Quantifying the Impacts of Digital Rights Management and E-Book Pricing on the E-Book Reader Market

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Abstract

The demand for electronic books (e-books) and the e-book readers are complementary. On the one hand, the emergence of e-book readers such as Amazon's Kindle has triggered the recent growth of the e-book market. On the other hand, several issues in the e-book market can affect the future of the e-book reader market. Considering this complementarity, this paper quantifies the impact of digital rights management (DRM) and discounted e-book pricing on the demand for e-book readers. We collect conjoint survey data to estimate a random coefficient demand model using a hierarchical Bayesian method. Our counterfactual experiments suggest two things. First, Kindle's and Nook's market shares would increase by dropping DRM. Consumer welfare would increase seven percent if all e-book readers dropped DRM. Second, an increase in e-book prices would increase iPad's market share at the expense of that of Kindle and Nook. Consumer welfare would decrease 6 to 10 percent if Kindle's and Nook's e-book prices went up by 50 percent.

JEL Code: L15, L63, O30

Keywords: electronic book; demand estimation; DRM; agency model

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1 Introduction

The Internet has completely changed the business model of the entertainment and publishing industry. The distribution of content such as music, movies, and books has become increasingly inexpensive. The online piracy of content has also provided consumers with a low-cost alternative. These changes create both challenges and opportunities in the industry. On the one hand, content providers facing these challenges find revenue generation extremely difficult. On the other hand, complementary hardware products such as iPod, iPad, and Kindle have increased in value.

How do these challenges and opportunities affect the dynamics between the content market and the hardware market? One of the key determinants is the complementarity between content and hardware. The electronic books (e-books) market demonstrates such complementarity. The history of the enabling technology for e-books dates back to the 1970s, but thus far, only a small portion of e-book readers use computers or smartphones to read e-books.[1] The e-book market did not explode until Amazon launched the Kindle reader in 2007.

Since the launch of Kindle, several e-book readers have been introduced in the market. The 2013 Bowker report places the market share of Apple's U.S. e-book reader at 14 percent, Amazon's Kindle at 55 percent, and Barnes & Noble's Nook at 12 percent. With the development of these e-book readers, the e-book market has grown substantially in recent years. According to the Association of American Publishers' annual statistics, e-book sales grew 46 percent in 2012 and constituted over 20 percent of the $6.6 billion U.S. book market.[2]

The complementarity does not only go one way. Two issues in the e-book market can affect the development of the e-book reader market. The first issue concerns copy protection system, otherwise known as the digital rights management (DRM). DRM imposes restrictions on what users can do with their e-books. For instance, DRM may prevent users from transferring ownership of an e-book . It can also tie the e-book to specific hardware or software. To deter

[1] According Bowker Market Research, the number of e-book buyers who use computers to read e-books constituted only six percent of the total e-book market in 2012 (and ten percent in 2011). The fraction of e-book readers who use iPhones or smartphones to read e-books is three percent for each device. See `http://www.publishersweekly.com/pw/by-topic/digital/devices/article/54705-kindle-share-of-e-book-reading-at-55.html`.

[2] Forrestor Research projects the U.S. e-book market to reach $13.6 billion by 2017. See `http://www.businessweek.com/articles/2013-02-12/building-a-better-e-book-than-amazon-and-apple`.

the widespread piracy of e-books, most major publishers and online retailers sell e-books with DRM protection. This affects the e-book and e-book reader market differently. Although DRM may protect the profits of e-books retailers, it limits the interoperability of e-book readers with e-books.

The second issue is the pricing model for e-books. Prior to the introduction of Apple's iPad in 2010, publishers sold e-books through a "wholesale" model, in which online retailers have freedom to set prices independently. E-book reader suppliers, particularly Amazon, used the "wholesale" model at that time to subsidize e-books and consequently boost the sale of e-book readers. Aiming to challenge the dominance of Kindle in the e-book reader market, Apple, made a deal with major publishers to shift to an "agency" model, in which publishers set the e-book price, and retailers receive a commission. Book prices went up by as much as 50 percent overnight. The U.S. Department of Justice accused Apple and the major publishers of price-fixing in the e-book market.[3]

This paper aims to provide an empirical groundwork for exploring the impacts of these two issues in the e-book market on the e-book reader market. The attainment of this objective necessitates a plausible demand model that is consistent with the assumption of complementarity between e-books and e-book readers. The estimation of our model would require repeated observation on consumer's choice of an e-book reader in an environment where both content and hardware prices vary. This type of data, however, is typically either unavailable or hard to obtain. Our approach is thus to design and collect survey data in which respondents are asked to choose among a set of e-book devices and outside options under different hypothetical scenarios. Because the policy variables such as the adoption of DRM and content pricing can be exogenously and randomly specified, the approach allows for a straightforward identification of the counterfactual effects using our demand model.

Specifically, we build a structural demand model of e-book readers. This model is a multinomial logit model with some novel features. We incorporate the availability of e-book content into a constant elasticity of substitution (CES) utility function to account for the complementarity between e-book varieties and e-book readers. Under this condition of complementarity, we

[3]The publishers settled ahead of the trial. Apple went on trial and was found guilty of conspiring with book publishers to raise e-book prices in violation of antitrust law.

assume that DRM affects the range of available e-books, and that platforms can sell e-books at a discount. The demand model has a full set of individual-specific random coefficients that can account for a significant part of the unobserved heterogeneity in the respondents' preferences. We follow Rossi, Allenby, and McCulloch (2005) in specifying a hierarchical Bayesian model for our demand estimation. We then use a hybrid of Gibbs Sampling and Metropolis-Hasting algorithm to implement posterior inferences.

To estimate our demand model, we use two survey data sets drawn from a large U.S. state university ($N = 1355$) and a commercial Internet survey firm ($N = 1652$). Although the survey structure does not allow us to elicit information on respondents' demand for e-books, our demand model still allows us to use the survey data to infer the complementary effect that the e-book market has on e-book readers. In fact, our estimation results characterize the demand for e-book readers reasonably well. For instance, the demand for Kindle is relatively price elastic with own-price elasticities ranging from -1.19 to -0.87. The demand for Nook is also price elastic with own-price elasticities ranging from -1.57 to -1.23. However, the demand for iPad is quite inelastic with own-price elasticities ranging from -0.28 to -0.22. We also show how observable characteristics and consumption experience elicit heterogeneous responses from the respondents. For instance, those who indicate that they currently read e-books are much less likely to prefer hard copy option over e-book readers, and they are also more sensitive to the presence of DRM in e-book readers. Those who have pirated e-books are more likely to choose outside option over any e-book readers or hard copy option.

As our model yields a sensible characterization of the demand for e-book readers, we then use our demand estimates to conduct counterfactual experiments for quantifying the impacts of the two issues on the e-book reader market. Our results suggest two things. First, if an e-book reader were to drop its DRM, then its market share would increase by about zero to one percent in the case of iPad and by four percent in the cases of Kindle and Nook. If all three devices abandoned DRM, then the overall market share for e-book readers would increase by one to two percent. Second, if Amazon's and Barnes & Noble's e-book prices increased by 20 percent (assuming an initial 50 percent price discount) in the agency model period, our model predicts that iPad's market share would increase by one to two percent and that Kindle's and Nook's market shares would decrease by the same amount; these effects would increase if e-book prices

reach the proposed ceiling.

The outline for the paper is as follows. Section 2 discusses some relevant literature and industry background. Section 3 describes a demand model for e-book readers and hierarchical Bayesian estimation. Section 4 explains our survey and summarizes the data sets. Section 5 discusses estimation results. Section 6 presents counterfactual experiments. Section 7 offers concluding remarks.

2 Literature and Market Review

2.1 Related Literature

As one of the most-studied online retail category, the book industry has been examined by a number of researchers with a focus on competition among online retailers and between online and offline retailers. For instance, Chevalier and Goolsbee (2003) estimate the own- and cross-price elasticities of online book sales at Amazon and Barnes & Noble and find that demand at Barnes & Noble is more price-elastic than that at Amazon.[4] Similarly, Smith and Brynjolfsson (2001) analyze panel data from a price comparison website and show that customers have a strong preference for Amazon over its rivals. Dedicated e-book readers play an important role in the e-book market, and our paper complements existing literature by examining the demand for e-book readers while considering content and hardware prices.[5]

The book industry is facing the same kind of digital disruption that has left the music industry vulnerable to online file sharing or piracy. Most studies on the music industry suggest that piracy hurts record sales.[6] Facing the challenges of piracy, content industries have been eager to adopt copy-protection technologies (or DRM). For instance, proprietary DRM used to be a key feature of digital music sold on Apple's iTunes Store, until Apple abandoned DRM in 2009. Theoretical models of DRM protection (e.g., Sundararajan (2004); Park and Scotchmer (2005);

[4]Using different methodology and data, De los Santos, Hortaçsu, and Wildenbeest (2012) find higher price elasticities for Amazon as well as lower price elasticities for Barnes & Noble compared with those reported by Chevalier and Goolsbee (2003).

[5]We also allow for the choice of hard copies in our survey. See Forman, Ghose, and Goldfarb (2009) for an analysis on channel substitution between online and offline retailers.

[6]See, e.g., Blackburn (2004), Liebowitz (2006), Rob and Waldfogel (2006), Smith and Telang (2012), and Zentner (2006). One notable exception is the work of Oberholzer-Gee and Strumpf (2007), who argue that piracy can boost record sales.

