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A Mathematical Model for Optimizing Customer Experience through the Multidimensional Sequencing of Hotel Rooms and Customer Reviews on Online Hotel Booking Sites

Napaporn Rianthong

Japan Advanced Institute of Science and Technology

Doctoral Dissertation

A Mathematical Model for Optimizing Customer Experience through the Multidimensional Sequencing of Hotel Rooms and Customer Reviews on Online Hotel Booking Sites

Napaporn Rianthong

Supervisor: Professor Youji Kohda, Ph.D.

School of Knowledge Science
Japan Advanced Institute of Science and Technology

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ABSTRACT

The focus of this dissertation is customer behavior during the process of searching the hotel information and booking a hotel through online travel agencies (OTAs). OTAs provide a large number of hotels to heterogeneous customers. Matching a hotel with a customer's preference is a challenge under the uncertain condition of customer (e.g., preference, arrival), especially when customers have multidimensional preferences and involve the impact of online review.

The full utilization of the product sorting and online review mechanisms is mainly concerned in this dissertation. In the current situation, a number of OTAs provide various hotel choices in a sorting feature. A customer can sort the presentation of available hotels based on single attribute such as sorting by price, review rating, star rating and website's favorite. Although the current sorting mechanism of OTAs (e.g., website's favorite) can provide the sequence of hotels efficiently in timely aspect, the sequencing might be biased because of the advertising fee to promote some hotels placed in the top list. Also, the current sorting mechanism of OTAs has limitations to satisfy the multidimensional preferences of customers, as most of them sort a number of hotels by considering single attribute (e.g., sorting by start rating). The number of hotels along with the sequence of available hotels shown on the website has the significant impact on the process of customer choice decision. Specifically, the online customers may fail to notice a satisfactory hotel if it is shown at the bottom of a long sequence. For an online review mechanism as well, a large number of online reviews involving unnecessary information (e.g., customer's complaints, bias review) are the barrier to reach a satisfactory hotel concerning the search time of customer.

In this dissertation, we presented the whole optimization of customer experience that uses OTAs searching for the hotel information and making a hotel booking transaction. The design and usage of the hotel sorting and online review mechanisms were investigated. Specifically, we proposed a new approach, based on a two-stage stochastic programming (2SSP) model, to design an optimal sequence of hotels and the selection of online reviews presented on the website. The objective is to help a customer could find a satisfactory hotel at the minimum number of search steps while satisfying the maximum utility gained from a selected hotel. We collected the customer data through a survey method and took the hotel information from the selected OTAs, mainly from Hotels.com and Agoda.com. This information was then used through the numerical experiments to simulate a case study of online hotel booking. The case study makes the proposed model close to the realistic mechanism. Even though our model might not 100% reflect the reality of online booking mechanism but none of the model in the research does as all the model are a simplified version of reality. Thus, it is our belief that the proposed model is a closest proxy of real customer searching behaviors as we incorporated the minimum and standard parameters taken from several surveys including the one we conducted.

Three model approaches were proposed in this dissertation (presented in Chapter 5, 6 and 7). That is, Chapter 5 mainly focuses on the design and usage of a hotel sorting approach. This model covers the basic idea of this dissertation that aims to maximize the customer experience through the profitable design of OTAs. It provides the interesting findings and the practical implications for OTAs and hotels. The OTA managers could adopt the proposed approach and the findings for decision making regarding to the strategy to sort the number of available hotels. Moreover, for the hotel managers, they can analyze their competitive position in the current market, and our model could extend to provide the direction of improvement to maintain the competitive advantages for online retailers.

We extended the first model (presented in Chapter 5) to incorporate full scale of parameters, mainly on the parameters of online review characteristics. Accordingly, the extension of the first model by incorporating the sorting approach for online reviews was presented in Chapter 6. Similarly, Chapter 7 incorporates the hotel sorting and online review selection mechanisms. The decision for the online review management is made on the basis of different perspectives as in Chapter 6 (e.g., the decision based on the target and valence of reviews) and Chapter 7 (e.g., the decision based on the online review indicators). Thus, three models are differentiated on the basis of assumption and purpose of study. Accordingly, the formulation of the proposed model and application are slightly different to response the different features of OTAs (e.g., Hotels.com and Agoda.com).

In summary, this dissertation provides the contribution to tourism industry, e-commerce and knowledge science. It provides a new framework that could promote the understanding of customer's behavior and profitable design of OTAs. It provides an effective approach that helps OTAs designing the product sorting and online review mechanisms to enhance customer experience. Also, three chapters provide a new and different perspective of website design and online review management.

