

## Pricing Product Lines of Digital Content: A Model Using Online Choice Experiment

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### Abstract

*With the rapid penetration of broadband technologies, content sellers have become one of the fastest growing businesses on the Internet. With content being made available in many forms and formats, these firms are grappling with the problem of pricing their product line appropriately. In this paper, we examine this problem in the context of a publisher who sells books in print and PDF forms online. At the time of this study, the publisher was already selling books in print form online and was contemplating the launch of PDF forms of these books. However, it was not clear how these forms were to be priced relative to each other. This decision depended on the relative preferences of customers for these different forms, their willingness to pay for these forms and the trade-offs involved. On the one hand, the PDF form could be priced low enough relative to the print form to stimulate market expansion for content, while on the other hand a low priced PDF form could cannibalize the print form resulting in lower revenues. In order to examine these issues, a novel choice experiment was conducted online at the publisher's website, and a model was developed to analyze the data and provide pricing recommendations. The paper describes the choice experiment, the model and the results. It provides useful insights into how online content providers can develop pricing models for their content.*

### 1. Introduction

The rapid penetration of broadband technologies worldwide has tremendously increased the market for online content in all types of forms – text, audio and video. Recent reports clearly emphasize the significance of this to content sellers and the economy as a whole - consumer spending for online content in

the US grew to \$2 billion in 2005, an increase of 15 percent compared to 2004 (Online Publishers Association Report, 2006). Much of this increase is due to newer forms of digital content, predominantly in the domain of music with new formats MP3, iTunes, .ogg, and other lossless forms. While it is true that the online revenue for such content is on the increase, there has also been significant loss of revenue in conventional forms such as CDs, thus indicating cannibalization of conventional and older forms by the newer forms. Similarly, sales of many newspapers have been cannibalized by online versions of the same, while content providers such as Wall Street Journal have seen the value of online content in expanding their overall market size by 4 - 5% (DowJones, 2007). Even within the online environment, emergence of newer forms and formats tend to be substitutes for older digital formats, leading to substitution effects. Since the content in many of the different forms and formats is the same (e.g., same music, same news-story, editorial, etc.), this substitution effect is not surprising.

The substitution effects among the different forms and formats is not a problem if the content provider is able to price all the forms the same – thus sale is any form is a useful sale. However, when the quality, marginal cost, and usability of the different forms differ substantially, then content providers generally face a dilemma. For example, consumers' price expectations for online forms are generally much lower than their price expectations for conventional forms, partially driven by the generally lower costs in producing and distributing content online. Thus, they would expect a PDF version of a book to have lower production costs than a print version and thus their willingness to pay for the PDF version might be lower than that for a print version.

Secondly, the quality and usability of the different forms may be significantly different that consumers may view the lower quality form as a poor substitute, thus affecting their willingness to pay for it. Some customers may view the print version of a book to be of higher quality and having more versatile uses than the PDF version. On the other hand, pricing one of the forms lower than the other may be a useful way to expand the market for content as more customers could afford to buy the content based on the lower prices for one of the forms.

Thus, what we have above is the classic product line pricing problem – pricing the different forms of content in such a manner as to maximize revenues (e.g., Dobson and Kalish 1988). This is precisely the same problem the focal online publisher in this paper faced in early 2002 as it was contemplating rolling out PDF versions of its print books that it sold online at its Website. While it already had 2500 titles of books in print versions sold at specific prices online, the issue was how to price the PDF versions relative to print to maximize the revenues. In order to do this, the publisher had to estimate customers' relative preferences for the two forms and their willingness to pay for each.

