Strategic Market Analysis in an Electronic Service Market

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***Abstract*- The electronic-book (e-book) is one of the new technological changes that have significantly influenced the publishing industry in the last century. This has forced publishers to reconsider their distribution channels, since the Internet has provided a new means with which to serve readers. In this paper, a strategic market analysis is proposed from the perspective of a traditional publisher that needs to decide whether to switch to e-publishing business. The analysis framework determines the publishing market equilibrium in three different market scenarios. Besides, it shows the impact of readers' choices and price sensitivities on the profits of publishers. The proposed framework has its basis on game theory and it is built in an oligopoly setting to reflect the severe market competition. The readers' utilities and demands are modeled using the multinomial logit model. Although the first scenario possesses a global optimum solution, in the remaining two market scenarios genetic algorithms are used in order to find the sub-optimal solutions of the oligopolies.**

Keywords*- *distribution channel; multinomial logit model (MNL); game theory; genetic algorithm

I. INTRODUCTION

Traditionally, the term "publishing" refers to the distribution of printed works such as books and newspapers. With the advent of digital information systems and the Internet, the scope of publishing has expanded to include electronic resources, such as the electronic versions of books and periodicals, as well as micropublishing, websites, blogs or video games. In this work, an electronic book (e-book) will be considered as the digital version of a traditional printed book (p-book) to be read digitally on a personal computer, handheld computer, PDA or a dedicated e-book reader. It has been estimated that e-book sales will account for 50% of the publishing industry's sales by 2020 and 90% by 2030 [1].

In this paper, a strategic market analysis framework in a publishing market is proposed in the presence of multiple competing publishers. The proposed publishing market consists of p-publishers (publishers of p-books) that try to decide on whether or not switch to e-publishing (publishing e-books). In this environment, a p-publisher is assumed to face three market scenarios, presented in sub-section 2.2. In each scenario, the publishers' decision variables are their offered unit prices. There are two types of prices for an e-publisher: A price for its traditional retail channel and a price for its electronic/Internet channel, while there is only the traditional retail price for a p-publisher. The traditional channel and Internet channel of a publisher are distinguished based on two features: the stocking and maintenance costs and price sensitivity of readers. It is assumed that readers will be more sensitive towards price, when they intend to buy a book from an electronic channel.

The proposed framework computes the unit prices, and accordingly the profits of the publishers in each market scenario. Since the publishers need to make their decision in an uncertain market environment, the customer utility and demand are modeled using the multinomial logit model (MNL), which is based on probabilistic theory, by assuming that a customer has also a no-purchase alternative. For each scenario, a non-cooperative pricing game is built, whose players are the publishers. Solving the game, the mutual best response strategies that determine the equilibrium point(s) are studied. With the optimum prices, the publishers calculate their expected demands and expected profits. For the first scenario, the equilibrium prices and profits are global optimum, since the profit maximization problem is proved to be convex. However, the maximization problems of the second and the third scenarios cannot be proven to be convexes, hence their optimum solutions are found using a type of local search algorithm: the genetic algorithms (GA). A genetic algorithm is an evolutionary optimization approach which is most appropriate for complex non-linear models where finding the location of the global optimum is a difficult task [2]. GA utilize a population of solutions in the search, rather than handling one feasible solution like in other local search methods, such as Simulated Annealing or Tabu Search. GA have good performance in large and complex search spaces, since they explore and exploit simultaneously the search space. They do not guarantee global optimality even it may be reached.

The rest of the paper is organized as follows. Section 2 discusses the related work in the literature and their differences from this one. In Section 3, the formulation of the model, three possible market scenarios and their demonstrative examples are given in detail. The results are discussed at the end of the Section 3. Finally, conclusions and future work are given in Section 4.