Keywords: Online hotel booking, Online review, Multi-dimensional sequencing, Multi-preference consumer, Stochastic programming

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TABLE OF CONTENTS

Chapter Title	Page
Abstract	i
Acknowledgements	iii
Table of contents	iv
List of figures	ix
List of tables	x
Chapter 1 Introduction	**1**
1.1. Background	1
1.1.1. Emergence of the Internet in tourism	1
1.1.2. Current mechanism of online travel agencies (OTAs)	2
1.2. Research motivation	6
1.3. Problem statement	8
1.4. Research objectives	9
1.5. Research questions	10
1.6. Research design	10
1.6.1. Survey method	12
1.6.2. The analysis of online review	12
1.6.3. A mathematical model approach	12
1.7. Significance and originality of the study	13
1.8. Structure of the dissertation	14
Chapter 2 Literature review	**16**
2.1. Hotel selection factor	16
2.2. Online review	19
2.3. Application of optimization model in e-commerce	22
2.4. Two-stage stochastic programming approach (2SSP)	23
2.5. Website interface design	24

Chapter Title	**Page**

2.6. Recommendation approach 25
2.7. Search behavior 26

Chapter 3 Research methodology **29**
3.1. Research activities 31

Chapter 4 Factor affecting on online hotel booking decision **38**
4.1. Introduction 38
4.1.1. Stage of customer behavior 38
4.1.2. Target customers 39
4.2. Research methodology 39
4.2.1. Questionnaire design 39
4.2.2. Data collection 40
4.3. Analysis of survey results 40
4.4. Discussion 45

Chapter 5 Multidimensional sequencing of hotel rooms **47**
5.1. Introduction 47
5.2. Research method 50
5.2.1. Service coding framework 50
5.2.2. Survey and modeling process 51
5.3. Problem description 53
5.4. Mathematical model approach 55
5.4.1. Formulation of a two-stage stochastic programming model (2SSP) 55
5.4.2. Customer choice model 58
5.4.3. Second-stage decision: Approximated customer choice model 59
5.4.4. First-stage decision: Sequencing model and two-stage stochastic programming model 61
5.4.5. Two-stage stochastic programming (2SSP) model 61
5.4.6. Discussion on the optimization model 64

Chapter Title	**Page**

5.5. Case study 64

5.5.1. Hotel characteristics 64

5.5.2. Customer characteristics in the selected area 65

5.5.3. Search cost of customer 66

5.5.4. Customer characteristics 66

5.6. Numerical experiment 68

5.6.1. Example of results derived from the proposed model 68

5.6.2. Analysis of numerical results 69

5.6.3. Effectiveness of the proposed model 73

5.6.4. Practical implementation 75

5.7. Findings and implications 77

Chapter 6 Multidimensional sequencings of hotel rooms and online reviews 80

6.1. Introduction 80

6.2. Research method 82

6.2.1. Service coding framework 82

6.2.2. Application of findings derived from prior literatures 82

6.2.3. Mapping a model 82

6.3. Problem description 83

6.4. Mathematical model approach 86

6.4.1. Formulation of two-stage stochastic programming model (2SSP) 89

6.4.2. Formulation of goal programming model 89

6.4.3. The proposed model 91

6.5. Case study 94

6.5.1. Hotel characteristics 94

6.5.2. Customer characteristics in a selected area 95

6.6. Numerical experiment 96

6.6.1. Example of results derived from the proposed model 96

6.6.2. Effectiveness of the proposed model 97

6.6.3. Analysis of numerical results 98

6.7. Conclusion 99

Chapter Title **Page**

Chapter 7 Multidimensional sequencing of hotels and online review selection **100**

7.1. Introduction 100

7.2. Research method 102

7.2.1. Service coding framework 102

7.2.2. Mapping a model 102

7.3. Problem description 102

7.4. Mathematical model approach 104

7.4.1. Formulation of a two-stage stochastic programming model 105

7.4.2. Customer choice decision 105

7.4.3. Second-stage decision: Customer choice model 107

7.4.4. First-stage decision: Hotel sequencing and online review selection 107

7.4.5. Sequencing model with two-stage stochastic programming 108

7.5. Case study 110

7.5.1. Hotel characteristics 110

7.5.2. Customer characteristics 111

7.6. Numerical experiment 112

7.6.1. Example of results derived from the proposed model 112

7.6.2. Analysis of numerical results 112

7.6.3. Effectiveness of the proposed model 113

7.7. Findings and implications 117

Chapter 8 Conclusion and implications **118**

8.1. Conclusion 118

8.2. Significance of research outputs 121

8.2.1. Contribution to knowledge science 121

8.2.1.1. Service value creation for the customers 121

8.2.1.2. Knowledge creation process 122

8.2.2. Practical implications for e-commerce and tourism industry 123

8.3. Limitations and future research 123

List of publication **125**

Chapter Title	**Page**

References	**126**
Appendix A	**133**
Appendix B	**137**
Appendix B-1	138
Appendix B-2	141
Appendix B-3	144
Appendix B-4	147