Bergemann, Eisenbach, Feigenbaum, and Shenker (2011); Kim and Waldman (2013)) suggest that there are tradeoffs between protecting content owner's property rights and increasing the value of content for its user. However, empirical evidence on the effect of DRM has rarely been documented so far.

There has been a growing interest in studying the possible spillover effects of the availability of content on complementary products. For instance, Hendricks and Sorensen (2009) show that the release of a new album substantially increases sales of old albums, and Mortimer, Nosko, and Sorensen (2012) show that music piracy has a positive effect on live concert demand. Complementarities also exist in hardware-software systems. Recently, Leung (2013a) shows that Apple's iPod sales could increase if music content were free. Similarly, Chao, Ho, Leung, and Ng (2013) show that jailbreaking (which allows the download of additional applications that are otherwise unavailable) could increase the market share of smartphones. Our paper contributes to this literature by quantifying the effects of DRM and content pricing on e-book readers.

Finally, Bayesian random coefficient models with mixture-of-normal priors have gained some ground as a method to capture consumer heterogeneity (see, e.g., Geweke and Keane, (1999, 2001); Keane and Wasi (2013). The reason is that estimates of price elasticities and consumer welfare could be biased if one fails to account for consumer heterogeneity while the Bayesian approach allows for more complete estimates of the counterfactual effects. Recent examples of Bayesian demand models include Burda, Harding, and Hausman (2008) on supermarket choices; Dubé, Hitsch, and Rossi (2009, 2010) on consumer packaged goods; Leung (2013b) on legal and illegal copies of Microsoft Office; and Panagiotelis, Smith, and Danaher (2013) on website visits, page views, and the sales amount for online retailers.

2.2 E-Book and E-Book Reader Market

The history of the enabling technology for e-books dates back to the 1970s. The book industry, however, did not undergo the massive transformation that it has only experienced in recent years (OECD (2012)). Although the digital version of publications can potentially and fundamentally change the way people purchase books, the dramatic growth in the e-book market has only been made possible by the development of dedicated e-book readers. The year 2007 is a milestone in both the e-book and e-book reader market. During this period Amazon launched its Kindle

reader together with the Kindle e-book store. Since the launch of Kindle, the e-book market has exploded with the release of new and competing e-book readers.[7]

Two controversial issues have arisen in the e-book market in recent years. These issues have significant impacts on the future of not only the e-book market but also of the e-book reader market. The first issue is the copy protection system or DRM. Even until now, many e-book buyers have the misconception that they own similar property rights as the owners of physical books. In reality, e-books are sold with a licensing contract that gives consumers conditional rights access to the e-books. To enforce the contract, most e-books are sold with DRM system that prevents buyers from copying, printing, and sharing the e-books even for personal uses. DRM has been frequently criticized by consumer groups, while publishers often claim that DRM is necessary in limiting copyright infringement and ensuring legitimate remuneration to the authors and the firms.

Similar to other system markets, interoperability of content across platforms is one of the key issues in the current policy debates. A number of integrated manufacturers (such as Amazon, Apple, and Barnes & Noble) have emerged in the e-book market, and most of them use incompatible DRM technologies to encrypt digital content that is sold through their platforms. The choice of reading device therefore affects the range of e-books available to the consumers. Critics argue that collaborating on an open standard for DRM, or even dropping DRM altogether, would increase the range of available content. However, to the best of our knowledge, no study has assessed the impact of DRM on the hardware market.[8]

Second, the pricing arrangements of e-books have undergone significant changes in recent years. The publishing industry has two value chain models. The first is the traditional wholesale model. In the wholesale model, publishers sell their books to retailers typically at 45 to 55 percent off the recommended retail price. The most popular e-book platforms are, however, vertically integrated. Sales to these online retailers are made at rates ranging from 55 to 65 percent off retail (OECD (2012)). The wholesale model gives retailers freedom to set their discounting policy. For example, Amazon wanted to increase the market share of the Kindle

[7]In a press release (May 19, 2011), Amazon announced that its sales of e-books had overtaken those of all print books (hardcover and paperback combined). See `http://phx.corporate-ir.net/phoenix.zhtml?c=176060\&p=irol-newsArticle\&ID=1565581\&highlight`.

[8]Examples of on-going standard setting efforts for DRM technologies include the Coral Consortium, Sun's DReaM project, and the Digital Media Project.

e-book reader and decided to heavily discount e-books by setting a price of $9.99 for bestsellers. Publishers feared that consumers would get used to such low prices.

Apple launched its iPad three years after Kindle. At that time, Kindle had already dominated the e-book reader market. To overcome Amazon's advantage in selling e-books at subsidized prices, Steve Jobs offered major publishers the ability to set the retail price for their books (also known as the agency model). The six major book publishers (Penguin, Harper-Collins, Simon & Schuster, Macmillan, Hachette, and Random House) then switched to the agency model.[9] The collective power of the major publishers eventually forced Amazon to accept the agency model. Prices for bestselling e-book titles therefore increased up to $14.99. According to the U.S. Department of Justice, e-book prices had increased on average by more than 20 percent shortly after Amazon and Barnes & Noble switched to the agency model (Palazzolo (2013)).[10]

3 Model and Estimation

3.1 Demand Model

Our demand model is based on the literature that estimates demand for durable goods and their use simultaneously. For instance, Dubin and McFadden (1984) lay out several econometric models consistent with utility maximization that could be used to describe appliance choice and electricity consumption. A key assumption here is that the discrete choice and continuous choice are made simultaneously; and the continuous decision at the time of the discrete choice is certain.[11] In our model, books are sold in a differentiated product market. This condition differentiates our model from those in the literature, which has typically modeled homogeneous

[9] Random House initially held out, but it adopted the agency model on March 1, 2011, making its e-books available on iBookstore.

[10] The agency model has raised the suspicion of regulators and is under scrutiny by competiting authorities in both the United States and the European Commission. Whether Apple tried to raise the e-book prices of other retailers (including Amazon and Barnes & Noble) through the most-favored nation clause is one of the central issues in the antitrust trial.

[11] Applications of this standard framework include the works of Cardon and Hendel (2001), Reiss and White (2005), and Lambrecht, Seim, and Skiera (2007). In the presence of multipart tariffs, uncertainty of future consumption at the time of discrete choice can be important in explaining consumers' ex-post regrets (see e.g., Miravete (2003); Narayanan, Chintagunta, and Miravete (2007); Iyengar, Jedidi, and Kohli (2008); Grubb and Osborne (2012)). As our model does not have a multipart tariff structure, we assume that consumers can perfectly predict their future usage.

consumption (such as electricity and cellphone usage).

Our approach is to derive the consumer's optimal e-book consumption from a CES sub-utility over a continuum of variety indexed by ω. Consider a choice set J with different modes of reading (i.e., different e-book readers and hard copies), from which each consumer $i \in \{1, \dots I\}$ chooses one (and only one). The consumer may also choose not to buy any of the products, in which case the mean utility of the outside good is zero. Let x_j be a vector of non-price attributes of choice $j \in J$ (with the first entry equal to 1), and let $\hat{u}_{ij}$ denote the attribute-based utility. We assume $\hat{u}_{ij} = \gamma_i x_j$ such that the constant term represents the utility (brand loyalty) that is not explained by the attributes.

Notice that the attributes of choice j do not matter unless this choice is actually selected. Let f_j denote the fixed price for choice j, and let $p(\omega)$ denote the price of variety ω. Consumer i has a budget of w_i to consume books, and he obtains utility from consuming $n_{ij}(\omega)$ units of each variety ω. Consumption decisions are analyzed as if they are contemporaneous with the j alternative mode choices. Specifically, we assume that the consumer maximizes the following form of utility function, subject to a budget constraint:

$$\max_{n_{ij}(\omega), j \in J} u_{ij} = \hat{u}_{ij} + \left(\int_{\Omega_j} n_{ij}(\omega)^{\frac{\sigma_i - 1}{\sigma_i}} d\omega \right)^{\frac{\sigma_i}{\sigma_i - 1}} + \epsilon_{ij} \tag{1}$$

$$\text{s.t., } f_j + \int_{\Omega_j} p(\omega) n_{ij}(\omega) = w_i \text{ for } \forall j \in J, \tag{2}$$

where $\sigma_i > 1$ is the elasticity of substitution, ϵ_{ij} is a standard i.i.d. demand shock, and Ω_j is the range of e-book varieties associated with choice j.

We note here that σ_i and Ω_j cannot be identified in our model. We instead identify certain measures of the price integrals, and argue that these measures are sufficient to capture the effects of changes in DRM protection and e-book pricing. We illustrate this condition as follows. Let $P_{ij} = \int_{\Omega_j} p(\tilde{\omega})^{1-\sigma_i} d\tilde{\omega}$ denote the price integrals for choice j of consumer i. From the first-order conditions, we derive the consumption of variety ω in a symmetric equilibrium: $n_{ij}(\omega) = \frac{p(\omega)^{-\sigma_i}}{P_j}(w_i - f_j)$. Substituting $n_{ij}(\omega)$ into u_{ij}, we can express the indirect utility as

$$v_{ij} = \hat{u}_{ij} + P_{ij}^{\frac{1}{\sigma_i - 1}}(w_i - f_j) + \epsilon_{ij}. \tag{3}$$

A couple of features of $P_{ij}^{1/(\sigma_i-1)}$ are amenable to our policy experiments. First, P_{ij} depends on the range of books available with choice j. In particular, a larger range of Ω_j indicates a larger $P_{ij}^{1/(\sigma_i-1)}$. As explained previously, platforms use DRM to limit copying and sharing of digital content. Thus, one can plausibly predict that Ω_j would increase if DRM protection were non-existent. We capture this effect by using a scale parameter δ_i in our estimation. Second, e-book content can be sold at a discount off retail price, which is $p(\omega)$. In particular, integrated platforms used to discount e-books below hard copy prices. If all books associated with choice j are sold at a discount $D_j \in (0,1)$, then $P_{ij}^{1/(\sigma_i-1)}$ would be higher by a proportion of D_j^{-1} because the content price is then $D_j p(\omega)$. Incorporating these two features into v_{ij} yields

$$v_{ij} = \hat{u}_{ij} + (DRM_j + (1 - DRM_j)\delta_i)D_j^{-1}\beta_{ij}(w_i - f_j) + \epsilon_{ij}, \tag{4}$$

where DRM_j is an indicator for DRM protection, D_j is a discount for content off retail price, and $\beta_{ij} = P_{ij}^{1/(\sigma_i-1)}$ is price integral associated with consumer i for choice j.