II. Related work

In literature, the GA have been applied frequently as a part of decision support systems. In one of the recent works, the authors have used genetic algorithms in identifying the optimal parameters for water resource modeling applications. Moreover, they have optimized the genetic algorithm model parameters [3]. In literature, it is possible to encounter the use of GA into the game theory-based models. These works are from various research areas. Riechmann [4] has shown that economic learning via GA can be described as a specific form of an evolutionary game. In his paper, he has pointed out that GA learning results in a series of near NE. In another research, the authors have discussed a new evolutionary strategy for the multiple objective design optimization of internal aerodynamic shape [5]. They have claimed that game theory replaces a global optimization problem by a non-cooperative game based on Nash equilibrium with several players solving local constrained sub-optimization tasks. The authors have stated that game theory is not only the primary method for the formal modeling of interactions between individual, but it also underlies how biologists think about social interactions on an intuitive level [6]. In their work, they have used GA as an alternative method of searching evolutionary stable sets in a well-studied game of biological communication. In a sense, the point of view in this work resembles to the one in the proposed framework in this paper, since GA are used to search the market equilibrium points in games for three different market scenarios.

There are numerous research in the literature on the adoption of e-books and e-publishing; however this paper's concern is a more specific area. The concentration is on the economics and management aspects of e-publishing. The most relevant research are as follows: Jiang and Katsamakas examine how the entry of an e-book seller affects strategic interaction in the book markets and impacts sellers or consumers [7]. Their work is a good example of the application of game theory in analyzing the market asymmetries. The research of Hua et al., has the same research question as the one in this paper [1]. In their research, the authors derive the conditions under which a publisher should sell only p-books, only e-books, and both of them simultaneously. They use the newsvendor model to analyze demand behavior; whereas the demand is modeled using MNL model in this paper. As the demand varies linearly on offered price, they can determine the closed-form expression of optimum prices. In this paper, the problems are solved using nonlinear techniques. Bernstein et al. use the MNL model for the equilibrium analysis of retailers [8]. They differentiate retailers' choices as "bricks-and-mortar" and "clicks-and-mortar", which represent the traditional retail channel and Internet channel, respectively. Their study has some common grounds with the one in this paper, since they analyze the supply chain channel structure choice in an oligopoly setting.

III. The model formulation

An n-firm oligopoly setting is considered to study the structure of the game [9]. In the proposed game, the publishers that sell their books through a retail store (*p-publishers*) want to reach more reader by publishing their books on an Internet channel (*e-publishers*). The *e-publisher*$_i$ will continue to sell its books on the retail stores, hence it has to define two different prices: a unit retail price p_i for its traditional channel and a unit online price p_{ei} for its Internet channel. The *p-publisher*$_i$ needs to define only its unit retail price p_i. As the stocking and maintenance costs of an e-book are assumed to be lower than the ones of a traditional book, the following assumptions on the prices are set: $p_{ei} \leq p_i$. $A = \{1, 2, \ldots, n\} \cup A_0$ denotes the set of publishers.

A. Customer Utility Model

A reader is assumed to derive a different utility when obtaining the book from a retailer's physical store (alternative i) than obtaining it in an electronic form (alternative ei). Furthermore, a reader is assumed to have a no-purchase alternative (A_0). In other words, if s/ he does not like any offer, s/ he will not buy any book. Then, the set of alternatives is $A^P = \{1, 2, \ldots, n\} \cup A_0$ when all the publishers sell from their retail stores, while it is $A^E = \{1, e1, 2, e2, \ldots, n, en\} \cup A_0$ when all publishers sell both from their retail stores and their online stores. It is also possible to have a case with k e-publishers and $(n\text{-}k)$ p-publishers, then the set of alternatives is $A^{EP}(k) = \{1, e1, \ldots, k, ek, k{+}1, \ldots, n\}$.

