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A Quantitative Analysis on E-Books Sampling Optimization

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Abstract

E-book sales have seen a slow growth in recent years. A major issue is how to attract consumers and promote sales. Motivated by the marketing strategy of free sampling, retailers start to offer free partial sampling of e-books. We propose a quantitative model for retailers to optimize the selection of e-books for sampling in their promotion campaign with a limited budget. Simulation-based numerical analysis shows that our model increases retailers' profit by around 8% when the free partial sampling strategy can double the e-book demand. We also develop a dynamic programming model to help retailers better utilize a budget in relatively long period of time. An experiment analysis reflects an improvement of retailer's profit of around 7%. Our model can be extended to other information goods such as digital music, video, and newspaper.

Keywords: E-book, Sampling, Information goods, Optimization, Dynamic programming

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1 Introduction

Publishers and retailers have seen an increase in e-book sales although the publishing industry on the whole is faced with a slower pace of growth as well as a grim forecast for the near future. Based on the combined data from both International Digital Publishing Forum [20] and AAP (American Association of Publishers) on e-book sales from year 2002 to 2014 (see Figure 1), we are able to see that there is an obvious trend of rapid growth in e-book sales. According to the data from Association of American Publishers (AAP), the total e-book sale in 2014 is $1.519 billion. The increase is almost 5 percent, or $70 million, up from $1.449 billion in 2013.

Multiple reasons are given to explain the growing trend of e-book sales. From the point of view of consumers, e-books have the following advantages over print books [8], [17], [22]: (1) convenience of reading, especially when traveling a long time; (2) easiness to carry a large number of e-books; and (3) relatively low price compared to print books. From the point of view of retailers, e-books are relatively easy to distribute to a critical mass of consumers. In addition, as retailers continue to improve e-book technology, services such as automatic bookmark, search functions, and personal library, etc. have been provided to e-book consumers, making e-book reading more comfortable.

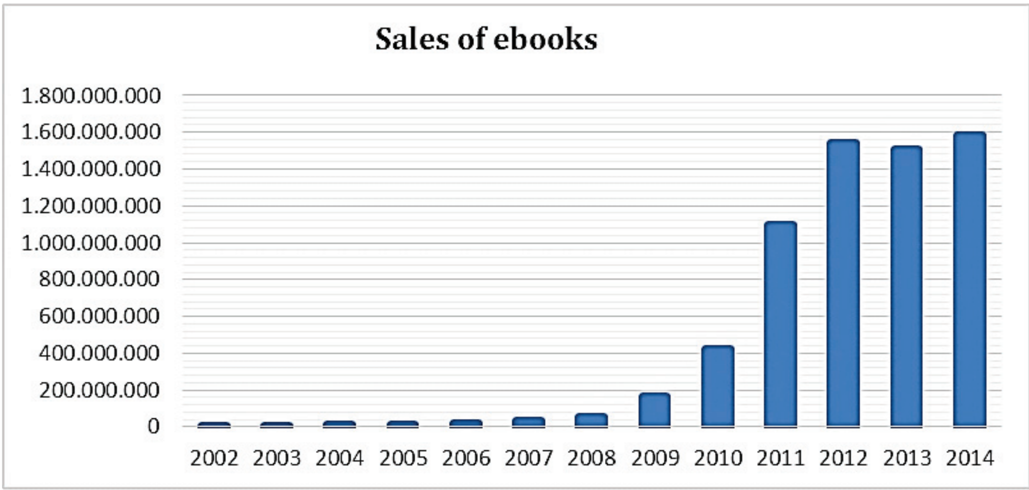

Figure 1: E-book sales in US
Source: International Digital Publishing Forum (IDPF) and American Association of Publishers (AAP)

However, the growth rate of e-book sales is getting slower in recent years. It is estimated that the growth rate of the sales of e-books will drop to single digit [16]. Figure 1 also shows that there is only a very small increase in the percentage in e-book sales in 2014. A recent AAP report showed that eBooks were down 11.1% in 2015, with most of the decline coming from Children/YA books (44.8%) [1]. To further boost the sales of e-books, retailers have implemented multiple strategies including introducing new e-book reading devices such as new version of Amazon Kindle or Tablet, enlarging the list of e-books available to readers who use smart phones and pads, encouraging more independent writers who want to build their reputation to publish e-books (e.g. Amazon Kindle Direct Publishing program), and distributing coupons and discounts, etc.

