

OPERATIONS RESEARCH APPLICATIONS IN ELECTRONIC COMMERCE: A LITERATUR REVIEW

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ABSTRACT

Widespread usage of computer and Internet in every sphere of daily life has contributed a strategic importance to electronic commerce (e-commerce). While improving quickly, e-commerce also creates different glamorous opportunities for Operations Research (OR). Commerce via Internet causes the transformation in OR-users. This transformation can be considered as more greater and untraditional format than before. In this study, a survey of OR applications in e-commerce is presented. In which areas of e-commerce OR practitioners are mostly active and how they are benefited from it are the main questions reviewed in this work. Meanwhile, why OR has a key role in digital economy improving widely is another question that is mentioned in this literature review. Finally, in the future new application areas for OR discipline are also considered. It is beyond the scope of this study to survey and review all of the publications in this topic. Thereby, only those works with highly valued contributions are included here.

Keywords: Operations Research, Electronic Commerce, Internet, Supply Chain Management

1.Introduction

The rapid improvements in information and communication technologies during the last quarter of the 20th century lead to a multidimensional variation and transformation process in economic, social and political directions. At the same time, with the globalization, scientific and technological revolution has started, affecting the whole system drastically. Those have caused to differentiate all forms of economic relationships. In this period, Information Technologies sector, in other words, “the new economy”, has brought about the swift improvement process of electronic commerce (e-commerce). Today, e-commerce symbolizes an important transformation like the invention of press or the industrial revolution. It is a common idea that the effects of e-commerce revolution in the globe will be more greater than the expected and this period is the e-commerce’s incremental period of time.

While improving very quickly, e-commerce also creates different glamorous opportunities for Operations Research (OR). Thinking about the sources of demand for OR, in traditional manner, decision-makers, managers, and goal creatives are mentioned. Advancing of Web, and relatively of e-commerce, changes this traditional situation in a significant point. Today, there are a new class of OR-utilizers, i.e. individuals using Web. This new class leads to a set of OR applications being greater than before potentially and, has non-traditional format (Geoffrion, 1998).

In this study, starting with the definition of e-commerce, firstly the question of “why OR in e-commerce?” will be answered. Then, the results of literature review on the issues in which areas of e-commerce OR practitioners are mostly active and how they are benefited from it will be discussed. Related real-world examples will also be mentioned. Finally, further directions on this topic will be considered.

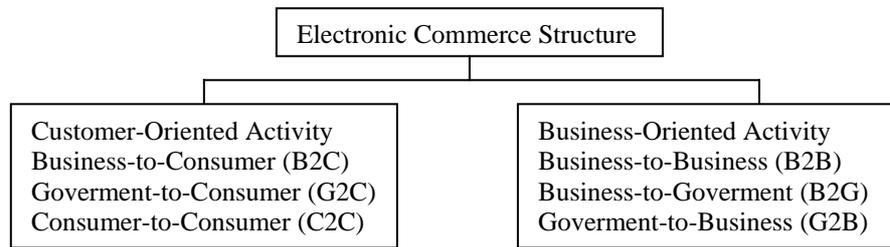
2.General Information About E-Commerce

Internet applications consist of three main classes: dynamic web sites, static web sites, and e-commerce. Today, business via Internet is increasing rapidly. At this point, it will be helpful for readers to define e-commerce which will be mentioned frequently in this work and to look for how it is generally classified.

E-commerce states all commercial operations based on processing, carrying, and saving information in different forms of individuals and societies in open network areas (Internet) or closed network areas (Intranet) which can be reached by limited users, and it aims at creating a value (Canpolat, 2001). E-commerce is composed of two main categories (Table 1), (1) consumer-oriented activity, and (2)

business-oriented activity. Both classes are supported by e-commerce network infrastructure implying with network infrastructure, network applications, and decision technologies.

