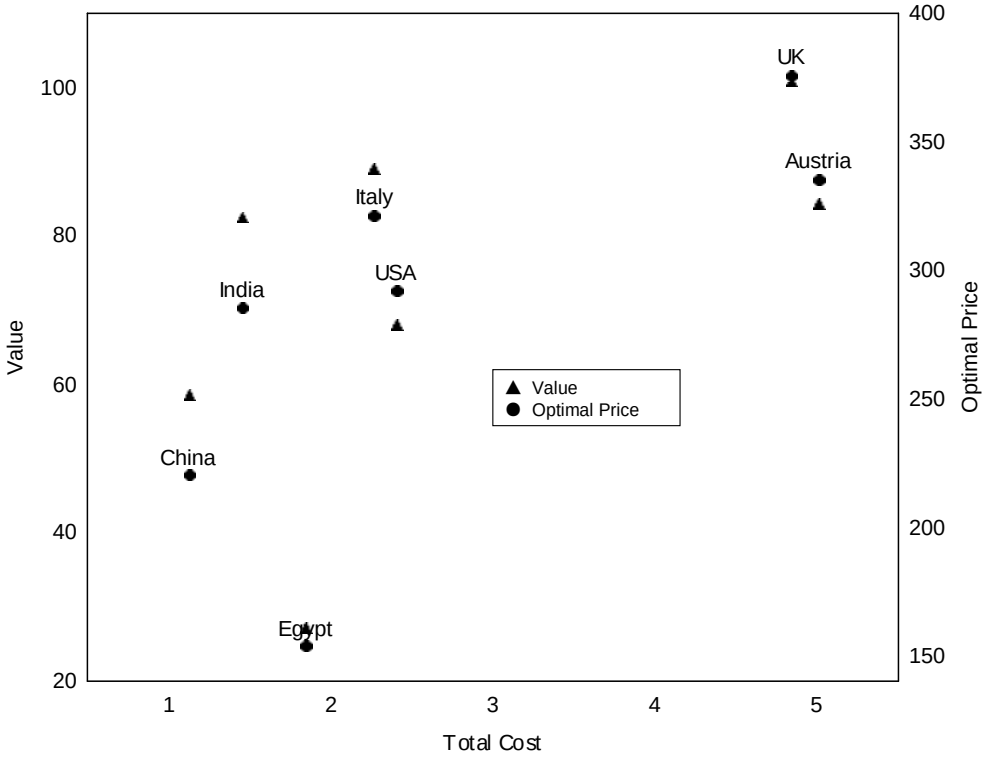

Figure 2: Optimal country-specific prices

We can observe that while product valuation and optimal prices are closer to each other for countries with higher piracy costs, for those with lower piracy costs, the distance is larger. The economic intuition behind this observation is particularly interesting for an industry where firms have long been considered to be endowed with monopoly power. For all practical purposes, IPR-based firms are monopolists in that they are often the sole owners of a product, and the basic principle behind monopoly pricing is to extract all consumer surplus, i.e., prices are close to product valuation. However, piracy acts like a competitor in this industry even if

the competing firm itself is not engaging in any sort of profit maximizing. This effectively restricts prices to be $p = \min\{\text{value,piracy-costs}\}$. From a firm's point of view, our results suggest that a trade-off matrix (Figure 3) between value and piracy costs can provide broad recommendations for prices.

The broad implication for a software vendor is that under certain conditions, pricing may have to be driven by piracy and enforcement situations, as monopoly policy of zero consumer surplus is not possible. Rather, competitive pricing, i.e., setting prices closer to the competitor (in this case piracy costs), is perhaps optimal. Ideally, of course, firms might like to influence the prevalent legal costs, as moral costs are more intrinsic and generic to country. But given that costs are split over two stages, we seek to further examine the nature of the share of costs in the first versus second stage.