Recently, retailers started a new promotion strategy: providing free partial samples of e-books. Compared with the strategies mentioned above, free partial sampling has two advantages. First, this strategy helps consumers reduce the degree of uncertainty. Books are, in essence, experience goods. Consumers with no idea about the quality of experience products are often reluctant to buy them. Jain et al. found that free-sampling is an effective method to promote new products when consumers do not have direct experience with the products [21]. Providing partial samples, such as the first chapter of a book, gives consumers better knowledge of the e-book, and helps them decide whether to buy it or not. Hu et al. also showed that sampling increases digital music sales [19]. Second, free partial sampling allows retailers to still have the possession of the e-books. In the free sampling of physical goods, the retailers will lose the control of the sampled products after they are sent out. With development in information technologies, retailers have more flexibility in deciding which part of the book to post as a free sample and how long the free sample will be offered to consumers, which changes the traditional consumption model from “buy and try" to “try and buy" [27]. There are several applications of e-book sampling in the market already (see Table 1).

Table 1: Example of e-book partial sampling applications

	iBooks	Smashwords	Kindle direct publishing
Retailer	Apple Inc.	Smashwords, Inc.	Amazon Inc.
Reading device	Apple iphone & Touch	Apple iphone, Amazon Kindle	Directly on the Website, Amazon Kindle
Free partial sampling strategy	Allow readers to get free samples of books such as the first chapter.	Sample most Smashwords eBooks for free.	Allow readers to read 10% of the e-book content before buying it.

Online music retailers often offer full samples of songs online for consumers to listen to before they buy them [26]. However, unlike online music which will be listened to repeatedly by consumers, many e-books such as romantic might only be read once. A full sampling of those books will probably result in loss of sales. In addition, the digital music sampling can control the quality of the sample. However, we haven't observed this strategy in e-book sampling.

To make full use of free partial sampling to stimulate sales of e-book, retailers need to decide which e-books for free sampling. On one hand, retailers' resources are limited. Jain et al. argue that firms need to determine the optimal level of sampling for new product diffusion [21]. They cannot afford to offer free samples for all e-books they have with the limited budget. On the other hand, retailers might not need to offer free sample for popular e-books with high demand such as best sellers. Therefore, the retailers will benefit if they can find the optimal selection of e-books with a budget constraint. However, little research has been done on the issue of optimization of online free partial sampling of e-books.

Our research aims to help retailers to model the optimal selection problem. Burmestera et al. studied how firms can reduce unlicensed content by optimizing timing and the pricing strategies [7]. However, our study focuses on retailers' decision on optimization of partial sampling promotion. More specifically, we want to answer the following research questions: (1) What is the optimal way of selecting e-books for free partial sampling given the retailers' budget constraint? (2) What is the optimal way to use the resources for e-book sampling in a dynamic setting? To answer the first question, we set up a mathematical model to optimally select e-books for free partial sampling under a budget constraint. For the second question, we develop a dynamic programming model to decide the optimal sampling strategy in multiple time periods. Our simulation results show that our model can increase the profits of e-book retailers in both cases.

Prior research of information goods sampling, such as digital music sampling often uses experiments to get consumers' feedback or empirical analysis to analyze impact of certain factors on music sales [11], [26]. For example, Tu and Lu [26] used experiments to collect consumer's preference on the four sampling strategies of online music retailers. Using a data set from leading music blog aggregator, Dewan and Ramaprasad [11] studied the relationship between music blogging and the sampling. However, our study focuses on retailers' decision to maximize the retailer's profits by using free partial sampling of e-books. Since we do not aim to collect consumers' feedback or study the impact of certain factors, both experiments and empirical analysis don't fit our research. Therefore, it is natural to use an optimization approach.

The rest of the paper is organized as follows. We provide a comprehensive review of related literature in Section 2. Section 3 introduces our mathematical programming model of e-book partial sampling and discusses its properties. We then use simulation-based numerical analysis to evaluate the performance of our model. In section 4, we establish a dynamic programming model to allocate resources for e-book sampling and present results of related numerical analysis. We conclude with discussions of our contributions and directions of future research in section 5.

2 Literature Review

Our study is based on research that has been already done on the strategy of free sampling. Heiman et al. proposed an analytical model to derive the optimal sampling strategy [18]. In their model, the effect of sampling was decomposed into a long run effect (goodwill building) and a short run effect (immediate sale). Their research showed that the short term cost of sampling can be compensated by long term goodwill building. Bawa and Shoemaker developed a model of free sampling and conducted two field experiments on free samples [4]. They reported that free samples were highly effective in increasing sales over a long period of time. However, this research focused only on sampling of physical products rather than digital goods such as e-books.