The customer utility is modeled using the multinomial-logit model (MNL). The MNL model is one of the random-utility models that are based on a probabilistic model of individual customer utility [10]. Let us assume that a customer has a utility for alternative i, denoted U_i. The probability that a customer selects alternative i from a subset A of alternatives is given by:

$$P_i(A) = P\left(U_i \geq \max\left\{U_j : j \in A\right\}\right) \quad (1)$$

If we assume that $u_1 = -bp$, this gives the following demand function:

$$d(p) = M \frac{e^{-bp}}{1+e^{-bp}} \quad (2)$$

where M is the market size and b is a coefficient of the price sensitivity. In the multiple-product case, by considering each user of the same type (b_i=b), the demand function of *publisher*$_i$ is given by:

$$d_i(p_1, p_2, \ldots, p_n) = M \frac{e^{-bp_i}}{1+\sum_{j=1}^{n} e^{-bp_j}},\ i = 1, \ldots, n \quad (3)$$

The MNL probability that a customer chooses product j as a function of the vector of prices p = $\{p_1, p_2, .., p_n\}$ is then given by:

$$Prob_j(\mathrm{p}) = \frac{e^{-bp_j}}{1+\sum_{i=1}^{n} e^{-bp_i}} \quad (4)$$

B. Choice of Channel Structure

In the proposed strategic analysis, each p-publisher that has an incentive to publish its books on an electronic environment, in other words that has an incentive to move to e-publishing business, faces three marketing scenarios:

1. *P-P competition*: All publishers in the market are p-publishers.
2. *E-P competition*: Some publishers remain as p-publishers, but the rest moves to e-publishing.
3. *E-E competition:* All publishers in the market are e-publishers.

The list of notation for the equilibrium analysis under different scenarios can be given as:

p_i^{PP} : Equilibrium price of *p-publisher*$_i$ under P-P competition,

p_i^{EP} : Equilibrium price of *p-publisher*$_i$ under E-P competition,

p_{ei}^{EP} : Equilibrium price of *e-publisher*$_i$ under E-P competition,

p_i^{EE} : Equilibrium price of *p-publisher*$_i$ under E-E competition,

p_{ei}^{EE} : Equilibrium price of *e-publisher*$_i$ under E-E competition,

$\prod_i^{PP}$: Equilibrium profit for *p-publisher*$_i$ under P-P competition,

$\prod_i^{EP}$: Equilibrium profit for *p-publisher*$_i$ under E-P competition,

$\prod_{ei}^{EP}$: Equilibrium profit for *e-publisher*$_i$ under E-P competition,

$\prod_{ei}^{EE}$: Equilibrium profit for *e-publisher*$_i$ under E-E competition.

1) Scenario I: P-publisher vs. p-publisher (P-P Competition)

In this scenario, the set of alternatives for readers is $A^P = \{1, 2, ..., n\} \cup A_0$. All p-publishers simultaneously set their prices. Each p-publisher's aim is to define its optimum price (p_i^{PP}) in the given market environment that maximizes its profit:

$$\max_{p_i^{PP}} \left(\Pi_i^{PP}\right) = \max_{p_i^{PP}} \left(p_i^{PP} - c_i\right)\left(M.\frac{e^{-b.p_i^{PP}}}{1+\sum_{t=1}^{n} e^{-b.p_t^{PP}}}\right) \quad (5)$$

$$\text{s.t. } p_i^{PP} - c_i \geq 0, \quad \forall i$$

$$p_i^{PP} \geq 0, \quad \forall i$$

where b is the price elasticity and c_i is the unit cost of *p-publisher*$_i$. The probability that *p-publisher*$_i$ with the price p_i^{PP} is chosen by a customer is given as:

$$\mathrm{Prob}_i^{PP} = \frac{e^{-b.p_i^{PP}}}{1+\sum_{t=1}^{n} e^{-b.p_t^{PP}}} \quad (6)$$