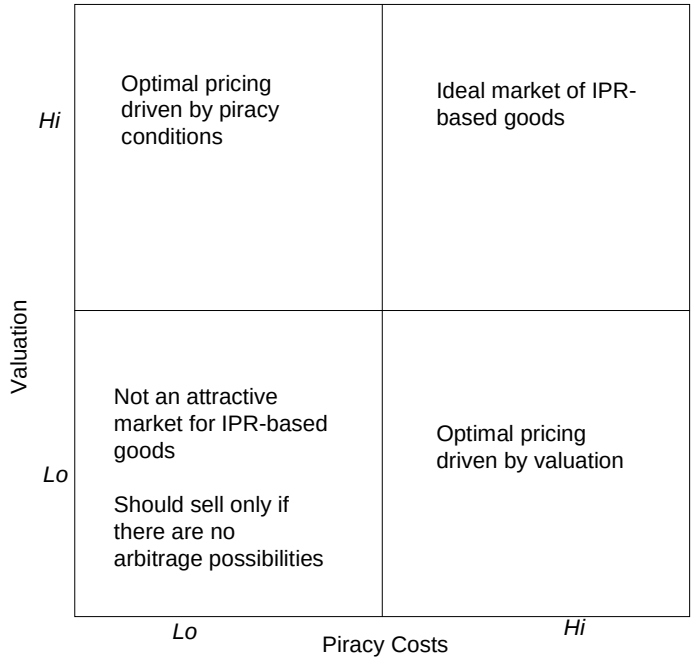

Figure 3: Optimal pricing strategies

4.2 Policy implications

The total piracy costs (sum of legal and moral costs), are split across the two levels. The share of total piracy costs in stage one (δ) is given by equation (13). Since legal and moral costs

vary by country and time, one can calculate δ for each country and Table 5 provides the descriptive statistics of this parameter. Intuition and prior empirical work might suggest that low levels of piracy in a country equate to consumers not engaging in piracy at all, i.e. $\delta \to 1$ wherein all costs come into play in the preventive stage itself. However, our results show that δ is actually smaller in countries with low piracy levels (see Figure 4). Remember that higher δ implies that a majority of the piracy costs are suffered in the *first* stage, i.e., more likely that people don't pirate at all and a lower δ implies that a majority of the piracy costs are suffered in the *second* stage, i.e., consumers are more likely to be deterred from holding a pirated copy.

Table 5: Global Variations in First and Second stage costs

Variable	Mean	Std. Dev	Minimum	Maximum
		Model 1		
δ (Delta)	0.63	0.06	0.51	0.83
Stage 1 Piracy Costs	1.92	0.73	0.50	3.06
Stage 2 Piracy Costs	3.12	1.31	0.76	5.21
		Model 2		
δ (Delta)	0.75	0.03	0.68	0.83
Stage 1 Piracy Costs	1.80	0.69	0.47	2.89
Stage 2 Piracy Costs	2.31	0.94	0.58	3.81