Assuming that the random utility term, ϵ_{ij}, is type I extreme value distributed, the likelihood that consumer i will choose j takes the following multinomial logit form:

$$D_{ij}(\mathbf{P}|\Theta_i) = \frac{\exp\left(\hat{u}_{ij} + (DRM_j + (1 - DRM_j)\delta_i)D_j^{-1}\beta_{ij}(w_i - f_j)\right)}{1 + \sum_{k=1}^{J}\exp\left(\hat{u}_{ik} + (DRM_k + (1 - DRM_k)\delta_i)D_k^{-1}\beta_{ik}(w_i - f_k)\right)}, \tag{5}$$

where $\mathbf{P} \equiv [x_1, \ldots, x_J; f_1, \ldots, f_J; D_1, \ldots, D_J; DRM_1, \ldots, DRM_J]'$ is a vector of price and non-price attributes, and $\Theta_i \equiv [\gamma_i, \delta_i, \beta_{i1}, \ldots, \beta_{iJ}, w_i]$ is a vector of individual-level parameters.

As Berry, Levinsohn, and Pakes (1995), Nevo (2000), and Petrin (2002) argue, random coefficient models permit more realistic estimates of consumer demands than homogenous coefficient models do. In a fast-growing market such as the e-book market, we can naturally consider that consumers have heterogeneous preferences, hence different coefficient values, depending on past consumption experience and observed characteristics. To validate this approach, we will later show how individual parameters are affected by such factors. For instance, those who currently read e-books may have different price sensitivities, hence values of the price integral (β_{ij}), from those who do not read e-books; those with piracy experience may have different demands for e-book devices and may also react differently to policy changes compared with those with no

such experience.

3.2 Bayesian Estimation

We follow Rossi, Allenby, and McCulloch (2005) to estimate a hierarchical Bayesian model with a mixture of K components of normal priors to flexibly estimate the proposed random coefficient model. This approach is more flexible than the classical approach because it does not restrict the coefficients to coming from a (single) normal distribution. Our approach also allows for correlated coefficients without additional computation time.

In the survey (to follow), we asked respondents to provide demographic and other relevant characteristics. Thus, we include a vector Z_i of observable characteristics to capture observed consumer heterogeneity. Let $t = 1, \ldots, T$ indicate a choice occasion. Then, the conditional likelihood of observing the choices consumer i makes across the T choice occasions is given by $\sum_{t=1}^{T} D_{ij}^{t}(\mathbf{P}|\Theta_i)$.

Letting $ind_i \in \{1, \ldots, K\}$ denote the latent variable that indicates the K mixture component from which each consumer's preference parameter vector is drawn, the demand model can be expressed as follows:

$$\begin{aligned} \Theta_i &= Z_i \triangle + u_i \\ u_i &\sim N(\mu_{ind_i}, \Sigma_{ind_i}) \\ ind_i &\sim MN_K(\gamma), \end{aligned}$$

where γ is a vector of hyperparameters of the priors on the mixing probabilities for each component, and $\triangle$ is a matrix of hyperparameters that determine the systematic effects of demographics on individual-level parameters. We define $\zeta = vec(\triangle)$ for ease of illustration. Therefore, parameters Θ_i are drawn from a multivariate distribution of K mixture-of-normals, where μ_k and Σ_k denote the mean and variance-covariance matrix of each component, respectively.

The complete specification with priors over the hyperparameters, including the demographic coefficients ($\bar{\zeta}$ and a_{ζ}^{-1}), the mixing probabilities (α), the means of the unobserved heterogeneity ($\bar{\mu}$ and a_{μ}^{-1}), and the covariance matrices for the unobserved heterogeneity (v and V), can be

given in the following conjugate forms:

$$\begin{aligned}
\zeta &\sim N(\bar{\zeta}, a_{\zeta}^{-1}) \\
\gamma &\sim Dirichlet(\alpha) \\
\mu_k|\Sigma_k &\sim N(\bar{\mu}, \Sigma_k \times a_{\mu}^{-1}) \\
\Sigma_k &\sim IW(v, V).
\end{aligned}$$

where the joint prior on μ_k and Σ_k is independent conditional on γ.

The unconditional likelihood function is complicated because it involves multidimensional integrals. We thus use Markov Chain Monte Carlo (MCMC) methods, which avoid the need for numerical integration. The MCMC algorithm provides random draws from the joint posterior distribution, and inference is based on the distribution of the drawn samples. We use a hybrid of a Metropolis method which employs customized candidate density to draw individual-level parameters, and an unconstrained Gibbs sampler for a mixture of normals conditional on the draws of individual-level parameters.[12] (Interested readers can find further details of the implementation in Ch. 5 of Rossi, Allenby, and McCulloch (2005).)

We report here a Monte Carlo exercise to show that the MCMC estimation procedure effectively recovers the parameters of our proposed model. This simulation involves $I = 300$ consumers. Each consumer makes choices as described in our model in $T = 16$ tasks. Each task

[12]Specifically, the MCMC algorithm alternately draws between the individual-level parameters in (6) and the hyperparameters in (7):

$$\Theta_i \quad | \quad ind_i, Z_i\triangle, \mu_{ind_i}, \Sigma_{ind_i} \tag{6}$$

$$ind, \gamma, \{\mu_k\}, \{\Sigma_k\} \quad , \triangle| \quad \{\Theta\}, \tag{7}$$

where the conditional posterior in (6) is proportional to the product of the likelihood in (5) and the prior of the hyperparameters. We use a Random-Walk Metropolis step to draw Θ_i. The draws of the hyperparameters in (7) are broken down into a succession of conditional draws:

$$ind|\gamma, Z, \triangle, \{\mu_k, \Sigma_k\}, \{\Theta\} \tag{8}$$

$$\gamma|ind \tag{9}$$

$$\{\mu_k, \Sigma_k\}|ind, \{\Theta\} \tag{10}$$

$$\triangle|ind, Z, \{\mu_k, \Sigma_k\}, \{\Theta\}, \tag{11}$$

where the draw of indicators in (8) is a multinomial draw based on the likelihood ratios with γ_k as the prior. The draw of γ conditional on *ind* in (9) is a Dirichlet draw. The draw of each (μ_k, Σ_k) in (10) is obtained using a standard algorithm to draw from a multivariate regression model. The draw of $\triangle$ in (11) requires that we pool data from all K components into one regression model.

has two choice options ($J = 2$) and an outside option along with a non-price attribute (x_j), the price of e-book readers (f_j), the DRM protection (DRM_j), and the discounts for e-books (D_j) that vary exogenously. In particular, we assume that $x \sim U[0, 1]$, $f \sim U[1, 2]$, $D \sim U[0.5, 1]$, and that the probability of an e-book reader that uses DRM is 50 percent.

The next step is to employ the MCMC algorithm discussed above to estimate the model's parameters using the simulated data set. We simulate the posterior 20,000 times, discard the first 10,000 draws as burn-in iterations, and retain the last 10,000 draws. Table 1 reports the true mean of the individual parameter values used to generate the simulated data set and the corresponding Bayes estimate of the unknown parameters based on the posterior distribution. The mean of the estimated parameters are fairly close to the true values. As our data sets have larger sample sizes, this exercise indicates that our model can be estimated reasonably well.

4 Data Set

As the type of data required for our analysis is usually unavailable, we elicit "stated preference" data in contrast to the "revealed preference" data from observed choices. In particular, conjoint survey, a method for eliciting stated preferences within an experimental design, has become the method of choice for quantitative preference measurement in many fields, including psychology and marketing.[13] The main part of our survey is a choice-based conjoint survey, in which respondents are asked to make hypothetical discrete choices (see, e.g., Louviere and Woodworth (1983)); in addition we ask respondents to report their demographic and other relevant information.

Questions about how closely tasks in a hypothetical setting can match those in a real environment are common. However, both marketing and economic applications have found considerable support because conjoint survey can generate reliable demand estimates (e.g., Brownstone and Train (1999); Hensher, Louviere, and Swait (1999); Carlsson and Martinsson (2001)). For instance, a conjoint survey with proper design principles allows the straightforward identification

[13]Conjoint survey has been relied upon extensively by many companies in making decisions, such as those related to new product development, pricing, segmentation, positioning, and advertising (see, e.g., Cattin and Wittink (1982); Krieger, Green, and Wind (2004)). Hensher (1994) reviews the use of conjoint analysis in transportation research.

of effects because researchers can precisely specify product attributes for which real world data provide no variation. Furthermore, large quantities of relevant data can be collected at a moderate cost.