In terms of sampling of digital good, Tu and Lu found that consumers' evaluation of music could be increased by higher quality of digital music sampling [26]. Wang and Zhang believed that free sampling of information goods would benefit a monopolistic seller even if the free samples are from third parties [27]. Dewan and Ramaprasad studied online music sampling on blogs [11]. Their results showed that the intensity of music sampling has a positive relationship with the popularity of the blogs, and this association has a strong tail effect. Our research differs from those studies in two aspects. First, we focus on the free partial sampling of e-books. Partial sampling is more favorable considering the nature of books, and the property of e-books makes it possible for retailers to carry out

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partial sampling promotions. Second, we use an optimization approach rather than an economic modelling or an experimental approach which is frequently used in the papers mentioned above. We don't use experiment approach because this method is often used to capture consumer's attitude toward sampling [26]. The economic modeling approach, on the other hand, usually studies whether the retailer should offer free sample [27]. However, our study aims to help the retailer implement the free sampling strategy.

Our study also drew insights from previous works in the literature of information goods. In a broad sense, e-book is one type of information goods whose content is consumed in digital format similar to digital music, videos, and software products [2], [15]. Prior research has frequently studied issues of information goods such as sharing [2], bundling [3], [15], pricing [10], [17], [23] competition [13] and versioning [5]. However, few research has paid much attention to the optimization of free partial sampling.

Different from previous research on the study of e-books from the aspect of copyright [25], higher education [24], online sales [6], reader's attitude [8], and the DIY textbook publishing [14], our study focuses on free partial sampling of e-books as a promoting strategy which is new to the publishing industry. What distinguishes our study is that we are interested in how retailers can use this strategy to maximize their profits with a limited budget. The research discussed above covered different aspects of our study, however, to the best of our knowledge, the issue of optimization of partial sampling of e-books has not been studied before.

3 Model

In this section, we developed a quantitative model for an e-book retailer based on the conceptual framework of partial sampling discussed in the previous section. We assume this retailer has a large number of e-books for sale. While free partial sampling usually results in an increase in demand, it will bring a certain level of cost as well. We aim to incorporate only the key variables that will directly influence the retailer's profits, including mainly the price, the cost, and the effect of partial sampling promotion. Since each book varies in terms of price, cost, and effect of partial sampling promotion, it is necessary to decide which books should be selected for the promotion. This model highlights a retailer's selecting of e-books for free sampling given the budget constraint.

While we agree that attributes such as e-book newness and length might also influence retailer's e-book sampling, such indirect influence will be represented by variables like effect of partial sampling promotion. Therefore, we haven't included these attributes in our model. This also helps us control the size of the problem. For e-books which do not provide any sampling, we assume that the demand will be lower than that for those with partial free sampling, which is consistent with previous literature [27].

We use *i* as the index of levels of free partial sampling, and *j* as the index of e-books. We assume that the demand of an e-book is a function of price p_{ij} and the partial sampling strategy. For a retailer who has *m* books and *n* levels of different sampling strategies, our model is as follows:

Objective Function:

$$\mathrm{Max}\ \pi = \sum_{i=1}^{m}\sum_{j=1}^{n}\pi_{ij}x_{ij} = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[d(p_{ij},x_{ij})p_{ij} - c_{ij}\right]x_{ij} \tag{1}$$

Subject to:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}c_{ij}x_{ij} \le B\ (\text{Budget constraint}) \tag{2}$$

$$\sum_{i=1}^{m}x_{ij} \le 1(\text{Constraint of only one level of free sampling}) \tag{3}$$

The decision variable is $\boldsymbol{x_{ij}}$, where
$\boldsymbol{x_{ij}=1}$, e-book *j* is chosen for free partial sampling level *i*
$\boldsymbol{x_{ij}=0}$, otherwise

In other words, we want to maximize the retailer's profits by applying only one level of free sampling promotion subject to the resource availability constraint. We assume that retailers can have a fairly accurate estimate of the profit $\boldsymbol{\pi_{ij}}$ and the cost of each book $\boldsymbol{c_{ij}}$ based on historical data. Please note that this problem can be reduced to a traditional *knapsack* combinatorial optimization problem and potentially very difficult to solve computationally, especially when the size of the problem is large [9]. This matches our research setting because retailers usually have hundreds or thousands of e-books to sell.