Table 1. E-commerce structure



3. Operations Research Applications in E-Commerce

The researches and papers reviewed mainly give a simple message: “OR has a key role in digital economy improving widespreadly” (Geoffrion, 2000). The reasons of that why e-commerce needs for OR can be summarized as follows:

a. Complexity: Complex situations could occur at any moment of design, planning, and processing. OR offers an analytical approach. If analysis means breaking into pieces of a complex total; OR can cope with the complexity created by e-commerce.

b. Risk and uncertainty: Since technological improvements happen more rapidly, past is not a good guide for today’s world. OR could deal with the risk and uncertainty by using statistics, decision analysis, and probability models.

c. Reliability: One of the main characteristics of e-commerce is that it should be understood profoundly. OR is a reliable tool for most business subjects having such a characteristic.

d. Speed and automation: Since it uses not only information technology but also decision technology; OR provides a decision that has a quick, repeatable, and automatic structure. Clearly, e-commerce means automating business processes and bringing together with the other companies by Internet interface.

This study addresses three issues of e-commerce in which OR is mostly active (Geoffrion and Krishnan, 2001):

(1) Information Goods and Services (B2C and B2B)-especially in online financial and travel-related services.

(2) Physical Goods and Services (B2C and B2B)-especially in Supply Chain Management (SCM) and electronic markets (e-markets).

(3) E-business Network Infrastructure and Its Applications-especially in network design and quality-of-service (QoS) improvement.

In other words, lots of areas taking part in e-commerce are the application areas that use OR techniques inside themselves. Main application areas can be summarized as online auctions and e-market’s design, Customer Relationship Management (CRM), data mining, search engines, dynamic pricing and yield management, individualization and suggestion technologies, modelling of QoS for network infrastructure, and SCM.

3.1. OR Applications in Information Goods And Services

3.1.1. OR Applications in Financial Services

OR has had an active role in financial applications for a long period. One of the examples for online financial advisor company is Optimal Retirement Planner site. This site, via today’s investments, planned dues, and desired yield, formulazes a model with Linear Programming and calculates the money that has the optimal value combined with the taxes suitable in the period of retirement. Another application example is the site named as Financial Engines Investment Advisor. In this site, Monte Carlo Simulation and Quadratic Programming are applied for probable investment results and portfolio optimization respectively.

3.1.2. OR Applications in Travel-Related Services

Before illustrating the examples, it should be emphasized on this topic that information services related with travel, especially travel agencies, are reviewed. "Direct sales" topic is one of the subtopics in physical services.

Airline sector could be considered as the leader in e-commerce principles before Internet improvement. B2B electronic information transfer firstly happened in this sector. Consequently, huge application opportunities have occurred for OR practitioners. Reservation system with computer can be considered as one of the first examples in e-commerce. This system improved by Sabre, Inc. and its extensions have become the basis of today's global reservation system.

Airlines use OR techniques for demand estimation and optimization, design of sales promotion, determination of cross sales like rental car, hotel, etc. (Lieberman, 2000). If it is examined in detailed manner, it can be seen that the role of decision support systems in travel-related services is important. The success of the communication, data, and control directly depends on it. Apart from this, a Dynamic Programming Algorithm optimizing marginal utility has been improved (Smith, et al. 2001). This algorithm assumes flying utilities as depending on some variables, such as the number of connected flights, airline company and total travel time. Moreover, searching for a least-cost ticket on Internet; although the utility function of the customer has not been known so that it is desired to be maximized, a search algorithm that aims at forming a set of higher probabilities which implies with an acceptable travel has been developed.

Another application area in e-commerce that has been very commonly confronted during this survey is the yield management which is based on the aim of gaining maximum income when there is a limited capacity in an airplane. As being near by the arrival time for plane, there occurs a dilemma between decreasing the general ticket price and rising up the prices for irreparable travelers having no more chance. For such a situation, dynamic pricing is a powerful technique. The answers of the questions "when and how much decrease or increase" lie in OR techniques.