Our survey was fielded twice. Each data source has advantages and disadvantages, and we replicate our results using each sample separately. The first survey was carried out with a large number of undergraduate economics students at the University of Colorado in Spring 2013. The aim was to effectively force a well-defined group of students to fill out the survey to minimize potential selection bias. To this end, we collaborated with all intro-level course instructors, most of intermediate-level course instructors, and some higher-level course instructors to administer the survey in class. A sample of 1355 students was established.

Student samples have some drawbacks, however. That is, the sample is not representative of the total population, and students need not complete the survey, creating occassional missing data. To supplement the student sample and to ensure the robustness of our subsequent analysis, we also launched the same survey with a commercial survey firm that maintains a panel of random U.S. population.[14] The resultant sample of 1652 respondents has a wide representation in terms of age and geographic location. For instance, the survey respondents may be still self-selected and limited to Internet users. Therefore, the two sets of data should be viewed as complements.

To design our survey, we initially conducted a pilot study with 63 undergraduate students at the University of Colorado. We chose the e-book readers to be included in our main survey by asking the respondents to indicate their favorite e-book readers. Kindle, Nook, and iPad were the most popular devices. We also asked students to indicate important attributes when choosing among e-book readers. Screen size and touch screen function were the most frequently mentioned attributes. We then selected five attributes to include in the main survey: (1) use of DRM, (2) touch screen function, (3) device price, (4) screen size, and (5) price discount available for e-books (or hard copy books).

To determine a viable range of hardware prices, we asked students to state the maximum

[14]We used SurveyMonkey Audience service. Respondents can only receive compensation if they answer all the questions. In addition to a $100 sweepstakes, the company makes a contribution of $0.50 to a charity of each member's choice. For details on their recruitment and sampling procedure, see `http://help.surveymonkey.com/articles/en_US/kb/How-do-Academics-use-SurveyMonkey-Audience`.

price that they are willing to pay for a plain e-ink reader and a tablet computer. We then determined $10 to $250 as a feasible range for Kindle and Nook and $100 to $850 as a feasible range for iPad. The survey contained a sequence of sixteen individualized choice tasks. Each choice set contained three e-book readers and an option to read hard copies; a respondent had to choose one of the five options in each task (where the fifth option is to choose none of the above). Figure 1 presents a sample of a conjoint task in our survey.

The alternatives in each choice set were based on a sixteen-profile, orthogonal array of four inside choices and four attribute levels. We constructed subsequent alternatives by using cyclically generated alternatives to each set (see Bunch, Louviere, and Anderson (1994)).[15] This mode of construction satisfies the three properties of efficient choice design (Sawtooth Software, 2008).[16] In specifying attribute levels, we divided the ranges of each attribute into low, medium low, medium high, and high categories. We then randomly selected a value from the corresponding range for each attribute level appearing in each option. We constructed four such versions of the questionnaire that were fielded randomly.

Table 2 reports the summary statistics of the student sample. Unsurprisingly, the average age is around 20, and male students comprise a slight majority of the respondents. Household income is coded as 0 for $0 to 20K, 1 for $20K to 40K, 2 for $40K to 60K, and so on. "Reading Habit" is an indicator variable that equals one if the respondent indicated "yes" to the question, "Do you read e-books?" "Piracy Experience" is also an indicator variable that equals one if the respondent indicated "yes" to the question, "Have you ever downloaded or pirated e-books?" Finally, students were asked to report their estimated annual budget for books. The mean budget is around $300.

Table 3 reports the summary statistics of the random sample. Age, gender, income, and education variables are based on registration information and the information provided by the survey firm. The category of these variables are rather coarse: for age, the coding is 0 for 18 to 29, 1 for 30 to 44, 2 for 45 to 60, and 3 for over 60; for income, the coding is 0 for $0 to

[15] To be precise, the attribute level of a new alternative adds one to the level of the previous alternative, and if the previous alternative is at the highest level, then the assignment re-cycles to the lowest level.

[16] Specifically, we follow i) minimal overlap: each covariate level is shown as few times as possible in a single task; ii) level balance: each covariate level is shown an approximately equal number of times; and iii) orthogonality: covariate levels are chosen independently of other attribute levels, such that each level's effect on utility can be measured independently of all other effects, to draw the levels of each covariate in our survey.

25K, 1 for $25 to 50K, 2 for $50 to 100K, 3 for $100 to 150K, and 4 for $150K or above; for education, the coding is 0 for "less than high school degree," 1 for "high school degree," 2 for "some college," 3 for "associate or bachelor degree," and 4 for "graduate degree." Budget for books is in $20 increments, and the mean is around $145.

Notable differences can be observed between the two samples. While only 35 percent of the students considers themselves as e-book readers, 53 percent of the general population indicates that they read e-books. The fraction of respondents who have piracy experience is 30 percent in the student sample but only six percent in the random sample of the U.S. population. As the random sample consists of older people, the former finding indicates that, in contrast to the popular belief, students or younger people in our sample do not prefer e-books compared with older people. The latter finding shows that the level of e-book piracy in the general population seems rather small, although one must consider the possibility of self-reporting bias.

We also asked the survey respondents to indicate the e-book device that they are using (where one or more choices were allowed). Tables 4 and 5 compare the user demographics of different e-book readers. Across the two samples, iPad users tend to have a higher income than the other groups, and about 70 to 80 percent of iPad users report that they read e-books, whereas over 90 percent of Kindle and Nook users do so. The bottom row shows the market share based on the current use of e-book readers in our sample. Although Kindle has a similar market share as iPad in the random sample, its share is only about half of iPad's in the student sample. Nook has about a quarter of Kindle's share.

5 Estimation Results

Figures 2 and 3 illustrate the kernel density estimates from the $K = 1$ (solid line) and the $K = 3$ (dotted line) normal mixture models. The estimates from the three-component model are visually different from those from the one-component model. The differences between the two cases arise because of the flexibility of non-normal prior (when $K > 1$), which permits highly accurate individual-level inferences. In fact, the log marginal likelihood is higher with the $K = 3$ mixture normal ($LL = -26,596$ and $-34,935$ for the student and the random sample, respectively) compared with the single normal prior ($LL = -27,117$ and $-37,087$, correspondingly). Hence,

we discuss our main results using the estimates from the three-component model.[17]

The top row of each figure shows the estimates for the brand dummy coefficient in γ_i. Both samples do not show marked differences among the four choice options. That is, Kindle and iPad seem to have on average a slightly higher constant coefficient than Nook or hard copy does, but the magnitude is not so large given other parameter estimates. The middle row contains estimates for the touch screen, screen size, budget, and DRM parameters. The range of screen size and DRM parameters seems relatively small compared with that of touch screen and budget for book expenditure. The bottom row illustrates the densities for the price integral for each choice option, and they are all skewed to the right. This result indicates that few people are sensitive to the prices of e-book content.

We report in Tables 6 and 7 the own- and cross-price elasticities using these estimates. Surprisingly, we find that the own-price elasticities of the three e-book devices vary greatly. The values are -0.87 to -1.19 for Kindle, -1.23 to -1.57 for Nook, and -0.22 to -0.28 for iPad, depending on the samples used. These estimates seem consistent with the observed price differences between these three devices. That is, iPad is the most expensive among them, and Nook is priced slightly below Kindle. The cross-price elasticities suggest that Kindle and Nook are closer substitutes between themselves than with iPad. This observation is consistent with the fact that the iPad is a new tablet that offers a range of features (such as web browsing, e-mail, music, and games).

Tables 8 and 9 show the estimated values of the hyperparameter matrix (Δ), which links the observed characteristics to individual-level parameters. These two tables show that some of the consumer heterogeneity can be explained by the observable characteristics in Z_i. For instance, male respondents across the two samples on average seem to have a brand preference for iPad over Kindle, Nook, and hard copies. They are also more sensitive (higher β_{ij}) to content prices offered by Amazon and Barnes & Noble relative to those offered by iPad. Another finding is that in the random sample, older people on average prefer significantly less, not more, hard copy option over any of the three reading devices, whereas those with higher income or education tend to prefer hard copy option over any of the e-book readers.

[17]We experimented with different values of K and concluded that $K = 3$ component normal mixture model can best fit the data in both samples. Note that the differences between the samples are not due to the different model specification because we use the same $K = 3$ component model across the two samples.

Some of these findings are intuitive and add to the plausibility of the model. For instance, those who currently read e-books have distaste for hard copy option as shown by the negative coefficient for hard copy option. They also have a higher sensitivity to DRM protection compared with those who do not read e-books, as shown by the higher values of $\log(1-\delta_i)$. This result indicates that the policy impact of dropping DRM would be great for current e-book consumers. Meanwhile, piracy experience is significantly negatively associated with the brand dummies for all e-book readers hard copy option. However, the effects of piracy experience on sensitivity to e-book prices are mixed. That is, piracy experience is positively associated with the sensitivity toward e-book and hard copy prices in the student sample, but it is negatively associated with Apple's e-book pricing in the random sample.

6 Counterfactual Experiments

Given the specifications of our demand model in Section 3, we now predict how changes in DRM protection and e-book discounts affect the demand for e-book readers and how consumer welfare changes. Notice that the indirect utility derived in (4) remains unchanged when we perform counterfactual experiments that affect the parameters of the model including the presence of DRM protection (DRM_j) and the rate of discount off retail (D_j). To be precise, the indirect utility is still given by (4) where all individual-level parameters in $\Theta_i \equiv [\gamma_i, \delta_i, \beta_{i1}, \ldots, \beta_{iJ}, w_i]$ are assumed to be invariant to a change in our policy variables.