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3.1 Numerical Analysis

In this sub-section, we use the method of simulation to make a numerical analysis. We choose simulation for two reasons. First, as mentioned earlier, the problem of e-book selection for partial sampling is an NP problem which is hard to solve in polynomial time. Second, simulation is an effective tool for analysis of non-linear phenomenon such as different demand functions of e-books. Useful insights often show up from results of stimulation [12].

The simulation process is as follows:

- Step One: We randomly assign prices to 200 e-books following a uniform distribution U [0, 100]. Millcitypressing (Site 1) shows that the key factor of the e-book cost the royalty percentage for e-book authors with general retailers are roughly 35% to 40%, and 70% from large retailers such as Amazon, Barnes & Noble, and Apple. Therefore, we set that the cost of an e-book follows a uniform distribution of [50%, 60%] of the book prices, which is close to the business practice in reality. We use the form of Demand =Log (Price)*100 to model a non-linear concave demand function, which is often used in numerical analysis simulation.

- Step Two: To capture the relationship between the free partial sampling of e-books and the demand, we model that the e-book demand will increase from sampling promotion by 20%, 40%, 60%, 80% and 100% respectively after the free partial sampling strategy is implemented. For example, in the case of 20%, we assume that the e-books which offer free partial sampling will increase the demand by 20%. The values of partial sampling promotion effect are chosen for illustration purposes, because there is a lack of industry reports or survey on the partial sampling promotion effect. This is often used in simulation when estimate in business practice is difficult to get [21]. Additionally, we make them in a reasonable wide range in our numerical analysis.

- Step Three: For each level of partial sampling promotion effect on the e-book demand in step two (20%, 40%, 60%, 80%, and 100%), we use our model to calculate e-book retailer’s profit based on the e-book prices, the cost, and the partial sampling promotion effect of demand and record the value.

- Step Four: We use the greedy approach as the benchmark of our numerical analysis. By greedy approach, our computation on the retailers’ profit is based on the first N books (N<= 200) within the budget which are selected to provide free partial sampling. We compare our results with the benchmark results.

Figure 2 presents the results of 200 rounds of simulation. From our results, we have seen that as the demand increases with free partial sampling promotion effect, our model generates more profits for the e-book retailers. If the free partial sampling doubles the demand, our model increases the retailer’s total profit by almost 8%. Given the fact that retailers usually have hundreds or thousands of e-books to sell online, this can be seen as a significant improvement. In addition, our assumptions are conservative and with a larger size of e-books and consumers in the market, the increase in retailers’ profits is likely to be more lucrative.

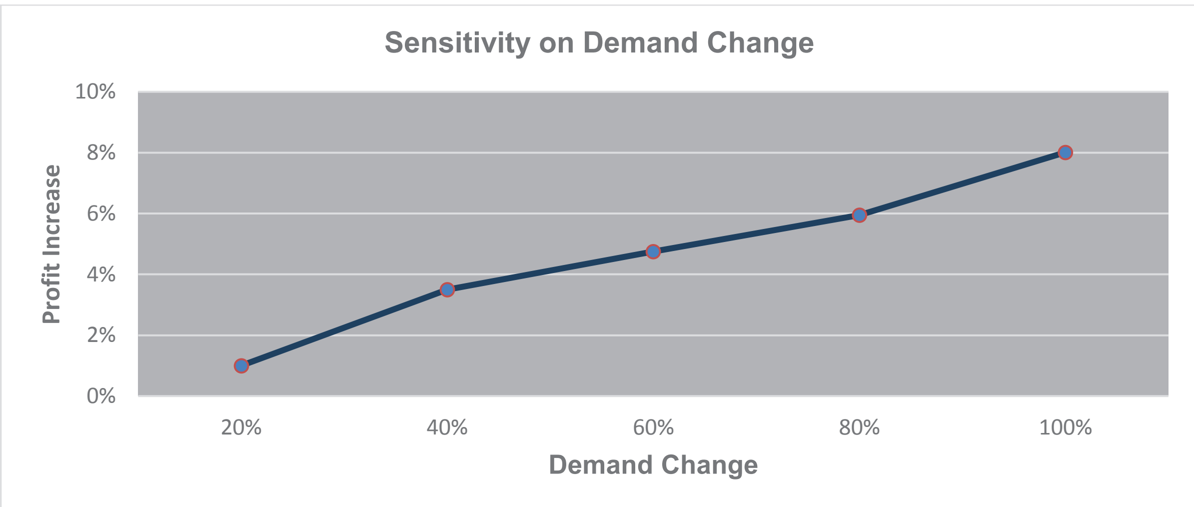

Figure 2: Simulation results

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4 Partial Sampling in Dynamic Setting

In the previous section, we assume that retailers keep one level of free partial sampling for a short period of time. In real business practice, however, retailers might have multiple levels of sampling strategy over time. For example, a retailer can set a high percentage partial sampling like 25% level, a low percentage partial sampling like 10% level, and no sampling. As discussed earlier in the paper, a larger partial sampling may attract more consumers but is also followed by a higher cost. It might be the case that a larger partial sampling in the current period will lead to insufficient resources to hold for even a lower percentage sampling in later periods.