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LIST OF FIGURES

Fig. 1.1 Website design and sorting mechanism of OTAs	3
Fig. 1.2 Design of online review presented on OTAs	5-6
Fig. 1.3 Model of a service system for online hotel booking	11
Fig. 3.1 Outline of research methodology	29
Fig. 5.1 Website design and sorting mechanism of OTAs	49
Fig. 5.2 Schematic of modeling process	50
Fig. 5.3 Schematic of survey and proposed model	52
Fig. 5.4 Framework for service system of online hotel booking	55
Fig. 5.5 A diagram of stages of decision	58
Fig. 5.6 Customer choice decision	59
Fig. 5.7 Effect of sample size on computation time and composite score	69
Fig. 5.8 Relationship between the ranking positon and number of potential customers	70
Fig. 5.9 Relationship between the ranking positon and hotel attribute	71
Fig. 5.10 Comparison of composite scores of different sorting methods and numbers of hotels shown on the website	72
Fig. 6.1 Website design and sorting mechanism of Agoda.com	81
Fig. 6.2 Sequencing of hotels and online reviews on OTAs	86
Fig. 6.3 Diagram of two-stage decision with the desired goal	91
Fig. 7.1 Website design and sorting mechanism of Hotels.com	101
Fig. 7.2 Overall stages of an online hotel booking decision	103
Fig. 7.3 Two-stage decision diagram	105
Fig. 7.4 Sequential searching behavior	106
Fig. 7.5 Hotel attributes versus ranking position of top-five hotels	113
Fig. 7.6 Comparison effectiveness of sorting methods	115
Fig. 7.7 Effect of re-sequencing period on average number of search steps and computation time	116
Fig. B-1 Basic components of a mathematical model on OPL	148
Fig. B-2 CPLEX Statistics	149
Fig. B-3 CPLEX Engine Log	149

LIST OF TABLES

Table 3.1 Outline of three proposed models 31

Table 4.1 The demographic characteristics of the respondents 41

Table 4.2 Purpose of using online travel agencies 42

Table 4.3 Elements of website on online hotel booking intention 42

Table 4.4 Hotel selection criteria 43

Table 4.5 Hotel sorting method on OTAs 43

Table 4.6 Importance of online review indicators 44

Table 4.7 The minimum acceptable review score 44

Table 4.8 Sorting methods of online review on OTAs 45

Table 4.9 Multiple regression results, dependent variable: expected utility 45

Table 5.1 Index variables 57

Table 5.2 Input parameters and description 57

Table 5.3 Steps showing the main concept of the sequence of proposed model 63

Table 5.4 Descriptive data of the subject hotels located in Chachoengsao Province 65

Table 5.5 Estimated ratios of customers 65

Table 5.6 Summary statistics of variables classified by customer type 66

Table 5.7 Summary of statistics of customer variables 67

Table 5.8 Multiple regression results, dependent variable: expected utility 68

Table 5.9 Example of results for the hotel sequencing decision and the number of hotels shown on the website 68

Table 5.10 Sample size of customers for making a sequence of hotels 69

Table 5.11 Impact of the number of hotels, presented on the website, on the composite score 71

Table 5.12 Impact of weight of search cost on the composite score 73

Table 5.13 Comparison of sequence effectiveness by our proposed model with that by website function. 75

Table 5.14 Impact of time to re-optimize the new sequence on the composite score and computation time 75

Table 5.15 Selected hotel characteristics 76

Table 5.16 Suggestion for performance improvement based on one attribute 77

Table 5.17 Suggestion for performance improvement by two attributes 77

Table 6.1 Index variables 87
Table 6.2 Input parameters 87
Table 6.3 Descriptive data of the subject hotels located in Kanchanaburi Province 95
Table 6.4 Estimated ratios of customers in Kanchanaburi Province 96
Table 6.5. Example of numerical results for the sequencing decision of hotels and online reviews 97
Table 6.6 Comparison the effectiveness of hotel sequencing by different sorting methods 98
Table 6.7 Comparison the results by different sorting methods of online reviews 99
Table 7.1 Input parameters and description 104
Table 7.2 Methodology of a proposed approximate method 110
Table 7.3 Descriptive data of the subject hotels located in Asakura, Japan 111
Table 7.4 Numerical results for the sequencing decision and the online review selection 112
Table 7.5 Comparison the effectiveness of sequencing by different sorting methods 114
Table 7.6 Effect of the re-sequencing period on the average searching step and computation time 116