Table 10 shows the benchmark figures used to represent the current states of the world. That is, all three e-book readers employ DRM protection, and the e-book discount rates are 50 percent for Amazon and Barnes & Noble and 35 percent for Apple's iBookstore. Note that the sources that suggest these numbers were introduced in the earlier part of this paper. Given the \$9.99 pricing that prevailed in the market (before Apple's entry), 50 percent discount implies a full retail price of \$20. Apple then had proposed price caps of \$12.99 (or \$14.99), which corresponds to a 35 (or 25) percent discount off retail. By contrast, Amazon sold one in three (or four) hard copy books at a discount ranging from 25 to 35 percent in the past (Streitfeld (2013)). This scenario indicates that on average, hard copies were sold at a discount of approximately 10 percent.

First, Tables 11 and 12 present our estimates of the counterfactual effect of abolishing DRM on the demand for e-book readers. The first row of each table represents the predicted market shares using the benchmark figures. The next three rows show how the market shares and consumer welfare would change if the three e-book readers were to drop DRM one at a time. Here, the effect of DRM is not significant for the iPad, but it is large and appears economically meaningful for Kindle and Nook. That is, if Kindle or Nook had no DRM protection in their devices, then the market share of these two devices would increase by approximately four percentage point. These gains in market share come as much from hard copy readers as from the competitors' market shares.

The change in aggregate consumer utility associated with DRM policy change is also considerable. If Kindle were to drop its DRM, then our model predicts that the consumer welfare would increase by more than four percentage point, whereas the effect is slightly lower for Nook in the student sample. In that student sample, dropping DRM for the iPad increases consumer welfare by about five percentage point even though it only increases iPad's market share by one percent. This may occur because iPad users also prefer the absence of DRM. The last row shows the changes in market shares when all three e-book readers were to drop DRM. Although overall market expansion effect is small (less than two percent), consumer welfare increases more than seven percentage point.

Tables 13 to 16 assess the robustness of our counterfactual experiments by investigating heterogeneous consumer responses along some behavioral dimensions. That is, DRM may matter greatly for current e-book readers because they are likely to encounter situations in which DRM restricts their reading experience. Similarly, DRM may matter little for non-pirating individuals because they have little incentive to circumvent DRM protection. The four tables are consistent with these conjectures. Conditional on reading experience, the market shares of Kindle and Nook increase by more than five percentage point, whereas they increase less than three percentage point conditional on not being an e-book reader. The results conditional on the piracy experience are very similar.

Our second counterfactual experiment is to show the effect of reducing price discounts for e-books. As we discussed above, the recent e-book price-fixing probe revealed that Amazon's e-book prices went up by at least 20 percent after publishers pressured Amazon and other online

retailers to adopt the agency model. Given the $9.99 e-book pricing in the benchmark, a 20 percent increase means an e-book price of $11.99, which corresponds to a 40 percent discount off the retail price ($20). However, Apple's agency model stipulated e-book prices up to $12.99 or $14.99. As the recent district court ruling shows, e-book prices for best-sellers went up more than 40 percent. Hence, we also consider policy changes that result in a 35 percent and a 25 percent e-book discount off retail, corresponding to the $12.99 or $14.99 cap.

Tables 17 and 18 show the predicted market shares and percentage changes in aggregate consumer welfare. The first row in each table represents our benchmark prediction as spelled out in Table 10. That is, the first row includes Apple's entry, but it assumes that Apple's agency model had no impact on the e-book prices sold by Amazon and Barnes & Noble at 50 percent discount. During the period, the e-book price-fixing case was concerned with the fact that the e-book discount rate was no more than 40 percent; our prediction in this scenario is represented in the second row. That is, iPad's market share would increase by one to two percent, whereas those of Kindle and Nook would decrease by the corresponding amount.

The effects of cutting back e-book price discounts would be larger if Amazon's and Barnes & Noble's e-book prices went up by 50 percent, which corresponds to the 25 percent discount rate. Here, iPad's market share would increase by two to four percent with a corresponding decrease in both Kindle's and Nook's market shares. Meanwhile, the impact of the e-book price increase on consumer welfare, as measured by a percentage change in aggregate utility, is unambiguously negative. The impact ranges between three and five percent welfare loss when the e-book discount is 40 percent off retail, and between six and ten percent welfare loss when the e-book discount is cut back to 25 percent. This implies that the e-book price-fixing had a negative effect on hardware and the e-book market.

Tables 19 to 22 turn to the heterogeneous responses from consumers depending on their previous experience. Similar to the above, consumer reaction to the changes in e-book price discount may differ between those who currently read e-books and those who do not. In line with our expectation, we find that iPad's market share gain is one percentage point higher among those who currently read e-books than those who do not. However, the difference between those who have piracy experience and those who do not does not exist in this policy experiment. This result is attributable to the fact that those who have pirated e-books are generally more sensitive

to price discounts, but pirating also eliminates the need to make a purchase. Thus, these forces seem to offset each other.

7 Conclusion

The e-book is a technological revolution in the history of the publishing industry. As such, it has raised important policy issues on copyrights and pricing strategies. One of the main contributions of this paper is that it provides a structural demand model for e-book readers while considering the complementarity between e-books and e-book readers. That is, we solve a maximization problem using CES utility function, which yields a reduced-form discrete choice equation. We flexibly estimate it using a hierarchical Bayesian method.

Our findings are consistent with those of others: Kindle and Nook are price elastic and closer substitutes, and iPad is considerably price inelastic. We also show quantitatively how the demand for these e-book readers and the hard copy choices are systematically linked together. That is, our counterfactual experiments show that DRM-free regime would increase the market shares of e-book readers and consumer welfare. E-book price increases are likely to increase the iPad's market share at the expense of other e-book readers and decrease consumer welfare.

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Figure 1: A Sample Conjoint Task (This need not be published)

	 Kindle E-Readers	 Nook E-Reader	 iPad	 Hard Copies
DRM	No	Yes	No	N.A.
Touch Screen	No	Yes	Yes	N.A.
Price	$40	$110	$600	$0
Screen Size	6 inch (size of an actual Kindle E-Reader)	7 inch (size of an actual Kindle Fire Tablet)	7.9 inch (size of an actual iPad mini)	N.A.
Price Discount for Books	60% off	40% off	20% off	No Discount

You would choose: Kindle _____ Nook ____ iPad _____ Hard Copies ____ None ____

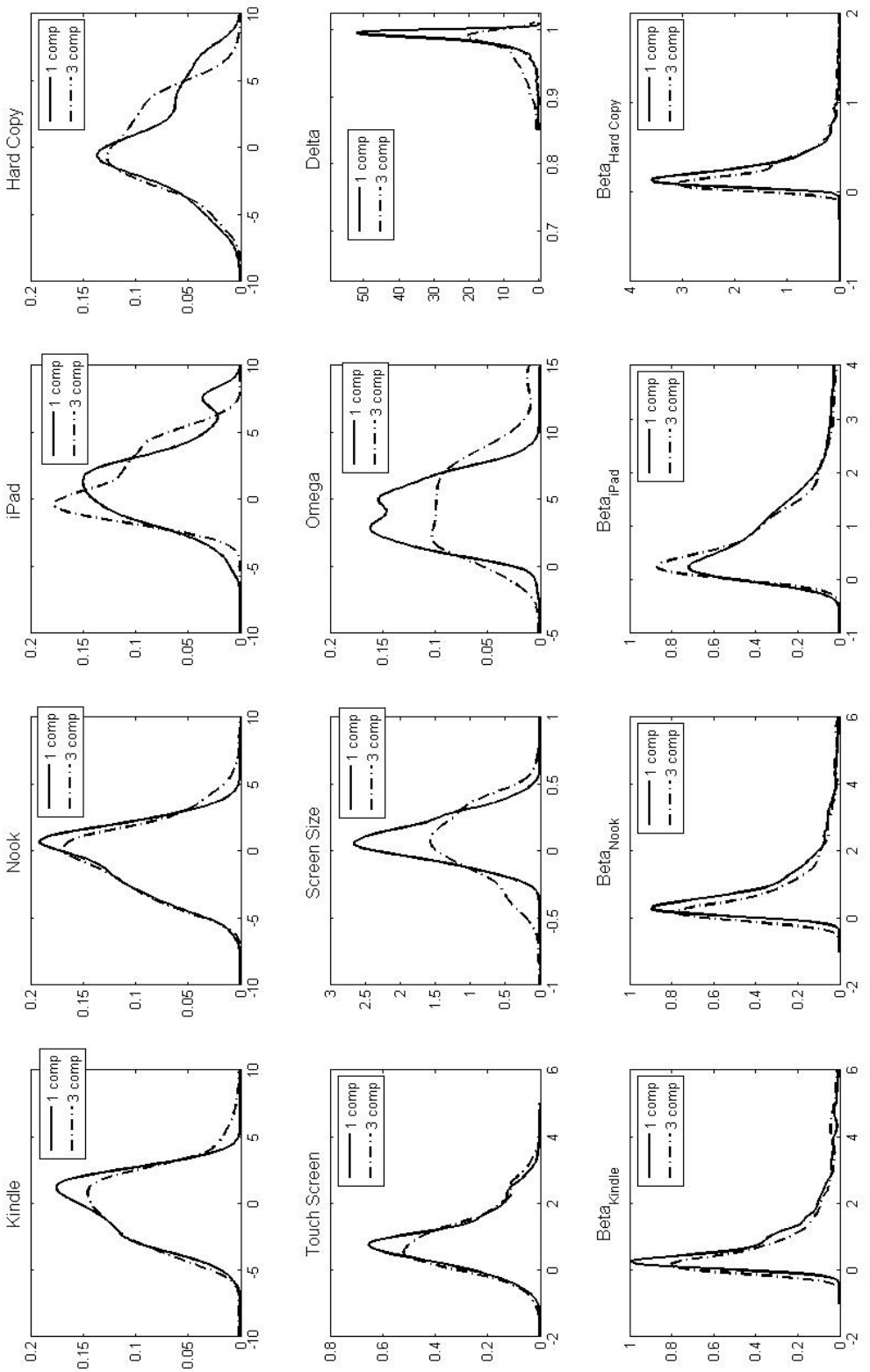


Figure 2: Kernal Densities of Estimates of Coefficients (Student Sample)