To help retailers find out the optimal allocation of resources in a relatively long period of time, we develop a dynamic programming model in this section. We assume that the price of e-books remains the same in this time period. We make the assumption of stable e-book prices for two reasons. First, while many retailers such as Amazon lowered print book prices from time to time, we haven't observed retailers frequently lowering their e-book prices in practice. One explanation may be that the retailer initially set print book prices with a large space for price dropping, but not for e-book prices. Second, this assumption allows us to focus on the demand of e-book which simplifies the model.

Similar to the model in previous section, we want to incorporate only the key variables that will directly influence the retailer's profits, including mainly the demand, the cost, and the remaining budget per time period. While we agree that attributes such as e-book author's reputation and e-book type might also influence retailer's e-book sales, their influence are mainly incorporated indirectly in variables such as demand per time period. Therefore, we haven't included these attributes in our model. This also helps us control the size of the problem.

The following is the list of notation we use in the model:
K refers to the levels of partial sampling percentages, such as 10%, 25%, etc.
c_i, *i* = 1,..., *K* refers to the cost related to the *kth* partial sampling percentage, and c_i is monotonically decreasing $c_1 > c_2 > \cdots > c_K$.
D_t, *t* = 1,...,*T* refers to the demand in each time period *t*.
B_t *t* = 1,...,*T* refers to the remaining budget at the beginning of period *t*
T refers to the number of time periods.

We formulate dynamic partial sampling as follows:

$$\mathrm{f}_{\mathrm{t}}^{\mathrm{T}}(\mathrm{B}_{\mathrm{t}}) = \mathrm{Max}\{\mathrm{D}_{\mathrm{t}} + \mathrm{f}_{\mathrm{t}+1}^{\mathrm{T}}(\mathrm{B}_{\mathrm{t}} - \mathrm{c}_{\mathrm{i}}\mathrm{D}_{\mathrm{t}})\} \tag{4}$$

where $f_t^T(B_t)$ refers to the cumulative demand from time period *t* to the end period *T* .

Boundary conditions

$$\mathrm{f}_{\mathrm{T}}^{\mathrm{T}}(\mathrm{B}_{\mathrm{t}}) = 0, \forall \mathrm{B}_{\mathrm{t}} \geq 0; \tag{5}$$

$$\mathrm{f}_{\mathrm{t}}^{\mathrm{T}}(0) = 0, \forall \mathrm{t} \geq 0. \tag{6}$$

In other words, we want to maximize the total demand for the retailer given a limited budget. Based on historical data of e-book sales, we assume that the retailer is able to have a fairly accurate estimate on the e-book demand and the cost of free sampling promotion.

4.1 Experiment Results

To illustrate the application of our model, we report here a simulation-based experimental analysis in the dynamic framework of multiple level of partial sampling of e-books. We aim to investigate the performance of dynamic partial sampling. The simulation process is as follows:

- Step One: We set the percentage level of free partial sampling as 10%, 15%, 20%, 25% and 30%. According to Smashword (Site 2), on average, the sampling percentage is 20%. Therefore, we have the partial sampling percentage from 10% to 30%. We do not choose a very high percentage because we believe that offering an extremely high percentage of sample reading such as 90% is a risky strategy, just like giving a whole e-book to consumers for free, and consumers may not consider purchasing the e-book after reading the most part of it. Additionally, we haven't seen extreme high sampling in practice.

- Step Two: We assume that the demand of e-books follows an exponential distribution with initial demand 100. The exponential distribution is commonly used in simulations [9].The deprecation rate of demand is 0.2. We set the cost for the five percentages in step one as 0.1, 0.2, 0.3, 0.4, 0.5 respectively. We do not have the exact same value of cost over sampling percentage because the marginal utility of providing more

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materials of the book may go down. The budget is set as 2000. These values in step two are chosen for illustration purposes, because there is a lack of industry reports or surveys on attributes such as cost over sampling percentage. This is often used in simulation analysis when it is difficult to estimate values in business practice [9], [21]. We also vary them on a reasonable range in our analysis.