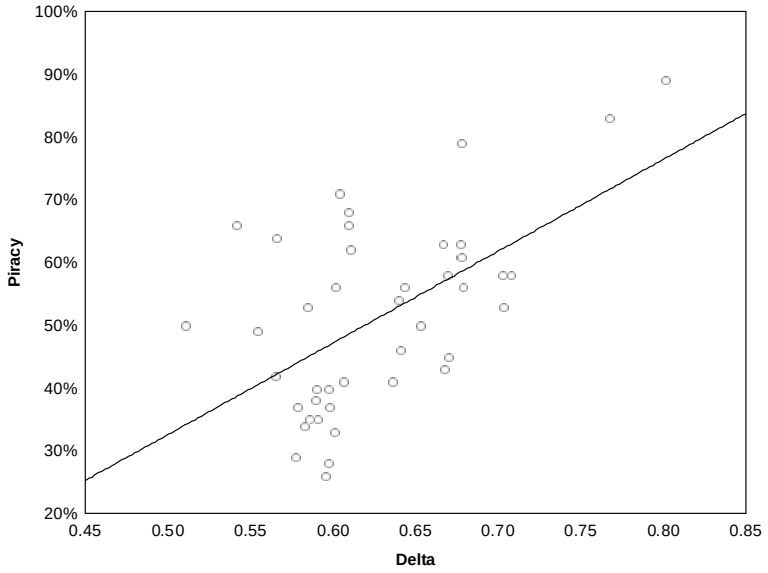

Figure 4: Piracy level and ratio of prevention to deterrence

Our findings show that lower piracy is *not* merely a result of consumers not pirating at all. Rather, it is a result of some pirates becoming buyers in the second stage. The latter is possibly due to the fact that post-updating, those who become buyers perceive a greater value for the product than those who remain pirates (an indication of piracy's sampling effect). Or it could be that consumers are stopped by the deterrence costs in the second stage, and hence end up buyers. Our results suggest that there is ample evidence of both.

First, we can see that $\beta_8 = \beta_1 - \beta_4$ (where β_1 and β_4 are value coefficients of buyers and pirates in the second stage) is both significant and positive, supporting the former argument. And second, we also see that the legal cost coefficient in the second stage is relatively high even if moral costs themselves do not appear to play a role in this stage. Also, we should take care to note that while the parameter δ is low for the countries with low levels of piracy, the piracy costs themselves (the total as well as the individual stages) are always higher than in countries that suffer greatly from piracy (see Figures 5a-5d).