The first order condition of the choice probability with respect to its price ($\partial \mathrm{Prob}_i^{PP} / \partial p_i^{PP}$) is negative, which means that the price increase of a *p-publisher*$_i$ reduces its own demand; whereas the first order condition with respect to its competitor's price ($\partial \mathrm{Prob}_i^{PP} / \partial p_t^{PP}$), $i \neq t$ is positive, which means that the price increase of the competitor's price increase the demand of *p-publisher*$_i$. As p-publishers determine their prices simultaneously, they need to consider the competition, i.e., the prices offered by other p-publishers in their market. The problem is modeled as a game where the *players* are the p-publishers, the *strategies of the players* are their offered unit prices and the *payoffs of the players* are their profit functions. Solving such a game means predicting the strategy of the publisher. One can see that if the strategies from the players are mutual best responses to each other, no player would have to deviate from the given strategies and the game would reach a steady state. Such a point is called the Nash equilibrium (NE) point of the game [11]. In the game, p-publishers determine their prices independently and the information is strictly limited to local information. Hence, the game has a non-cooperative setup. Global optimality conditions are used in order to analyze the existence and the uniqueness of the equilibrium point. The constraints in the proposed problem (5) are linear, so they are convexes. Therefore, the vector $\mathrm{p} = \left[p_1^{PP}, p_2^{PP}, .., p_n^{PP}\right]$ denotes the solution (the NE) of this game with: $p_i^{PP} = BR_i\left(\mathrm{p}_{-i}^{PP}\right)$, where p_{-i}^{PP} represents the vector of best responses of all *p-publisher*$_t$, $t \neq i$. The NE is the point that solves the set of equations: $\frac{\partial \Pi_i^{PP}}{\partial p_i^{PP}} = 0, \forall i$. It is also the global optimum of the given problem.

This scenario is demonstrated on a simple but representative example with two p-publishers in the market. The target customer group is assumed to be consist of M=100 readers. The unit costs of two p-publishers *(c_1=c_2)*

are assumed to be the same and equal to 1. The price sensitivities in the readers' demand functions are differentiated in order to analyze the impact of readers' price sensitivities on the publishers' price determination. The price sensitivity of customers of p-publisher$_1$ (b_1) is taken as 1, whereas the one of customers of p-publisher$_2$ (b_2) is taken as 1.5. For the first scenario, the equilibrium price values and related demands and profits are given in Table 1. As the price sensitivity of the customers of *p-publisher$_2$* is set higher than the one of *p-publisher$_1$*, *p-publisher$_2$* offers a lower price (p_2^{PP}= 1.7123) in the equilibrium. The demand values in given tables are found using Eq. (3).

TABLE I. PRICE, DEMAND AND PROFIT VALUES AT EQUILIBRIUM IN SCENARIO 1

	Equilibrium values	
	p-publisher$_1$	*p-publisher$_2$*
Offered price	2.1123	1.7123
Profit	11.2342	4.5592
Demand	9.2907	13.8630
Total profit of p-publishers	15.7934	

2) Scenario II: E-publisher vs. p-publisher (E-P Competition)

In the second scenario, the first $k\left(1 \le k \le n\right)$ publishers are assumed to be move on e-publishing, whereas the remaining *n-k* publishers are stayed as p-publisher. The set of alternatives for consumers is $A^{EP}\left(k\right) = A^{P} \cup \{e1, e2, ..., ek\}$. In this scenario, *p-publisher$_i$* determines only one price (p_i^{EP}), but *e-publisher$_i$* determines both a price for its traditional channel (p_i^{EP}) and a price for its Internet channel (p_{ei}^{EP}). The p-publisher's price is assumed to be influenced from other p-publisher's prices, whereas the e-publisher's price is influenced from both other e-publishers' prices and from the price of its own traditional channel. In other words, if *e-publisher$_i$* increases its Internet channel price (p_{ei}^{EP}), the demand to its traditional channel increases. From this point of view, two channels of an e-publisher can be considered as "competing" [8]. Both type of publishers' aim is to define their optimum prices (p_i^{EP} and p_{ei}^{EP}) that maximize their profits. *P-publisher$_j$* wants to maximize its profit:

$$\max_{p_j^{EP}}\left(\Pi_j^{EP}\right) = \max_{p_j^{EP}}\left(p_j^{EP} - c_j\right)\left(M.\frac{e^{-b.p_j^{EP}}}{1+\sum_{t=k+1}^{n} e^{-b.p_t^{EP}}}\right)$$

$$\text{s.t. } p_j^{EP} - c_j \ge 0,\ j = k+1, k+2, ..., n \quad (7)$$

$$p_j^{EP} \ge 0,\ j = k+1, k+2, ..., n$$

On the other hand, the objective of *e-publisher$_i$* is to choose p_i^{EP} and p_{ei}^{EP} that maximizes its own profit: The first term of the profit function belongs to the profit earned from p-publishing, while the second term belongs to the profit earned from e-publishing. In the proposed model, the coefficient $\vartheta \ge 1$ is inserted to the demand function because an e-reader's sensitivity to price is assumed to be higher than the one of a p-reader. In this setting, it is not possible to derive closed-form expressions for the equilibrium prices, demands and profits. The convexity of the maximization problem in this scenario cannot be demonstrated. Therefore, the GA is used as a computing technique to find sub-optimal solutions. In the GA implementation, three different population sizes are utilized: 100, 125, 150. The profit functions of the publishers are used as fitness functions in order to decide the chromosome in the next generation. For the GA, the most frequently used stopping criterion is the specification of a maximum number of generations. In the GA implementation of the scenario, the maximum number of generations is defined as 250, which means that the algorithm terminates once the iteration number reaches 250. For each population size, the GA is run 50 times and the best result is chosen from these 50 results. The solutions have shown that the optimum solution does not depend on the initial population size in this scenario. The second scenario is demonstrated on an example with *e-publisher$_1$* and *p-publisher$_2$* in the market. For the second scenario, the equilibrium price values and related demands and profits are given in Table 2. The results at the equilibrium point confirm that the e-publishing price is lower than the p-publishing prices because of lower publishing costs. *E-publisher$_1$* reaches bigger market share, which is proportional to its total profit, since it offers two different publishing channels for different preferences.

TABLE II. PRICE, DEMAND AND PROFIT VALUES AT EQUILIBRIUM IN SCENARIO 2

	Equilibrium values		
	e-publisher$_1$		*p-publisher$_2$*
	e-publishing	*p-publishing*	*p-publishing*
Offered price	1.3839	1.7124	2.1426
Profit	14.0419		4.5729
Demand	9.6630	13.1912	9.9370
Total profit of publishers	18.6148		

3) Scenario III: E-publisher vs. e-publisher (E-E Competition)

In the last scenario, it is assumed that all n publishers in the market adopt e-publishing. The set of alternatives is then $A^{EE} = \{1, e1, 2, e2..., n, en\} \cup A_0$. All e-publishers determine two prices: A price for their traditional channel (p_i^{EE}) and a price for their Internet channel (p_{ei}^{EE}). Each e-publisher's aim is to define its optimum prices (p_i^{EE} and p_{ei}^{EE}) in the given market environment that maximizes its own profit:

$$\max_{p_i^{EE}, p_{ei}^{EE}} \left(\Pi_i^{EE}\right) = \max_{p_i^{EE}, p_{ei}^{EE}} \left(p_i^{EE} - c_i\right)\left(M.\frac{e^{-b.p_i^{EE}}}{1+\sum_{t=1}^{n} e^{-b.p_t^{EE}} + e^{-\vartheta b.p_{ei}^{EE}}}\right)$$

$$+\left(p_{ei}^{EE} - c_{ei}\right)\left(M.\frac{e^{-\vartheta b.p_{ei}^{EE}}}{1+\sum_{t=1}^{k} e^{-\vartheta b.p_{et}^{EE}} + e^{-b.p_i^{EE}}}\right)$$

$$\text{s.t. } p_i^{EE} - c_i \geq 0, \quad \forall i$$
$$p_{ei}^{EE} - c_{ei} \geq 0, \quad \forall i$$
$$p_i^{EE} \geq 0, \; p_{ei}^{EE} \geq 0, \quad \forall i \qquad (8)$$