- Step Three: Based on the five different sampling strategies described in step one (10%, 15%, 20%, 25% and 30%), we use our dynamic model to calculate the retailer's profits in the whole time period of partial sampling which is divided into 20 periods. This number of time periods chosen is consistent with literature [21]. We then record the values for each round.

- Step Four: Similar to the numerical analysis in sections 3.1, we also choose a benchmark case, which is the strategy of keeping providing the highest percentage of partial sampling under the same rate of depreciation. We compare our results with the benchmark results.

We run the simulation 200 times. Our results show that our dynamic sampling approach can increase the retailer's total profit by approximately 7.27%. While such increase does not seem promising for one book, our model will benefit the retailer significantly with large quantity sales online.

5 Conclusion and Future Research

The sales figure for e-books has obviously seen slow growth in recent years [1], [16]. Although retailers have adopted multiple strategies such as introducing new reading devices, involving more authors and offering coupons and discounts etc., the results are not satisfying. A new strategy of providing free partial sampling of e-books has been implemented recently. In this study, we present a quantitative model for e-book retailers to optimize free partial sampling strategy with a limited budget. Simulation results show that our model helps retailers increase the profit from e-book sales. We also develop a dynamic programming model for the e-book retailers to apply partial sampling over a relatively long period of time.

Our research provides theoretical and managerial implications in the following four ways. First, we add to the literature of free sampling promotion. Our research focuses on partial sampling of information goods e-books which is different from previous studies of physical products sampling. It is also different from other type of information goods sampling such as digital music sampling which often give the consumers the full length song as a sample with controlled quality. We haven't used experimental approach or economic modeling, which are widely used in prior research of information goods sampling because they don't fit our research purpose. We instead choose the best fitting research tool, the quantitative analysis approach, to help the retailer maximize its profits. Second, our study enriches the research of information goods by studying the free partial sampling strategy of e-books. Prior research has studied many other issues concerning e-books such as e-book sales [6], e-book pricing [17], [22], textbook publishing [24], and use of e-books in the higher education [25]. However, it has not paid enough attention to the promotion of e-book sales using sampling strategy. Our research has shown that partial sampling is an effective strategy for retailers to promote their e-book sales. Third, simulation based on our model shows that the partial sampling strategy works better when there is a strong correlation between sampling and increase of demand. Therefore, e-book retailers should focus on those books which may attract a large number of potential consumers after they read the sample chapters. Fourth, our study also reminds the retailers that they may consider several sampling strategies with different level of partial sampling. They can then dynamically allocate their resources by adjusting the sampling level over time. Although our research is only restricted to e-books, it can be extended to other types of information goods such as digital music, online videos, and online newspaper and magazines, etc.

We haven't incorporated the competition in our model because we want to focus on the retailer's sampling strategy. The competition will probably be of a Bertrand competition setting and the retailers will either provide more part of the book as free sample or decrease in price as the competition intensifies. Eventually, they will end up with completely free e-books and no revenue.

Our models have made several oversimplifications. First, we assume that there is no cost for the retailer if the e-books are not selected for sampling promotion. Second, we assume a non-linear demand function in log format, which might be too simple for reality. Third, we have considered only the case of fixed budget and the fixed e-book price in the Dynamic modeling setting. In addition, some values of attributes such as partial sampling promotion effect and cost of sampling in the dynamic model setting in the simulation are not based on real business data because there is a lack of industry reports on these attributes. Future research can consider extending our research by revising those assumptions.

There are several limitations in our study. First, we only considered the role of retailers in our model. In reality, it is possible that other participants such as publishers will also influence the retailer's sampling strategy. A natural extension is to study how retailers' strategies will change when publishers have their own sampling plans. Second, in our model we assume that free sampling will not substitute information goods. For example, digital music samples often featured limited sampling period, shortened length, downgraded quality, restricted portability, etc. Consumers will still buy the music after they listen to the sample. Future research may consider when and where the partial sampling may decrease the demand of e-books. Third, we have only briefly discussed the case of competition in our model, because we want to focus on the key research topic of retailers' sampling strategy. Adding competitors might lead to an overcomplicated model. However, it will be interesting to see what will happen when there are multiple competing retailers in the market.

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http://www.millcitypress.net

Site 2: Smashwords
http://www.smashwords.com

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