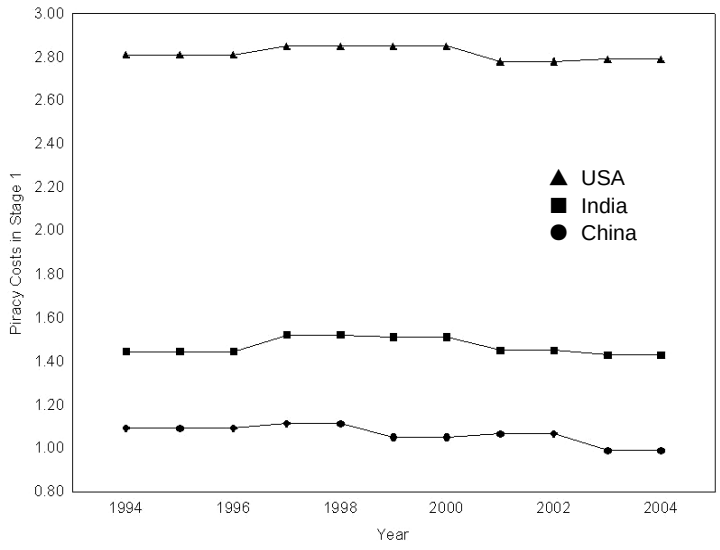

Figure 5a: Variation across Countries in Stage 1 Piracy Costs

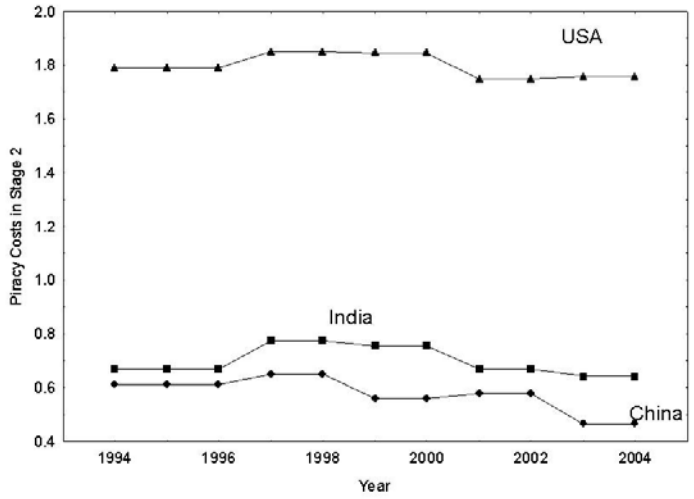

Figure 5b: Variation across Countries in Stage 2 Piracy Costs

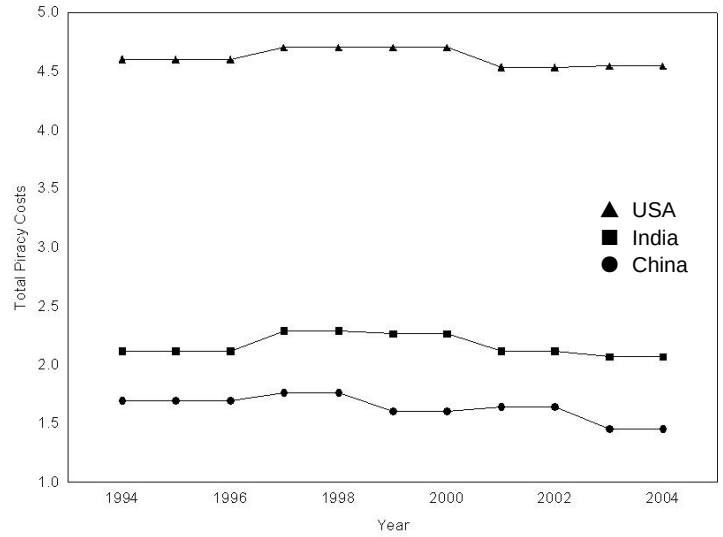

Figure 5c: Variation across Countries in Total Piracy Costs

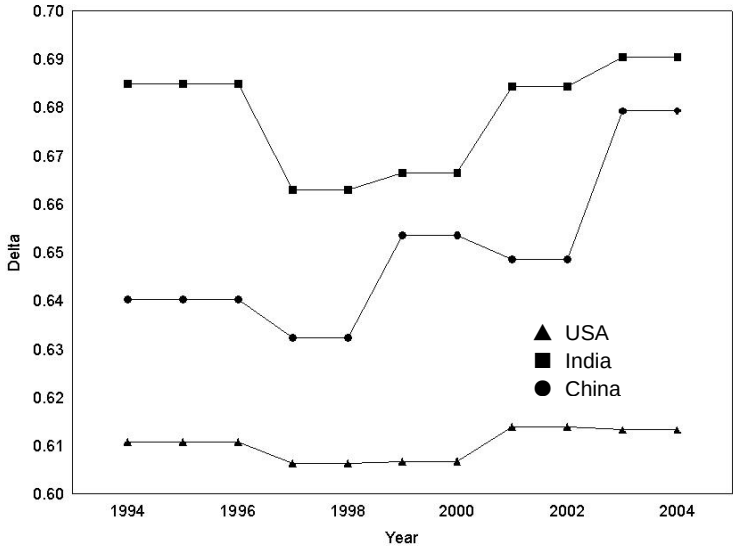

Figure 5d: Variation across Countries in δ

Note that in constructing regulatory implications, we should keep in mind that there is no one global regulator of public policy. Rather, the results should be meaningfully interpreted by the U.S. software industry so as to influence IPR protection in different countries. The impact of legal costs in the second stage can largely be associated with enforcement-related activities; our findings point out that in countries with low piracy, the second-stage costs dominate the first-stage ones. And since the second-stage costs are entirely composed of legal costs, an important implication is that the industry should not only push for countries to enact laws to protect IP, but rather the enforcement of these laws should be emphasized. This implies that just because a country has signed a WTO agreement, it doesn't mean that piracy will reduce, follow-up actions regarding overall enforcement continue to be important. Indeed a recent event study on piracy pre and post legal actions pursued by the Recording Industry Association of America, finds that while such actions cannot eliminate piracy they do have positive outcomes that are important to managing piracy (Bhattacharjee, et al. 2006).

To summarize, we provide compelling evidence for the differential impact of legal and moral costs on piracy levels in different countries. Clearly, legal costs, an outcome of legal controls put forth by regulators thwart piracy albeit to different degrees across different countries. This study therefore calls for regulators to critically examine their legal controls geared to deter piracy.

4.3 Limitations and future research

An important limitation of our work is that due to constraints, we only have aggregate information on software piracy. It would be interesting to break down piracy based on software categories to see if some suffer more piracy than others. The specific impact of sampling effects of piracy and the price points could be better understood if data were available at this granular level. Further, we also do not include the size of the local software industry in each country.