The convexity of the maximization problem cannot be demonstrated, the sub-optimal solutions are computed using the GA. The unit costs of p-publishing and e-publishing are assumed to be the same for two e-publishers and they are set to 1 and 0.75, respectively. The equilibrium price values and related demands and profits are given in Table 3. Both e-publishing and p-publishing prices of *e-publisher*$_2$ are lower than the ones of *e-publisher*$_1$. The reason is that both types of readers (e-readers and p-readers) of *e-publisher*$_2$ are more sensitive to price than the readers of *e-publisher*$_1$. *E-publisher*$_2$ is obliged to hold its prices down in order to grab more readers.

TABLE III. PRICE, DEMAND AND PROFIT VALUES AT EQUILIBRIUM IN SCENARIO 3

	Equilibrium values			
	e-publisher$_1$		*e-publisher*$_2$	
	e-publishing	*p-publishing*	*e-publishing*	*p-publishing*
Offered price	1.3775	2.1349	1.3210	1.7446
Profit	13.3059		7.4673	
Demand	12.9251	6.9969	7.3918	7.5115
Total profit	20.7732			

Based on the numerical results of three demonstrative examples, it is possible to make some observations. The scenario where the sum of the profits of all the publishers in the market is maximum is the third one: the E-E competition. The E-E competition can be interpreted as the industry equilibrium. The results show that the coefficient of price sensitivity (b) is the fundamental factor that determines both types of price levels. As the price sensitivity of readers increases, publishers are obliged to decrease their prices in order to maintain more reader. In this sense, it is the reader that determines the price level. In the case *e-publisher*$_1$ is alone in the market (E-P competition), its demand and accordingly its profit are higher than in the competitive market (E-E competition). In the case there is at least one e-publisher in the market, the p-publisher loses profit. The p-publisher cannot reduce price like an e-publisher because of its higher maintenance and stocking costs. An e-publisher's profit reaches its maximum level, if its competitor is a p-publisher.

IV. CONCLUSIONS

With the proliferation of smart mobile phones, such as iPhone or Blackberry, or the dedicated e-readers, such as Kindle or Nook, more and more young readers are accustomed to reading the electronic versions of the books and magazines. This has an increasing effect on the adoption rate of e-publishing; however it creates a pressure on the publishers. Now, publishers need to analyze the market more deeply in order to maintain their customer base. The principle objective of this work is to propose a strategic analysis framework which would be valid for different types of decision environments by making slight modifications. The concentration is on the publishing industry, especially on a p-publisher that tries to decide on whether to enter the e-publishing business. However, the same decision support framework can help an existing firm when changing its business, or an existing firm to determine new prices, or a new entrant firm to determine prices. The framework is built on game theory basis, since a successful business strategy needs to consider the actions of other players in a competitive market. Using a local search algorithm, the GA, in order to find the equilibrium points of the games is the other contribution of this work. The numerical results have shown that GA can found similar results with a non-linear solver. The results have revealed that the price sensitivity of readers is the most fundamental parameter that affects both the choice of the reader and the price of the book. The higher the reader's price sensitivity is, the more the publisher tends to sell e-book to the reader.

Going forward, the equilibrium points may be found by using other soft computing algorithms and different algorithms can be compared in terms of obtained values and the execution time. Since the games are played offline in the proposed framework, the execution times are not questioned. The price sensitivity coefficient has a direct and profound impact on the equilibrium results, a future work can concentrate on determining it in the most efficient way. Some regression techniques can be useful in the presence of real life data.

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