The above problem is related to a large body of literature in marketing that deals with the measurement of consumer utility for product features and attributes, with conjoint analysis being an important tool for estimating consumer preference parameters (Green and Srinivasan 1990; Green and Kreiger 1989). Extant research that has taken conjoint analysis preference estimates as input for product-line design include papers by Kohli and Sukumar (1990), who propose heuristic to solve the product-line design optimization problems, Kohli and Mahajan (1991) who consider reservation prices in determining optimal pricing for multi-attribute products, and Dobson and Kalish (1993), who extend their earlier work by including cost data. Our problem is related to the above research in terms of its focus on estimating consumer preference parameters and using it as an input to the determining optimal prices in the static model. However, unlike the conjoint models, our approach focuses only on estimating customers' total valuation for the product form rather than estimating the part-worths for attributes of product forms. This is perfectly appropriate for the application context because the design of the specific product forms are already fixed and the publisher is not looking to design the optimal combination of the attributes to maximize customer valuation, but rather estimate

valuation of customers given the *specific fixed* designs.

In this paper, we describe a novel online live choice experiment that we used to measure the preferences of actual customers of the online publisher. The choice experiment was so designed to elicit the estimates that we needed for our model which focused on two key measures - cannibalization of print by PDF at different price levels of PDF relative to print and the market expansion effect at different price levels of PDF. We estimated these rates using spatial choice models for customers in each zip-code in the US and aggregated them to determine the optimal pricing policy. In this paper, we focus only on the online choice experiment and the model to estimate the two key measures – cannibalization rate and the market expansion rate – which are the key input to decision making. (The details of the spatial model can be obtained from published sources – Jank and Kannan 2005)

The contribution of our paper is two-fold. First, we provide a clear illustration of how online content providers can use their Website design and experiment with prices for alternative forms of content using novel experimental designs to obtain estimates of consumer choice under different scenarios. Second, we propose a simple and elegant model using probability theory to get quick estimates of key revenue impacting measures that can be used to set optimal pricing policies. In the next section, we describe the product-market of the publisher and some details about its Website. Section 3 discussed the online choice experiment. Section 4 provides the estimation model. Section 5 provides details of the aggregate results and the optimal policy generation. We conclude in Section 6.

## 2. Publisher Product-Market

The online publisher's product-market consists of scholarly and research-oriented books. Other players in this market include university presses and a number of commercial publishers. The publisher publishes study reports and books across the natural and social sciences, engineering, and medicine. More than 85% of the titles published by the publisher can be categorized as specialized, focused publications that cater to several distinctly niche markets such as researchers, faculty, students, policymakers, and practitioners with well defined needs (see [www.nap.edu](http://www.nap.edu)). Overall, the publisher's product line has very limited competition. Some books have absolutely no competitors and others, even those

adopted for classroom use, have very few. The publisher has the right and is required to publish all content generated under the aegis of its parent research academies. Thus, given the specialized and unique nature of the content, we considered the market for publisher's products at the customer level to be monopolistic. Thus, we focused on the customers arriving at the Website to understand what the cannibalizing and market expansion effects of introducing the new form are, without having to consider any competition.

In 2002 the publisher was selling a significant portion of sales to individual customers through its Website. In addition to selling printed books online, the publisher provided free full-content browsing of those books in low-resolution image format at the

Website. For example, customers could browse through contents of each book, page by page at the Website. This allowed customers to fully know what content they were getting when they purchased the books. Many customers who purchases books at the Website routinely checked this browse section during their visits to the Website. This feature also allowed the publisher to gauge (through Webpage visit counts) how many customers were seriously interested in the content of a book and were considering it. We used this feature to our advantage in designing the online choice experiment. The publisher was contemplating selling value-added PDF versions of their books online, and grappling with how to appropriately price the different forms of their content. In the next section, we describe the online experiment.