Note that while all piracy data is restricted to software from U.S.-based firms, one important indicator could be the local production itself. Countries with a large installed local base might do a better job of production and enforcement. Finally, we believe that the results from this study could be extended to study piracy in the music, movie and video-games piracy industries.

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An Empirical Examination of Global Software Piracy: Implications for Pricing and Public Policy

Managerial Insights

Piracy is one of the most important factors threatening the software industry in its effort to create a global marketplace for its products – annual global losses are suggested to be upwards of $34 billion. Historically, this industry has practiced a single-price approach to global pricing. One main managerial implication of our work is the recommendation for country-specific pricing as a function of a country's cultural and institution elements along with the potential buying power of its consumer-base. We specifically lay-out a recommendation matrix that identifies groups of countries where-in it is optimal to engage in value-based pricing in some versus piracy-driven pricing in others. While there is some evidence of the benefit of enforcement actions in combating piracy in the US, our research seeks to find global evidence for the role of cultural and institutional factors. We show that piracy is low in certain countries not mainly because they are culturally pre-disposed towards respecting copyright laws, rather in these countries the extent of post-piracy costs through legal mechanisms is relatively severe. From a public policy point of view this points out that not only do countries need to join world copyright protection bodies, but the subsequent follow-up actions need to be commensurate with the original intention of these groups.

Appendix A

Sources	Concept Measured
	1. Rule of Law
Columbia University (CUD)	For the most part, is the state seen as legitimately representing its citizens? Rate the state's adherence to the rule of law, considering the country as a whole.
Global Insight (DRI)	Losses and Costs of Crime : A 1-point increase on a scale from 0" to "10" in crime during any 12-month period. Kidnapping of Foreigners: An increase in scope, intensity, or frequency of kidnapping of foreigners that reduces the GDP growth rate by 1% during any 12-month period. Enforceability of Government Contracts : A 1 point decline on a scale from 0" to "10" in the enforceability of contracts during any 12-month period. Enforceability of Private Contracts: A 1-point decline on a scale from 0" to "10" in the legal enforceability of contracts during any 12-month period.
Economist Intelligence Unit (EUI)	Violent crime Organized crime Fairness of judicial process Enforceability of contracts Speediness of judicial process Confiscation/expropriation
Heritage Foundation (HER)	Black market Property Rights
Amnesty International (HUM)	Independence of Judiciary
Political Risk Services (PRS)	Law and Order.

Business Environment Risk Intelligence	Direct Financial Fraud, Money Laundering and Organized Crime
World Markets Research Center (WMO)	Judicial Independence An assessment of how far the state and other outside actors can influence and distort the legal system. This will determine the level of legal impartiality investors can expect. Crime How much of a threat businesses face from crime such as kidnapping, extortion, street violence, burglary and so on. These problems can cause major inconvenience for foreign investors and require them to take expensive security precautions.
	2. Control of Corruption
Columbia University (CUD)	Rate the severity of corruption within the state To what extent do the country's primary political decision makers (e.g. chief executive and cabinet members) engage in patterns of nepotism, cronyism and patronage? To what extent do the country's civil services (occupying middle and higher management roles) engage in patterns of nepotism, cronyism and patronage? To what extent do patterns of nepotism, cronyism and patronage undermine the state's ability to exercise the basic functions of government effectively? To what extent do patterns of nepotism, cronyism and patronage distort broad patterns of economic development?
Global Insight's (DRI)	Risk Event Outcome non-price: Losses and Costs of Corruption: A 1-point increase on a scale from 0 to 10" in corruption during any 12-month period. "
Economist Intelligence Unit (EIU)	Corruption
Political Risk Services (PRS)	Corruption within the political system, which distorts the economic and financial environment, reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability, and introduces an inherently instability in the political system.
Business Environment Risk Intelligence	Indirect Diversion of Funds

World Markets Research Center (WMO)	Corruption: This assesses the intrusiveness of the country's bureaucracy. The amount of red tape likely to countered is assessed, as is the likelihood of encountering corrupt officials and other groups

Note: Excerpt from D. Kaufmann, A. Kraay and M. Mastruzzi. "Governance Matters III: Governance Indicators for 1996–2002", May 2003, *World Bank Governance & Anti-Corruption Working Papers.*

We choose to use Control of Corruption Index from World Bank Governance & Anti-Corruption (WBG) instead of Transparency International Corruption Perception Index (TI) because TI index relies on a subset of the sources WBG use to create the index (10 data sources in TI vs. 14 sources in WBG). In addition, TI index uses simple average of scores as the estimate of corruption, while WBG construct Control of Corruption Index based on a weighted average of scores.