Figure 3: Kernal Densities of Estimates of Coefficients (Random Sample)

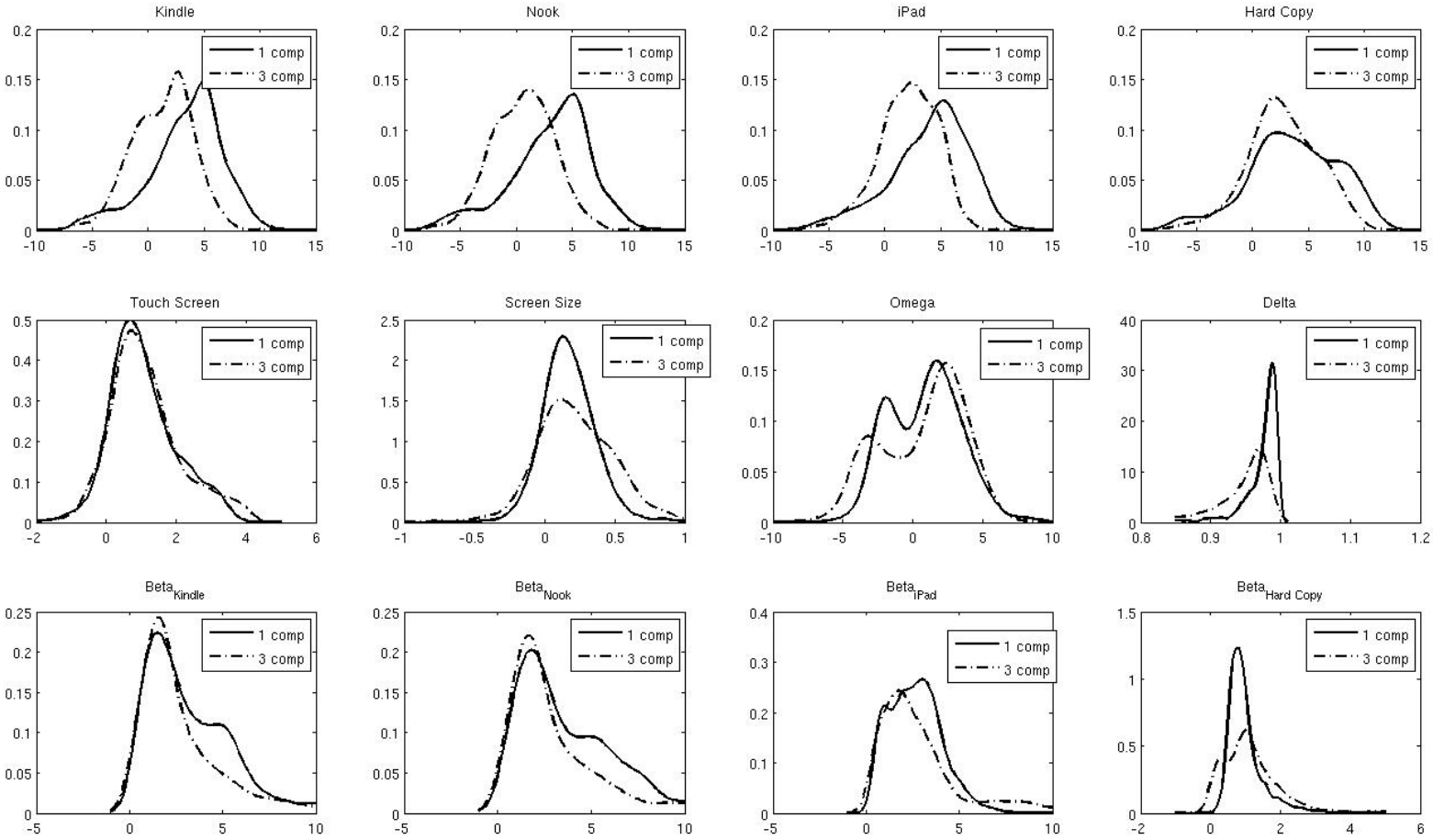


Table 1: Comparing True and Estimated Parameters in Monte Carlo Exercise

	Parameter Labels	True Mean Values	Estimated Mean Values
Choice dummy 1	v_{i1}	-2.0	-2.0
		(0.7)	(0.4)
Choice dummy 2	v_{i2}	-1.0	-0.9
		(0.7)	(0.3)
Non-price attribute	γ_i	0.5	0.5
		(0.5)	(0.3)
Budget	w_i	3.0	2.7
		(0.7)	(0.5)
DRM	δ_i	0.7	0.7
		(0.4)	(0.4)
Price integrals 1	β_{i1}	1.0	1.1
		(0.7)	(0.5)
Price integrals 2	β_{22}	1.5	1.7
		(0.7)	(0.7)

Standard deviations are reported in brackets.

Table 2: Summary Statistics of Demographics (Student Sample)

Variable	Mean (Std. dev.)
Age	19.8 (1.7)
Male	0.64 (0.48)
Income (in $20K)	4.88 (3.40)
Reading Habit	0.35 (0.48)
Piracy Experience	0.30 (0.46)
Budget for Books ($)	304 (411)

$N = 1355$.

Table 3: Summary Statistics of Demographics (Random Sample)

Variable	Mean (Std. dev.)
Age Group (0-3)	1.68 (1.07)
Male	0.49 (0.50)
Income Level (0-4)	1.79 (1.32)
Education Level (0-4)	2.76 (1.00)
Reading Habit	0.53 (0.50)
Piracy Experience	0.06 (0.24)
Budget for Books (in $20)	7.31 (9.21)

$N = 1652$.

Table 4: Demographics by Current Ownership (Student Sample)

Variable	Kindle	Nook	iPad	Other	None
Age	19.8	20.0	19.9	20.5	19.8
Male	0.55	0.50	0.63	0.65	0.64
Income (in $20K)	4.75	4.23	5.62	3.53	4.69
Reading Habit	0.95	1.00	0.68	0.83	0.05
Piracy Experience	0.48	0.42	0.43	0.51	0.20
Budget for Books ($)	330	$324	384	296	276
% of Sample	12.7%	3.3%	27.3%	4.4%	47.6%

Table 5: Demographics by Current Ownership (Random Sample)

Variable	Kindle	Nook	iPad	Other	None
Age Group (0-3)	1.68	1.79	1.65	1.55	1.69
Male	0.44	0.35	0.47	0.57	0.53
Income Level (0-4)	1.96	2.04	2.23	1.73	1.49
Education Level (0-4)	2.86	2.87	2.93	2.88	2.63
Reading Habit	0.94	0.90	0.82	0.91	0.10
Piracy Experience	0.09	0.06	0.07	0.12	0.03
Budget for Books (in $20)	8.42	7.76	8.43	7.72	6.60
% of Sample	26.2%	7.7%	23.9%	7.4%	40.6%

Table 6: Own Price Elasticities (Student Sample)

with respect to	Kindle	Nook	iPad
Kindle's price	-1.19	0.77	0.20
	[-1.27, -1.11]	[0.71, 0.84]	[0.18, 0.23]
Nook's price	0.66	-1.57	0.20
	[0.62, 0.71]	[-1.67, -1.49]	[0.18, 0.22]
iPad's price	0.12	0.13	-0.28
	[0.11, 0.14]	[0.12, 0.16]	[-0.31, -0.26]

The 5th and 95th percentiles of the estimates are reported in brackets.

Table 7: Own Price Elasticities (Random Sample)

with respect to	Kindle	Nook	iPad
Kindle's price	-0.87	0.76	0.13
	[-0.92, -0.82]	[0.71, 0.82]	[0.12, 0.15]
Nook's price	0.58	-1.23	0.11
	[0.54, 0.61]	[-1.30, -1.17]	[0.10, 0.13]
iPad's price	0.09	0.10	-0.22
	[0.08, 0.10]	[0.09, 0.11]	[-0.24, -0.21]

The 5th and 95th percentiles of the estimates are reported in brackets.