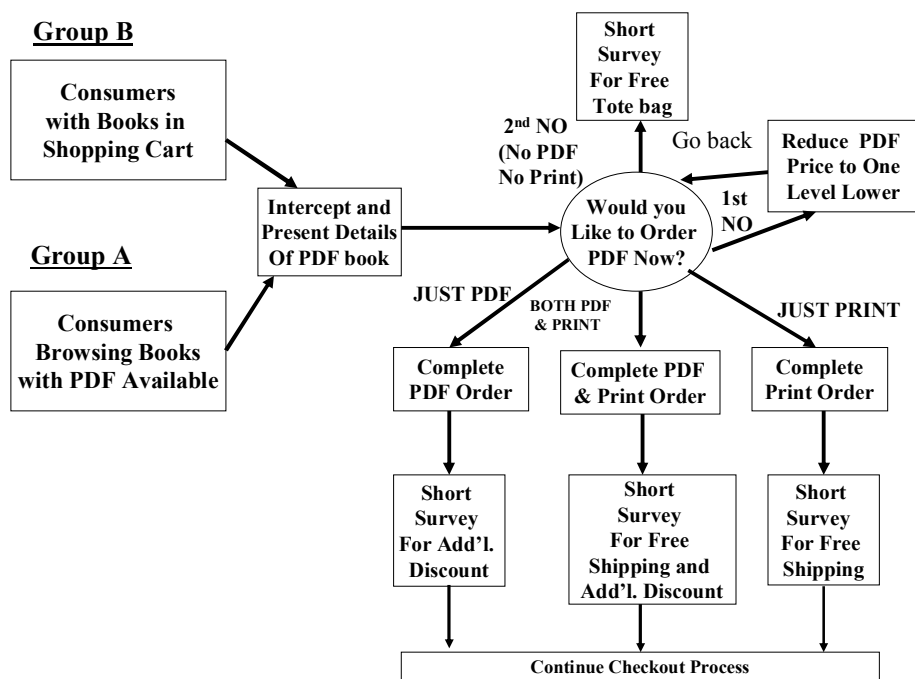


Figure 1: The Online Choice Experiment

### 3. Online Choice Experiment

In order to assess the demand for the PDF form and its impact on the substitution of print form and possible market expansion, a series of online pricing experiments were conducted to gauge customers' interest in the PDF form and their purchase of the PDF form at different price levels relative to print

price. This specific online experiment focused on estimating the extent of substitution of the print form by the PDF form and the extent of market expansion (purchase of PDF by customers who otherwise might not have bought the print form) at different price levels of PDF. Given that the ratio of number of purchasers to number of visitors to the site (defined as those entering the Web site and

viewing at least one Web page) is quite low, the experiment targeted customers who showed sufficient involvement in a title as evidenced by their behavior at the Web site. Since there are many visitors who come to the Web site and do not go beyond the first Web page, customers targeted included browsers of titles (who made at least one click that is necessary to get to the information about a title or search for a title) and the purchasers, thereby focusing on the more "serious" visitors at the Web site. The online experiment details are presented schematically in Figure 1.

The population of serious visitors was sampled by intercepting them at two points to participate in this online choice experiment, one at an earlier stage of the (possible) purchase process and the other at a later stage in the purchase process. One group of respondents (Group A) was intercepted when they were browsing the information or the contents of a title at the free-browse section. When a user clicked at the title information page or in free browse section, he/she was intercepted. These respondents showed enough interest in the title to browse through the title information or content and could have moved on to purchase a print copy or could have left the web site without purchasing the title. However, they could be classified as serious visitors based on their Web site behavior, showing sufficient involvement with the product. Analyzing their choice behavior could provide insights into the customers' relative preference for the print and PDF forms. The other group of respondents was intercepted after they had picked up a print copy of a title in their shopping cart and clicked on the button to check-out their shopping cart (Group B). These customers were almost ready to purchase the print copy of the title. (Of course, they could also abandon their shopping carts and quit, which we do account for in our model). This intercept captured respondents who might have obtained information about the title from sources outside the Web site or those who might have browsed the contents on their previous visits or those who browsed on the current visit and did not get samples, essentially at a later stage in the purchase process. This group did not include any respondent already intercepted as part of Group A.