Appendix B

Table B-1: Empirical Literature on Piracy
(Includes all types – music, movies, and software; both global and local)

STUDY	INCLUDES SOCIO-DEMOGRAPHIC FACTORS	INCLUDES PRICE VARIABLE	INCLUDE FACTORS AFFECTING MORAL COSTS	INCLUDE FACTORS AFFECTING LEGAL COST	DATA	FINDINGS
Secondary Data						
Givon et al. (1995)					Monthly shipment data on DOS-based microcomputers and two software products (Word processor and spreadsheet) from January 1987 through August 1992.	Software piracy helps to increase the legal penetration and diffusion of software. Word-of-mouth interactions influence potential users of software to adopt the product and eventually buy it. More than 80% of word processor and spreadsheet purchased in UK was the result of influence of piracy.
Gopal & Sanders (2000)	X				Software piracy level in 65 countries in 1997	Strong negative correlation between per capita GNP and piracy rate for countries with GNPs less than $6000.
Husted (2000)	X		X		39 counties software piracy in 1996	GNP per capita, individualism, power distance, and income inequality significantly influence piracy level.

Marron & Steel (2000)	X		X	X	Average software piracy level in 77 countries in 1994-1997	Economic development, individualism, and the strength of contract protection are negatively correlated with average piracy level in 1994-1997.
Hui & Png (2003)	X	X			Average music piracy level in 28 countries in 1994-1998	The reported music piracy level by IFPI was over assessed. The true "loss" is only 42% of the reported figure. The positive influences of piracy on legitimate demand were trivial compared to its negative effect. Differential pricing strategy may help to reduce average piracy level and increase legitimate demand.
Moores (2003)	X		X		Average software piracy level in 45 counties in 1994-1999	Personal wealth and moral factor (especially Individualism) are two influential factors on average software piracy rates in 1994-1999.
Shin et al. (2004)	X		X		Software piracy in 49 counties in 1999	Strong negative relationship between the national income and software piracy level, positive relationship between collectivism and software piracy level.
Depken & Simmons (2004)	X		X		Software piracy in 65 countries in 1994	Socio-economic factors and social moral propensity affect piracy rate at country level.

Banerjee et al. (2005)	X			X	Software piracy in 53 counties from 1994-1999 (panel data analysis)	Economic factors (GDP, openness), corruption control, civil liberty, and economic freedom are all significantly related with piracy level.
Proserpio et al. (2005)	X		X	X	Average piracy in 76 countries for software piracy, 73 for music piracy, and 64 for movie piracy in 1999-2002	Individualism, law enforcement, GDP and average level of education of the population are influential factors on average piracy level across three product categories: software, music, and movie.
Zentner (2005)	X	X			Music sales in 65 countries for the years 1997-2002	Countries with a higher share of peer-to-peer users suffered higher drops in music sales.
Bagchi et al. (2006)	X		X	X	37 countries piracy in 1996, 2001, and 2003	Legal factors and moral factor (individualism) are influential factors to control piracy. Nations with less corruption and weak collectivism had lower piracy rate.
Primary Data (Surveys)						
Swinyard et al (1990)			X		Survey on a sample of students in U.S. and Singapore.	Asians have more casual attitude toward piracy. These attitudes toward piracy are rooted in cultural that emphasize sharing creative work.
Logsdon et al. (1994)			X		Survey on a sample of 371 students in U.	Software piracy was not perceived as an ethical behavior by most of the students in the survey.