3.2. OR Applications in Physical Goods And Services

Traditionally, supply chain has been assumed as a linear system that starts with raw material and finishes up accession to the customer. Today, supply chains have more dynamic structure than the past. With the high speed communication by Internet, companies apart from distributors have two new opportunities for selling their goods or services through Internet. Those are sales of their own products by using company's own Web site, i.e. Direct sales, and e-markets in which customers and salers come together on the Net and the transaction costs decrease. In e-markets, products from different dealers are gathered and offered to the customers. According to Forrester Research, in 2004, 53 percent of the B2B e-commerce will occur through e-markets. Automotive, hard industry, electronic, and energy are the most known sectors appeared on those. With this new structure, there is not only a horizontal relationship between customers and dealers but also a necessity for dealers (or customers) to act together (Keskinocak and Tayur, 2001). For direct sales and e-markets, the Web sites, [Prentice Hall](#) and [Amazon](#) can be given as examples respectively.

OR techniques find themselves different application areas by using real-time information on supply and demand. In generally, companies use OR tools in sales, CRM, and advertisement. Each potential customer visiting a Web site offered product or service presented to be sold should decide on whether to purchase or not and what he will purchase from this site. In this decision stage, Multi Criteria Decision Models are used to help customers' decisions. Similarly, it is confronted with the models in the framework of customer service management. Those models are developed to help purchase decisions by using OR tools. The models which provide complementary goods and services showing on the screen in the right time, are mainly formed by following customer's Internet service server and collecting that information in a database. Further, special algorithm that has been developed to answer customer's expectations and complaints quickly and accurately are used (Sodhi, 2001).

To give more specific examples, [OptiBid](#) site could be mentioned. This online auction site uses a system which is based on Integer Programming and it has a multi-attributive system together with Internet concept. With this programming technique, the site is used by dozens of transportation companies in order to choose transportation servers in e-markets. [Trajecta, Inc.](#) uses stochastic optimization models to help the banks in the management of credit cards' portfolios. [MarketSwitch](#) is an advisor site that helps Internet advertisement networks and e-commerce sites to show the advertorials and promotions on the screen in the right time, as mentioned before. While doing this, Constrained Optimization is used (Geoffrion and Krishan, 2001).

3.2.1. Models and Algorithms Suggested For Online Auctions

Online auction is one of the most popular sale tool in e-commerce. Due to its calculation ability, Internet provides saling the same product in different units in one session. Although they have short background, today online auctions are one of the most improving tool in e-commerce, by reaching 1 billion \$ operation volume until now. Another attractive characteristic of these auctions is the variability in products.

Beam, et al. (1999) present multi-unit auction site that uses Markov Chains and optimization by considering batch size and pricing.

Davenport and Kalagnanam (2001) suggest a complex integer programming model used in procurement of direct inputs in production process. In their model, if direct inputs of a computer, like RAM, screen, keyboard, are purchased in a great number, dealers may reduce the sales price in some ratios. We could face with different pricing strategies in e-commerce, as in the economy. When deciding on accepting the offers of dealers, the batch size taken from each dealer and reservation price could be given as the examples of decision maker's constraints. In this study, authors claim that although there are some business constraints, in the optimal design of an online auction site, another factor is its economic situation.

In the work of Pinker, et al. (2001), the writers suggest a combination of Bayes' analysis and Dynamic Programming for the problem of multi-unit auction site's design. In each sequential auction's stage, since less products are offered, more revenue is gained. However, at the same time, each additional auction enanches fixed costs and inventory costs. In this complex design problem, it is confronted with two important design questions: (1) optimal product quantity offered in each period, and (2) optimal auction number. Some of the conclusions derived from this study are as follows: In case the batch size has an optimal solution, total profit is sensitive to total number of sessions. If the distribution of the offered values are known, through sequential auctions, optimal batch size increases monotonously.