For the experiment, the publisher offered PDF forms of approximately 500 titles out of the 2500 or so titles it carried in print form at the Web site. If any respondent in Group A was browsing the content or information of a title for which a PDF form existed, he or she was intercepted (1 in 4 at

random) as they browsed and was provided information on the PDF form along with its price. The customer was provided the option to buy the PDF form or decline the offer. They were also offered the chance to purchase the print form at the regular print price. (As shown in Figure 1, they were also offered the option to buy both PDF and print, however with no special discounts. They had to pay the full price of each form. We do not consider these bundle purchases in this paper to keep the exposition simple). Thus, for our analysis, the respondent in Group A either bought the print form, or the PDF form or none. For a respondent in Group B, a similar offer on the PDF form was made when he or she picked up a print copy in their shopping cart with for which a PDF form existed and clicked on the check-out button. Thus, the customer either bought the print form or the PDF form (or bought nothing by abandoning the cart).

After the experiment treatments, all the respondents were debriefed irrespective of whether or not they had purchased a product. Most of them also participated in a survey regarding their perceptions of the quality of PDF form vis-à-vis print form in return for an incentive (free shipping or a purchase discount or a free book depending on whether they purchases a print or PDF or none). All respondents were tracked by their IP addresses and their click-stream data collected for significant actions.

Intercepting serious visitors at the two distinct points at the web site (browsing content - Group A, and making print purchase - Group B) can help estimate not only the relative preference for PDF versus print form, but also the substitution of print form by PDF form. Since respondent Group A and Group B are sampled from the same population of serious visitors, albeit at different points at the Web site, intercepting Group B respondents provides information regarding the substitution of print by PDF (respondents switching from print to PDF) among those who buy print form. Meanwhile an analysis of relative print purchase rates of Group A respondents in the presence of PDF forms and the PDF purchase rates can provide insights into the market expansion due to PDF forms as we will show in the model section that follows.

In the choice experiment, print book prices were not changed. They were kept at their usual levels so as to eliminate any confounds due to the reference effects among consumers. PDF prices were set at 110%, 100%, 75%, 50%, 25% and 0%

relative to the print book price. These specific levels were chosen because the publisher was considering pricing the PDF forms in this range. The PDF prices were displayed in absolute dollar terms. For each title, the price of the print form was held constant, while the PDF price was set at one of the above six levels relative to print form. The PDF prices of the 500 titles were so set that, within a subject category, each of the print book price levels was associated with each of the six different PDF price levels. For example, the PDF versions of titles in the education category, the print forms of which were priced at \$30, were priced at levels ranging from 110% to 0% of the print book price with generally equal shares for all the price levels. The PDF prices were also so assigned to achieve similar share balance across the number of Web page visits for the specific titles (a measure of their popularity and potential sales). Thus, among the \$40 "most popular" books, the PDF prices were so assigned to cover all the price ranges (110% to 0%). This ensured that the experiment results were valid for all categories of subjects, price levels of print books, and for all levels of potential sales. The experiment was run for a total of three weeks.

#### 4. The Model

##### 4.1 Determining the Impact of PDF form

As discussed in the previous section, we assume that the respondents in Group A and Group B are samples from the same population of serious customers who show interest in the content of the books. This is a fair assumption given that these customers all use the online channel both to inspect and purchase the books, and thus Group A and Group B respondents differ in only where they are intercepted. From Group A respondents, we get insights into purchase probabilities when both product forms - print and PDF - are available, as they are presented with details of print as well as PDF forms while they make their choice.

Let us define the events:

1. Purchasing Print when both Print and PDF are available = A,
2. Purchasing PDF when both Print and PDF are available = B,
3. Purchasing neither when both Print and PDF are available = C.

We have the estimates of the following purchase probabilities from Group A data by fitting a choice model for Group A data. (This is conditional on

specific prices of print and PDF, which we ignore at this point for expositional reasons):

$$P(\text{Print when both forms available}) = P(A|A,B,C) = a, \quad \text{Eqn. 1}$$

$$P(\text{PDF when both forms available}) = P(B|A,B,C) = b, \quad \text{Eqn. 2}$$

$$P(\text{No Purchase when both forms available}) = P(C|A,B,C) = c. \quad \text{Eqn. 3}$$

Note that these are purchase and no probabilities when all options – print, PDF, and no purchase (A,B,C) are available in the choice set.