					S. university and Singapore university	Software industry should educate users and change their attitudes and behaviors towards piracy.
Simpson (1994)	X		X		Survey on 209 business students	Socio-demographic factors such as gender, religion, and motivation for personal gain are significant predictors of piracy behavior. However, consumers' unethical perception of piracy was not a significant factor in determining the propensity to pirate.
Cheng et al. (1997)	X	X			Survey on a sample of business students.	Household income is highly correlated to software piracy. The authors suggest that a pricing strategy based on a potential buyer's household income.
Gopal & Sanders (1998)	X		X	X	Survey on a sample of M.B.A. students in a U. S. university	Deterrent information (information about copyright law, penalties, and impact of piracy) and ethical index are correlated with lower piracy rate. Deterrent controls or reducing market price can reduce piracy.
Gupta et al. (2004)	X		X	X	Survey on 689 software consumers	Ethics/moral factor is embedded in legal aspects, social support, personal attitudes and perceptions of economic loss, and age. These factors significantly influence piracy behavior.
Limayem et al. (2004)			X	X	Survey on 127 undergraduate business students in Canada	Social factors and beliefs concerning consequences of software piracy significant affect on software piracy intentions.

Chiou et al. (2005)			X	X	Survey on 207 youngsters age 15-19 in Taiwan	Perceived prosecution risk, magnitude of consequence, and social consensus are very important in influencing customer's attitude and behavior towards music piracy.

Table B-2: Analytical Literature on the Piracy
(Includes all types – music, movies, and software; both global and local)

STUDY	STUDY CONSIDERS						
	POTENTIAL BENEFITS	PRICE	TECHNICAL PROTECTION MEASURES	MORAL COSTS	LEGAL COSTS	RESEARCH MODEL	MAJOR FINDINGS
Conner & Rumelt (1991)	X	X				Monopoly framework, Positive network externality—Consumer's willing to pay increases in the number of users.	Piracy has positive benefit of network externality by increasing the size of the installed base. It may also boost the demand for the software. When network externalities are present, protection technology has two opposite effects: profit can rise or fall as the level of piracy protection is increased.
Takeyama (1994)	X	X			X	Monopoly framework, Positive network externality--Copyrights product users are categorized into two segments—high-value users and low-value users. Consumer's product utility depends positively on the number of users.	Firms should charge higher price to high-value users to fully exploit network effects. Full enforcement of copyright protection may reduce user bases and therefore, decrease firms' profits.

Shy & Thisse (1999)	X	X	X			Positive network externality in duopoly setting.	When network effects of piracy is weak, software companies are better off with technology protection. When network effects are sufficiently strong, non-protection is a better strategy for both firms since such a strategy leads to large network sizes, and high consumer's valuations.
Belleflamme (2002)	X	X				Monopoly framework, Weak positive network externality—Consumers are uniformly distributed and have heterogeneous value on original and copy of products.	The network effect of piracy is limited in a certain range; therefore, piracy always reduces software companies' profits.
Haruvy et al. (2004)	X	X	X			Dynamic utility-based model at the individual level. Individual's value of the software increased in the number of users.	Individual adopter's value on new software product is adjusted with the user base over the life of software. Interplay of level of externality, cost of protection, speed of penetration, and length of product life, may enhance or deter the process of product

							diffusion.
Nascimento & Vanhonacker (1988)		X	X			Diffusion model and monopoly setting	Copy protection works only when legal sales diffuse much faster than pirate and the costs of protection are low.
Prasad & Mahajan (2003)	X	X				Diffusion model of piracy at the aggregate level	To speed up the diffusion of software products, software companies should start with minimum protection before the product has diffused half way, and then impose maximum protection afterwards.
Chellappa & Shivendu (2003)		X	X	X	X	Quality segmentation in global motion picture market.	When facing threats of piracy, movie studios should segment motion picture markets and provide regional technology standards.
Sundararajan (2004)		X	X			Price discrimination, quantity-price schedule. Consumers' value of product is heterogeneous and uniformly distributed.	When facing high piracy rate, software companies need to segment their customer and charge lower market price to subsidize customers who have lower value type.
Chellappa & Shivendu (2005)	X	X		X	X	Price discrimination, quality-price schedule.	Piracy offers a sampling opportunity for consumers. Software

						Two-stage consumption model where consumers' valuations on digital product are heterogeneous. Consumers update their product valuation after they experience the product.	companies can take a sampling strategy to exploit this externality benefits. For under-valued products, piracy may be beneficial to legal sales.