Wu and Jin (2001), in their study, examine different models including customers and dealers competing with each other in the market by assuming that together with e-commerce, the structure of supply chain has also been conceptually transformed. Further, it is also assumed that the demand is a linear function of the price. For the market, there is also a 3rd group, called as electronic brokers (e-brokers), generally service servers, which conduct some commercial activities, especially shopping. In such auctions, the side starting the agreement and offering is called as "Stackelberg Leader", usually they are dealers or e-brokers. In this work, four different models are studied according to whether each side has entire information about the other side or not (assymetric information). In this study, "how competition affects the customer in e-commerce", "whether there is more better (optimal) solution for the dealer or not", and "how the broker company's role shaped in reaching optimal solution for both sides" can be concluded.

3.3. OR Applications in Network Infrastructure

The development of network infrastructure leads to the improvement of e-commerce applications. With the widespreaded usage of Internet, these applications have been focused on service quality.

Bhargava (1998), in his study, suggests that the future of OR in e-commerce is concentration of OR practitioners on TCP/IP-based networks. Furthermore it is claimed that, apart from applet and the other service servers technologies, Java applications will be the leader of network infrastructure. In this paper in which it is emphasized that Java technologies are more powerful than the others, he also suggests that those technologies will supply plentiful opportunities for the developers and practitioners of OR/MS applications.

Looking from the customer's perspective, in redesignation of Local Access Networks in network infrastructure for e-commerce, Queing Theory and new statistical techniques different from the traditional Poisson Models are used to respond to different types of the calls (Willinger and Paxson, 1998). Moreover, in order to minimize the response time of the service server, mininum-costed, multi-unit flow algorithms are utilized.

4. Conclusions and Further Directions

Today, increasing number of the business processes is managed through Internet. Therefore the necessity of OR tools and its algorithms in this new era should not be overlooked. E-commerce itself will bring new opportunities differing from optimization models for OR practitioners. This necessity will be

observed in diverse areas of e-commerce, such as SCM, manufacturing, customer service, e-tailor system design, pricing, advertising, internet congestion control, and more (Little, 2001). In the future, it is expected that the demand for OR techniques will rise up. OR practitioners, in order to reply this demand and to take action in this field, should comprehend e-commerce processes and follow progress in information technologies.

It is expected that there will be dozens of application areas for OR applicants in the near future. For example, the concept of "extension period" will be one of these areas. Now, it is observed that if there is no order in the last 5 minutes of the online auction, the closed time of the auction is extended to additional 5 minutes, while in some sites, this period can only be 1 minute (Lucking-Reiley, 2000). For further study, in order to determine optimal extension period of time for online auctions instead of trial-and-error concept, it is suggested that other technologies could be focused on.

Another research area, may be the determination of the optimal buyout price level in online auctions. If a customer offers the enough price, named "buyout price", which was determined by the dealer before the session, the session is finished without waiting the close time of the auction. However, if the dealer waits until the end of the auction total time, he/she might sell his/her product for better price. Similarly, if the customer waits, he/she might purchase the product for cheaper price. This could be another further optimization problem waiting to be solved.

Moreover, the models improved for e-markets have been mentioned before. In the papers reviewed for this study, the problems are solved under the assumption of deterministic demand and it is function of the price. If the demand has a stochastic structure, customer will face with more complex optimization problem. In that case, the comparison of the problems solved with deterministic demand and the ones that may be solved with stochastic analysis, may be another research field.

In this paper, a literature survey of OR application in e-commerce is presented. No extensions of these applications are included here. To sum up, due to the reasons of the significance of e-commerce with respect to theory and practice, and the attractiveness of the difficulties on the researchers faced with its efficient solutions, it can be said that e-commerce will be a glamorous field for OR practitioners, they will be focusing on the studies in this field for following days.

Internet Adresses (alphabetized, underlined in the main text, all sites begin with http://)

Amazon (www.amazon.com)

Financial Engines Investment Advisor (www.financialengines.com)

MarketSwitch (www.marketswitch.com)

OptiBid(www.logistics.com/static/static1-1.asp)

Optimal Retirement Planner (www.i-orp.com)

Prentice Hall (www.prenhall.com)

Trajecta, Inc. (www.trajecta.com)

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