Group B respondents are intercepted when they are ready to check out with a print copy in their shopping cart, indicating their commitment to purchase the print copy. Note, however, that committing to purchase print is not the same as purchasing print as customers could change their mind and/or abandon cart. Once they commit to buy print, they are, then, presented with the option to buy PDF or continue to purchase the print form. Thus, from Group B respondents we get insights into how those customers, who commit to purchase print when their only options are to buy print or not to buy anything, behave when their alternative set is increased to add the option of buying PDF.

Let us define the following events:

4. Committing to purchase print or picking print when only print form is available = D
5. Making no commitment to buy print when only print form is available = E

We define:

$$P(\text{Picking Print when only Print is available}) = P(D) = Y, \quad \text{Eqn. 4}$$

$$P(\text{Not picking Print when only Print is available}) = P(E) = (1-Y). \quad \text{Eqn. 5}$$

Note that knowing *Y* will allow us to estimate how many customers seriously consider purchasing books. Since we intercept customers after they pick Print (on the way to check out) we cannot directly estimate the above probabilities. However, the following probabilities can be directly estimated from Group B respondents data by fitting a choice model (to obtain probabilities conditional on specific prices of print and PDF).

$$P(\text{Print when both forms available given they picked Print when only Print is available}) =$$

$$P(A|A,B,C|D) = p, \quad \text{Eqn. 6}$$

P(PDF when both forms available *given* they picked Print when only Print is available) =

$$P(B|A,B,C|D) = r, \quad \text{Eqn. 7}$$

P(No purchase when both forms available *given* they picked Print when only Print is available) =

$$P(C|A,B,C|D) = (1-p-r), \quad \text{Eqn. 8}$$

Equation (8) captures those who decide not to purchase or abandon cart after picking print in their cart.

The following conditional probabilities, which we also wish to determine, are unknowns at this point:

P(PDF when both forms available *given* they did not pick Print when only Print available) =

$$P(B|A,B,C|E) = X, \quad \text{Eqn. 9}$$

P(Print when both forms available *given* they did not pick Print when only Print available) =

$$P(A|A,B,C|E) = Z, \quad \text{Eqn. 10}$$

P(No purchase when both forms available *given* they did not pick Print when only Print available) =

$$P(C|A,B,C|E) = (1-X-Z). \quad \text{Eqn. 11}$$

The probability in Equation (9),  $X$ , is the market expansion due to PDF. Assuming that IIA (Independent of Irrelevant Alternatives) conditions hold in the data, the probability in equation (10) is equal to zero (i.e.,  $Z = 0$ ). In order to estimate the impact of PDF on purchase probabilities and market expansion, we need to estimate  $X$  and  $Y$ . We use Bayes' rule to estimate them as a function of the known probabilities.

P(PDF when both forms available) =

$$P(B|A,B,C) = P(B|A,B,C|D)*P(D) + P(B|A,B,C|E)*P(E) \\ b = r.Y + X(1-Y). \quad \text{Eqn. 12}$$

P(Print when both forms available) =

$$P(A|A,B,C) = P(A|A,B,C|D)*P(D) + P(A|A,B,C|E)*P(E) \\ a = p.Y + Z(1-Y), \quad \text{Eqn. 13}$$

where  $Z = 0$ .

From Equations (12) and (13), we can solve for  $X$  and  $Y$  as follows:

$$X = (b.p - r.a)/(p - a) \\ Y = a/p. \quad \text{Eqn. 14}$$

The total market size can be estimated from  $Y$ , using the actual sales of Print, while  $X$  provides the market expansion due to PDF and  $r$  the substitution impact of PDF on print.