Table 8: Coefficients Explained by Demographics (Student Sample)

	Kindle	Nook	iPad	Hard Copy	Touch Screen	Screen Size	Budget (w_i)	DRM ($\log(1-\delta_i)$)	β_{kindle}	β_{nook}	β_{ipad}	$\beta_{\text{hard copy}}$
Age	0.10	0.10	0.10	0.12	0.04	0.00	-0.01	0.15	-0.02	-0.01	-0.01	0.00
	(0.04)	(0.05)	(0.03)	(0.06)	(0.03)	(0.01)	(0.03)	(0.06)	(0.02)	(0.02)	(0.01)	(0.02)
Male	-0.06	-0.18	0.13	-0.34	-0.29	0.03	-0.28	-0.20	0.12	0.19	0.09	-0.11
	(0.13)	(0.18)	(0.15)	(0.25)	(0.08)	(0.02)	(0.10)	(0.17)	(0.05)	(0.05)	(0.04)	(0.05)
Reading	0.08	-0.00	0.03	-1.10	0.08	0.03	0.15	0.33	-0.00	-0.14	-0.01	-0.00
Habit	(0.33)	(0.29)	(0.34)	(0.22)	(0.10)	(0.03)	(0.09)	(0.14)	(0.07)	(0.07)	(0.04)	(0.05)
Piracy	-0.49	-0.60	-0.31	-0.51	-0.14	0.02	-0.08	-0.01	0.11	0.18	0.05	0.04
Experience	(0.43)	(0.41)	(0.40)	(0.24)	(0.11)	(0.03)	(0.08)	(0.16)	(0.05)	(0.05)	(0.04)	(0.06)
Budget	-0.29	-0.52	-0.16	-0.51	-0.11	0.03	0.31	-0.25	-0.17	-0.20	-0.09	0.03
(in $1000)	(0.32)	(0.36)	(0.40)	(0.31)	(0.14)	(0.03)	(0.09)	(0.21)	(0.07)	(0.07)	(0.05)	(0.07)
Income	-0.02	-0.03	0.00	0.05	0.02	0.01	0.02	0.04	-0.02	-0.01	-0.01	-0.01
(0-10)	(0.04)	(0.04)	(0.04)	(0.03)	(0.02)	(0.00)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)

Standard deviation of the estimates are reported in brackets.

Table 9: Coefficients Explained by Demographics (Random Sample)

	Kindle	Nook	iPad	Hard Copy	Touch Screen	Screen Size	Budget (w_i)	DRM ($\log(1-\delta_i)$)	β_{kindle}	β_{nook}	β_{ipad}	$\beta_{\text{hard copy}}$
Reading	2.13	1.69	2.24	-0.95	-0.13	-0.06	0.55	0.40	-0.24	-0.28	-0.16	0.06
Habit	(0.29)	(0.31)	(0.35)	(0.41)	(0.10)	(0.03)	(0.11)	(0.11)	(0.06)	(0.06)	(0.04)	(0.06)
Piracy	-1.03	-0.81	-0.82	-2.00	-0.51	-0.01	-0.09	0.25	0.00	-0.11	-0.17	0.20
Experience	(0.49)	(0.40)	(0.37)	(0.49)	(0.23)	(0.04)	(0.18)	(0.24)	(0.11)	(0.12)	(0.08)	(0.11)
Budget	0.01	-0.01	0.03	0.01	-0.01	-0.00	0.01	-0.01	-0.01	-0.00	-0.01	0.01
(in $20)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Male	0.39	0.30	0.59	0.21	-0.47	0.07	-0.33	0.41	0.06	0.10	-0.03	0.00
	(0.37)	(0.36)	(0.36)	(0.35)	(0.08)	(0.03)	(0.09)	(0.11)	(0.06)	(0.05)	(0.04)	(0.06)
Age	-0.21	-0.29	-0.37	-0.89	-0.00	0.04	0.02	-0.01	-0.04	-0.10	-0.05	-0.04
	(0.07)	(0.07)	(0.07)	(0.12)	(0.04)	(0.01)	(0.05)	(0.07)	(0.03)	(0.03)	(0.02)	(0.02)
Income	-0.15	-0.02	-0.01	0.33	0.08	0.01	0.06	-0.04	-0.01	-0.01	-0.00	-0.06
	(0.13)	(0.09)	(0.12)	(0.14)	(0.04)	(0.01)	(0.04)	(0.05)	(0.03)	(0.02)	(0.02)	(0.02)
Education	-0.10	-0.12	0.04	0.29	0.03	-0.00	0.08	0.10	0.06	0.05	0.05	0.04
	(0.09)	(0.10)	(0.09)	(0.22)	(0.05)	(0.01)	(0.05)	(0.06)	(0.03)	(0.04)	(0.03)	(0.04)

Standard deviation of the estimates are reported in brackets.

Table 10: Benchmark E-book Market

	Kindle	Nook	iPad	Hard Copy
Device Price	\$140	\$120	\$400	\$0
E-book Discount	50%	50%	35%	10%
DRM	Yes	Yes	Yes	-
Touch Screen	Yes	Yes	Yes	-
Screen Size (inch)	6	6	9.7	-

Table 11: Market Shares of Different E-book Readers (Student Sample) (%)*

	Kindle	Nook	iPad	Hard Copy	Welfare Increase
Current	24.39	18.60	27.16	23.97	
	[23.43, 25.35]	[17.95, 19.27]	[26.28. 28.12]	[23.39, 24.51]	
No Kindle DRM	28.50	17.82	26.08	22.41	4.11%
	[27.66, 29.33]	[17.10, 18.59]	[25.32, 26.91]	[21.91, 22.91]	[3.26%, 5.13%]
No Nook DRM	23.51	22.32	26.21	22.66	2.71%
	[22.43, 24.54]	[21.46, 23.20]	[25.33, 27.14]	[22.17, 23.14]	[2.11%, 3.41%]
No iPad DRM	24.15	18.61	28.13	23.60	5.14%
	[23.18, 25.21]	[17.97, 19.27]	[27.18, 29.04]	[23.03, 24.12]	[3.41%, 7.15%]
No DRM	26.12	19.54	26.49	22.51	7.22%
	[25.24, 27.03]	[18.74, 20.39]	[25.53, 27.32]	[21.98, 23.02]	[5.08%, 9.74%]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 12: Market Shares of Different E-book Readers (Random Sample) (%)*

	Kindle	Nook	iPad	Hard Copy	Welfare Increase
Current	26.48	18.58	23.69	26.66	
	[25.82, 27.16]	[18.03, 19.15]	[23.03, 24.35]	[26.24, 27.08]	
No Kindle DRM	29.94	17.90	22.70	25.38	4.51%
	[29.30, 30.60]	[17.33, 18.47]	[22.14, 23.32]	[24.95, 25.83]	[3.56%, 5.47%]
No Nook DRM	25.43	22.21	22.82	25.46	4.51%
	[24.76, 26.07]	[21.63, 22.81]	[22.21, 23.43]	[25.04, 25.88]	[3.77%, 5.41%]
No iPad DRM	26.80	18.84	23.46	26.45	2.23%
	[26.13, 27.44]	[18.29, 19.44]	[22.90, 24.01]	[26.01, 26.90]	[1.60%, 3.03%]
No DRM	27.67	20.36	22.11	25.53	7.38%
	[26.95, 28.38]	[19.72, 21.01]	[21.61, 22.65]	[25.09, 25.97]	[6.02%, 8.88%]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 13: Market Shares by Reading Habit (Student Sample) (%)*

	With Reading Habit			No Reading Habit		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	30.05	19.44	30.55	21.37	18.15	25.35
	[28.48, 31.54]	[18.12, 20.85]	[28.95. 32.06]	[20.15, 22.53]	[17.32, 19.11]	[24.35. 26.42]
No Kindle DRM	35.60	18.23	29.03	24.72	17.61	24.50
	[34.00, 37.08]	[16.89, 19.64]	[27.52, 30.47]	[23.73, 25.78]	[16.62, 18.60]	[23.55, 25.45]
No Nook DRM	28.76	24.69	29.21	20.71	21.06	24.61
	[27.22, 30.26]	[23.08, 26.32]	[27.63, 30.68]	[19.39, 22.06]	[20.08, 22.08]	[23.54, 25.65]
No iPad DRM	29.61	19.40	32.26	21.24	18.18	25.92
	[28.16, 31.01]	[18.08, 20.77]	[30.74, 33.76]	[19.97, 22.52]	[17.34, 19.14]	[24.76, 27.02]
No DRM	32.04	20.82	30.07	22.96	18.86	24.58
	[30.50, 33.48]	[19.21, 22.45]	[28.37, 31.55]	[21.97, 24.08]	[17.96, 19.86]	[23.56, 25.53]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 14: Market Shares by Reading Habit (Random Sample) (%)*

	With Reading Habit			No Reading Habit		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	32.95	20.84	26.82	19.07	15.98	20.09
	[32.01, 33.98]	[20.01, 21.69]	[25.91. 27.77]	[18.30, 19.85]	[15.24, 16.76]	[19.38. 20.87]
No Kindle DRM	37.89	19.97	25.30	20.83	15.53	19.72
	[36.93, 38.84]	[19.19, 20.79]	[24.54, 26.12]	[20.05, 21.65]	[14.75, 16.31]	[18.98, 20.48]
No Nook DRM	31.49	26.02	25.37	18.48	17.84	19.89
	[30.52, 32.48]	[25.18, 26.87]	[24.56, 26.21]	[17.69, 19.21]	[17.05, 18.71]	[19.20, 20.65]
No iPad DRM	33.23	20.92	27.12	19.43	16.46	19.26
	[32.32, 34.21]	[20.11, 21.75]	[26.30, 27.91]	[18.65, 20.22]	[15.72, 17.24]	[18.56, 19.99]
No DRM	34.56	23.16	24.99	19.77	17.14	18.81
	[33.56, 35.58]	[22.26, 24.08]	[24.24, 25.76]	[18.95, 20.54]	[16.37, 18.01]	[18.15, 19.47]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 15: Market Shares by Piracy Experience (Student Sample) (%)*