Appendix C

IDC and BSA's Measures of Piracy Rates[7]

Software Categories Examined in IDC and BSA's Study

The software categories studied in the IDC and BSA's global piracy report included business applications software. From 2003, they also included operating systems, finance and tax packages, PC computer games, and industry-specific applications. Within the software load, IDC and BSA accounted for: software running on new computers, new software running on existing computers, software obtained from retired computers, software obtained for free as shareware or open source, and software running on Windows and non Windows OS. Free open source software, freeware and shareware were considered legitimate software and were not considered pirated.

IDC and BSA Global Piracy Study Methodology

Measure	Data Source
Hardware units (PC shipments)	IDC PC Trackers track PC shipments in 60+ countries from data provided by suppliers IDC Black Book
Average # Software Load per PC	IDC Surveys in 15 countries IDC Local Analyst Research
Software market revenue	IDC Software Trackers IDC Local Analyst Research captured software revenues annually in 60+ countries through interviews with in-country suppliers and cross-checks with financial statements. IDC Vendor/Channel Interviews
ASVs (average system value)	IDC Pricing Trackers IDC Local Analyst Research IDC Vendor/Channel Interviews

$$\#\text{ Software Units Installed} = \#\text{ PC Shipment} \times \text{Average \# Software Load per PC}$$

$$\#\text{ Software Units Sold} = \text{Software Mrt Revenue} \div \text{ASVs}$$

$$\#\text{Software Units Pirated} = \#\text{ Software Units Installed} - \#\text{Software Units Sold}$$

$$\text{Piracy Rate} = \#\text{ Software Units Pirated} \div \#\text{Software Units Installed}$$

$$\text{Value of Pirated Software} = (\text{Legitimate Market Value})/(1-\text{Piracy Rate}) - \text{Legitimate Market}$$

Measure of Average Value of Country-specific Software (where i denotes country)

$$\text{Total Market Value of Software}_i = \text{Value of Pirated Software}_i \div \text{Piracy Rate}_i$$

$$\text{Average Value of Software}_i = \text{Total Market Value of Software}_i \div \#\text{ PC in Use}_i$$

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[7] Source: Second Annual BSA and IDC Global Software Piracy Study, 2004 p10-14. http://www.bsa.org/globalstudy/upload/Global-Software-Piracy-Study-English.pdf

Appendix D

Computing Producer Pricing Index of Pre-Packaged Software[8]

Producer Pricing Index (PPI) is created based on the survey on producers in each industry. For any given industry, producers are selected for the survey via a systematic sampling from a listing of all firms that file with the Unemployment Insurance System. After a firm is selected and agrees to participate in the survey, a probability sampling technique called disaggregation is used to determine which specific products or services will be in the PPI. The formula used to calculate the PPIs is a modified Laspeyres index. The Laspeyres index compares the base period revenue for a set of goods to the current period revenue for the same set of goods. The PPI that we use is specifically created for the software industry, and corresponds to the aggregate measure of software piracy that we get from BSA.

The following formula closely approximates the actual computation procedure:

$$\mathrm{I_i} = \left[\left(\sum Q_0 P_0 (P_i / P_0)\right) / \sum Q_0 P_0\right] \times 100$$

Where:

P_0 is the price of a commodity in the base period; P_i is the price of a commodity in the current period; and Q_0 is the quantity of the commodity shipped during the base period. In this form, the index is the weighted average of price relatives (price ratios for each item $= P_i / P_0$. The expression $Q_0 P_0$ represents the weights in value form.

[8] Source: Producer Pricing Index: Frequently Asked Questions. U.S. Bureau of Labor, http://www.bls.gov/ppi/ppifaq.htm#6