## 4.2 Estimating Choice Probabilities

The estimates of choice probabilities of purchasing print, PDF and no purchase from Group A ( $a$ ,  $b$  and  $c$ , respectively) and the corresponding conditional choice probabilities from Group B ( $p$ ,  $r$  and  $(1-p-r)$ ) vary depending on the specific price of print, the relative price of PDF (as a percentage of print), and the absolute price of PDF (interaction between the above two prices). These estimates are derived by fitting multinomial logit choice models to Group A and Group B data separately. However, there is clear evidence that these purchase probabilities tend to vary by the geographical region from where the customer accesses the publisher's Web site. The reason for this variation could be due to penetration of broadband varying across geography (lower penetration more likely to buy print), technology readiness and innovativeness of customers (the US East and West coastal regions are more technology ready and hence more likely to buy PDF) and so on. In order to account for these spatial variations, we fitted spatial multinomial logit choice models as follows to Group A and Group B data separately. (For a detailed exposition of such models, please see Jank and Kannan, 2005 and Bradlow et al 2005).

Let  $z_i = (z_{i,Lat}, z_{i,Long})$ ,  $i = 1, \dots, N$  denote the spatial coordinates – latitude and longitude – of the zip-code the observed response  $y_i$ . Let  $u_i = u(z_i)$  denote a vector of unobserved stochastic terms (random effects) associated with location  $z_i$ . The response variable  $y_i$  takes on only one of  $J$  values – print, PDF or no purchase – and conditional on  $u_i$ ,  $y_i$ 's are independent realizations of a multinomial random variable; that is

$$y_i | u_i \sim \text{Multinomial}(\pi_{i,Print}, \pi_{i,PDF}, \pi_{i,NoPurchase})$$

where  $\pi_{ij} = \Pr(y_i = j | u_i)$  is the probability of choosing alternative  $j$  conditional on the random effects,  $u_i$ . Since these probabilities are specified conditionally on the random effect, they are

associated with location  $z_i$ . Without loss of generality, let “No Purchase” denote the baseline alternative. We model the logit of  $\pi_{ij}$  as

$$\log\left(\frac{\pi_{ij}}{\pi_{i,NoPur}}\right) = X_i^T \beta_j + X_i^T u_{ij}, \dots j = \text{Print, PDF}$$

where  $\beta_j$  is a  $(p \times 1)$  vector of unknown logit parameters associated with alternative  $j$  and  $X_i$  is a  $(p \times 1)$  vector of known covariates. If we assume zero mean for the  $u_{ij}$ s, then the above model implies that the logit parameters associated with alternative  $j$  vary randomly across geographical regions according to a distribution that is centered at  $\beta_j$ .

The estimation of the above model provided us with the required choice probabilities for each zip-code in the country. Using these more precise estimates, we were able to estimate the cannibalization and market expansion effects at each zip-code level for each level of print price and relative price of PDF and then aggregated it to the US market level to determine the overall pricing policy.

### 4.3 Estimating Impact of PDF Pricing Policy

Based on the estimates from 4.1 and 4.2, the overall impact of PDF forms with prices at a specified relative level with respect to print was determined as follows:

1. We determined from the sales database for the firm:
  - a. the average dollar sales in past two years for each zip code,
  - b. the unit prices paid for each individual print title purchased in each zip code,
  - c. the distribution of price paid for print books over the last two years, and
  - d. using the above distribution as prior, and actual prices paid for print books in each zip code, obtain the posterior distribution of price paid for print books for each zip code.
2. Based on the model derivation in 4.1 and results, average sales in each zip code and the posterior distribution of prices paid for print books in each zip code, we determined the projected sales of print and PDF forms at various levels of print book price and relative prices of PDF combinations.
3. Finally, we aggregated the projected sales for all zip codes with positive sales in the

past 2 years to arrive at the overall sales under different relative price levels of PDF. Since book sales in some zip codes tend to be sporadic over time, we chose a 2 year horizon to capture zip codes with positive sales.