	With Piracy Experience			Without Piracy Experience		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	25.12	17.75	30.01	24.08	18.95	25.98
	[23.55, 26.76]	[16.38, 19.11]	[28.47. 31.78]	[22.90, 25.16]	[18.22, 19.77]	[25.00. 27.05]
No Kindle DRM	30.45	16.46	28.54	27.70	18.39	25.06
	[28.69, 31.98]	[15.11, 17.83]	[27.08, 30.03]	[26.69, 28.75]	[17.53, 19.33]	[24.15, 26.01]
No Nook DRM	23.46	23.13	28.72	23.53	21.99	25.17
	[21.99, 25.00]	[21.56, 24.73]	[27.26, 30.29]	[22.28, 24.76]	[21.04, 22.97]	[24.13, 26.26]
No iPad DRM	24.78	17.70	31.44	23.89	18.98	26.75
	[23.26, 26.40]	[16.37, 19.04]	[29.69, 33.11]	[22.62, 25.05]	[18.26, 19.76]	[25.64, 27.83]
No DRM	26.69	19.71	29.33	25.88	19.47	25.31
	[25.02, 28.21]	[18.17, 21.32]	[27.72, 30.95]	[24.87, 26.96]	[18.61, 20.37]	[24.31, 26.25]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 16: Market Shares by Piracy Experience (Random Sample) (%)*

	With Piracy Experience			Without Piracy Experience		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	24.03	16.86	23.57	26.64	18.69	23.70
	[21.51, 26.78]	[14.95, 18.99]	[21.31. 25.86]	[25.95, 27.38]	[18.11, 19.29]	[23.02. 24.40]
No Kindle DRM	30.38	16.33	22.37	29.91	18.00	22.72
	[27.78, 32.95]	[14.47, 18.40]	[20.45, 24.36]	[29.24, 30.59]	[17.40, 18.59]	[22.14, 23.37]
No Nook DRM	23.08	22.21	22.59	25.58	22.21	22.83
	[20.74, 25.58]	[20.08, 24.36]	[20.53, 24.79]	[24.90, 26.23]	[21.60, 22.86]	[22.20, 23.44]
No iPad DRM	24.12	17.12	24.15	26.97	18.96	23.41
	[21.51, 26.84]	[15.15, 19.33]	[21.91, 26.55]	[26.29, 27.68]	[18.39, 19.56]	[22.82, 23.99]
No DRM	26.96	20.49	21.34	27.71	20.35	22.16
	[24.38, 29.54]	[18.49, 22.60]	[19.37, 23.53]	[27.00, 28.43]	[19.69, 21.03]	[21.64, 22.75]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 17: Market Shares of Different E-book Readers (Student Sample) (%)*

	Kindle	Nook	iPad	Hard Copy	Welfare Change
Current	24.87	18.69	26.83	23.92	
	[24.04, 25.70]	[17.97, 19.39]	[26.08. 27.67]	[23.30, 24.50]	
Kindle, Nook Discount	23.03	16.52	28.75	25.31	-5.60%
= 40%	[22.29, 23.74]	[15.89, 17.16]	[27.97, 29.62]	[24.70, 25.88]	[-6.07%, -5.07%]
Kindle, Nook Discount	22.16	15.64	29.57	25.91	-7.45%
= 35%	[21.40, 22.89]	[15.04, 16.28]	[28.78, 30.45]	[25.32, 26.48]	[-8.08%, -6.73%]
Kindle, Nook Discount	20.64	14.25	30.94	26.91	-9.97%
= 25%	[19.87, 21.35]	[13.64, 14.89]	[30.13, 31.89]	[26.32, 27.50]	[-10.85%, -8.97%]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 18: Market Shares of Different E-book Readers (Random Sample) (%)*

	Kindle	Nook	iPad	Hard Copy	Welfare Change
Current	26.48	18.58	23.69	26.66	
	[25.82, 27.16]	[18.03, 19.15]	[23.03, 24.35]	[26.24, 27.08]	
Kindle, Nook Discount	25.64	17.49	24.67	27.46	-3.15%
= 40%	[24.95, 26.32]	[16.96, 18.06]	[23.99, 25.34]	[27.01, 27.91]	[-3.46%, -2.88%]
Kindle, Nook Discount	25.21	17.03	25.11	27.83	-4.28%
= 35%	[24.48, 25.89]	[16.51, 17.61]	[24.43, 25.79]	[27.36, 28.29]	[-4.70%, -3.90%]
Kindle, Nook Discount	24.39	16.26	25.91	28.50	-5.93%
= 25%	[23.60, 25.14]	[15.73, 16.82]	[25.22, 26.60]	[27.95, 28.98]	[-6.51%, -5.41%]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 19: Market Shares by Reading Habit (Student Sample) (%)*

	With Reading Habit			No Reading Habit		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	30.05	19.44	30.55	21.37	18.15	25.35
	[28.48, 31.54]	[18.12, 20.85]	[28.95. 32.06]	[20.15, 22.53]	[17.32, 19.11]	[24.35. 26.42]
Kindle, Nook Discount	27.67	17.58	32.89	19.48	15.82	27.42
= 40%	[26.19, 29.11]	[16.43, 18.86]	[31.26, 34.42]	[18.17, 20.68]	[14.99, 16.72]	[26.34, 28.50]
Kindle, Nook Discount	26.64	16.83	33.88	18.64	14.90	28.27
= 35%	[25.16, 28.04]	[15.73, 18.09]	[32.23, 35.45]	[17.28, 19.85]	[14.06, 15.79]	[27.16, 29.34]
Kindle, Nook Discount	24.89	15.63	35.52	17.25	13.49	29.60
= 25%	[23.46, 26.28]	[14.59, 16.80]	[33.88, 37.15]	[15.80, 18.46]	[12.60, 14.40]	[28.45, 30.69]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 20: Market Shares by Reading Habit (Random Sample) (%)*

	With Reading Habit			No Reading Habit		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	32.95	20.84	26.82	19.07	15.98	20.09
	[32.01, 33.98]	[20.01, 21.69]	[25.91. 27.77]	[18.30, 19.85]	[15.24, 16.76]	[19.38. 20.87]
Kindle, Nook Discount	31.99	19.63	28.10	18.36	15.04	20.73
= 40%	[31.00, 32.07]	[18.84, 20.52]	[27.15, 29.08]	[17.58, 19.11]	[14.31, 15.79]	[20.02, 21.50]
Kindle, Nook Discount	31.48	19.12	28.69	18.02	14.63	21.02
= 35%	[30.50, 32.55]	[18.35, 20.04]	[27.73, 29.71]	[17.24, 18.78]	[13.89, 15.39]	[20.30, 21.80]
Kindle, Nook Discount	30.49	18.26	29.74	17.40	13.96	21.53
= 25%	[29.43, 31.60]	[17.51, 19.20]	[28.77, 30.82]	[16.57, 18.26]	[13.21, 14.71]	[20.79, 22.33]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 21: Market Shares by Piracy Experience (Student Sample) (%)*

	With Piracy Experience			Without Piracy Experience		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	25.12	17.75	30.01	24.08	18.95	25.98
	[23.55, 26.76]	[16.38, 19.11]	[28.47. 31.78]	[22.90, 25.16]	[18.22, 19.77]	[25.00. 27.05]
Kindle, Nook Discount	23.12	15.61	32.38	22.00	16.77	28.06
= 40%	[21.61, 24.66]	[14.36, 16.82]	[30.77, 34.31]	[20.74, 23.11]	[16.07, 17.52]	[27.03, 29.15]
Kindle, Nook Discount	22.23	14.77	33.35	21.09	15.91	28.92
= 35%	[20.75, 23.77]	[13.56, 15.97]	[31.70, 35.30]	[19.81, 22.20]	[15.21, 16.62]	[27.88, 30.03]
Kindle, Nook Discount	20.76	13.45	34.89	19.55	14.56	30.32
= 25%	[19.29, 22.25]	[12.24, 14.69]	[33.13, 36.92]	[18.27, 20.66]	[13.87, 15.29]	[29.24, 31.44]

* The 5th and 95th percentiles of the estimates are reported in brackets.

Table 22: Market Shares by Piracy Experience (Random Sample) (%)*

	With Piracy Experience			Without Piracy Experience		
	Kindle	Nook	iPad	Kindle	Nook	iPad
Current	24.03	16.86	23.57	26.64	18.69	23.70
	[21.51, 26.78]	[14.95, 18.99]	[21.31. 25.86]	[25.95, 27.38]	[18.11, 19.29]	[23.02. 24.40]
Kindle, Nook Discount	22.99	16.26	24.53	25.81	17.57	24.68
= 40%	[20.38, 25.84]	[14.42, 18.42]	[22.15, 26.99]	[25.10, 26.51]	[17.01, 18.17]	[23.97, 25.38]
Kindle, Nook Discount	22.54	16.02	24.96	25.38	17.09	25.12
= 35%	[19.87, 25.42]	[14.16, 18.16]	[22.51, 27.41]	[24.64, 26.08]	[16.54, 17.69]	[24.42, 25.84]
Kindle, Nook Discount	21.77	15.63	25.72	24.56	16.30	25.92
= 25%	[19.02, 24.89]	[13.74, 18.00]	[23.20, 28.28]	[23.75, 25.29]	[15.74, 16.89]	[25.19, 26.67]

* The 5th and 95th percentiles of the estimates are reported in brackets.