## 5. Results and Implications

Using the estimates from the spatial choice models fitted to Group A data and Group B data, and we applied the methodology outlined in section 4.3. Based on the average sales data for each zip code and the posterior distribution of prices paid for titles published in the last 2 years, we made forecasts, for each zip code, of the sales of print versus PDF at different relative prices of PDF. These forecasts were summed across all zip codes that existed in the sales file, to arrive at the total sales forecast at different relative PDF price levels. Table 1 below provides the break-up of the marginal impact on sales into substitution effect of print by PDF and market expansion due to PDF (the data is disguised but the relative effects are real). As seen in the table, a PDF price of 75 relative to print price maximizes sales.

**Table 1: Impact of PDF Prices on Overall Sales**

PDF Price as a %age of Print Price	Substitution Impact of PDF on Print	Market Expansion Impact of PDF	Overall Marginal Impact
0	-\$7,123,000	\$0	-\$7,123,000
25	-\$3,547,050	\$1,271,540	-\$2,275,510
50	-\$2,456,500	\$1,496,660	-\$959,840
75	-\$771,800	\$1,868,460	\$1,096,660
100	\$0	\$916,670	\$916,670
110	\$244,630	\$639,760	\$884,390

The results in the Table also pointed out that there were some customers who would switch from the print form to the PDF form even if it were priced at 110% of the print price. These were customers who had much higher preference for the PDF form as compared to the print form and were willingness to pay higher prices than prevailing print prices for obtaining the PDF form. That is why we see in Table 1 that even with PDF form at 100% and 110% of the print price, the online publisher would have still come out ahead in terms of overall revenue. The optimal pricing policy was, obviously, to price PDF forms at 75% of the print book prices. Going from 75% to 50% made the cannibalization impact much higher than the market expansion effect and as a result the impact swings from positive net of approximately one million dollars to a negative net of one million dollars.



One of the assumptions underlying the above analysis is that customers who purchase the PDF forms do not share it with other customers, thus increasing the cannibalization impact of the PDF on print. While the possibility for such content piracy exists, it is expected to be quite minimal given that the publisher already provides free content of the book in e-form at their Web site and given that the subject matter is quite niche and of limited value to the larger population. Thus, customers of the publishers are not likely to resort to content piracy.

## 6. Conclusions

Our overall objective in this paper was to highlight how a common managerial problem faced by many online content providers – specifically, pricing the different forms of content that are being sold at their Web sites – can be tackled by using novel choice experiments on their Web sites, and combined with simple statistical and choice models to estimate the measures of importance such as cannibalization and market expansion. We presented the details of the online choice experiment and a simple model to estimate the required measures. The key contribution of our paper is in presenting a method to estimate the overall size of customers who consider purchasing the content, using our experimental design. This is generally not easy to estimate at a Web site where many visitors are not serious visitors and it is tough to identify who is a serious buyer and who is not. This is a key factor in determining the market expansion potential of new forms of content and we have shown how this can be determined creatively.

The pricing policy we have examined is quite straightforward in the sense that we did not make any changes to the print price, but rather determined the PDF price as a constant percentage of print across all titles and subject categories. The reason for such simple treatment is motivated by the application more than anything else. The online publisher did not want to change prices of existing print titles and wanted an easy-to-implement pricing policy for the PDF versions. It is, of course, possible to make the pricing analysis more sophisticated by considering marginal costs, profits at different print price levels and by using optimization models to determine optimal pricing levels for print and PDF versions for each individual title. Another easy extension could be to analyze the purchase of bundles of these forms and find an optimal policy that includes the bundle option. In fact, this is a

pricing scheme which the online publisher did experiment with and implement as part of the PDF launching strategy. (We did not focus on it in this paper to keep the exposition simple and focused on our overall theme).

In terms of the design of the product forms, which has not been the focus of our analysis in this paper, there are recent approaches with specific focus on bundling and unbundling of content (see Koukova et al 2006) which might form useful extensions to our study. This may have some implications on the long-tail of sales distributions on content (see Anderson 2006).

As a final piece of information, the online publisher did implement the PDF pricing policy at 75% of the print book price for all its PDF titles starting April 2003. The validation exercise conducted with the actual sales data over the course of one year provided remarkable support to the model results.

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