CHAPTER 1
INTRODUCTION

E-commerce has become a popular trend of business model which significantly changes the way of shopping behavior and business process in many industries. According to a report of Forrester (2016), online sale derived from U.S market will increase to reach $ 523 billion by 2020 whereas the number of online customers will hit 270 million people. Also, online sale was estimated to grow by an average rate of 9.32% from 2015 up to the five coming years. The number of online transactions will increase continuously with the development of multiple devices whereas mobile devices simulate the large portion of online activities. E-commerce has received attention by many researchers from various fields such as marketing, business management, tourism management, service science and management science.

1.1. Background

1.1.1. Emergence of the Internet in tourism

The hospitality and tourism industry plays a major role in the boom of E-commerce. The growth of E-commerce has dramatically revolutionized the distribution channel of travel products. The service providers in tourism industry (e.g., hotel, airline, and car rental company) provide their own website to allow a customer directly books a service conveniently through an online channel. Moreover, most of them cooperate with online travel agencies (OTAs) to expand the distribution channel. In recent years, online travel agencies (OTAs) have become a major channel for the travel distribution, representing 38% of the global online market (PhoCusWright, 2014) and OTAs market will growth by 25% annually. Within the travel product, the hotel booking transaction creates the second largest revenue via online channel. Online hotel sales continued to grow rapidly at 11% to reach $ 52.5 billion in 2015. In 2016, OTAs will increase the transaction of hotel bookings to cover 51% of online hotel market (PhoCusWright, 2016). A hotel placed in a list of OTAs, e.g., expedia.com, can increase the number of reservation rate by 7.5% to 26% according to the study of Anderson (2011). Nowadays, a number of travelers tend to use OTAs for their information searching process and booking transaction due to the ability to facilitate the transaction at low search cost, offer special deal and discount, collect various hotels with an opportunity to compare the price rate, and provide an additional useful information about accommodations and prior customer experience (Carvell and Quan, 2008). The examples of popular OTAs are as Expedia.com, Hotels.com, Agoda.com and Booking.com.

Information is an important factor for a purchasing decision of travel products due to the intangibility of products during a booking stage and the possible perceived risk taken from unsatisfied service experience. The customers of travel products, especially hotel, show a higher involvement in the information searching for a satisfactory choice than that of other industries. The emergence of the Internet has changed the ways of customer's behavior with responding to the current issues on information searching process for a travel product. The information available on OTAs provides the relevant details help to make a comparison and validate the hotel choices.

Moreover, the Internet provides an opportunity for customer to participate and share the experience related to products freely. That is, the social media and customer review act as the environment to develop the cooperation among customers and hotels. A hotel can evaluate the satisfaction level and actual requirement of customers which is a valuable source to improve the hotel's service in the future. In the service research, the participation of customers is perceived as the ways of co-creation value and leads to the service innovation. In recent years, it is essential for any hotels to cooperate with OTAs due to its advantages to provide real time information service, economic global accessibility, interactive communication features and unique customization capabilities.

In summary, the emergence of the Internet plays a prominent role to enhance the distribution channel, information searching process and customer's involvement in tourism industry.

1.1.2. Current mechanism of online travel agencies (OTAs)

Online travel agencies (OTAs) provide the information service to an online traveler. The quality and accuracy of information content along with the website feature and functionality of OTAs are all the key aspects which add the service value to online booking experience and enhance the customer satisfaction (Benckendorff, 2006).

Considering the website feature shown in Fig.1.1, most of OTAs present a number of available hotels located at the same location in a sorting feature. The design of sorting (or product list or sequencing of product choice) has been the most effective interface design in an online shopping context (Hong et al., 2004). The current sorting mechanism of OTAs shows a list of available hotels sorted by single attribute such as sorting by price, star rating, distance, review rating and website's favorites. A list of hotels is normally presented along with hotel information (e.g., price, photo, special deal, star rating, location, amenities, room type, and supply of room) and online review (e.g., overall review rating, individual review rating and individual text comment). The default page of OTAs presents a list of hotels sorted by website's favorite. Sorting by website's favorite is classified as the recommendation mechanism to recommend the good hotel to match with most of customer's preferences. However, OTAs perform a business on a commission fee thereby they may generate the revenue on the rooms booked through their website. The commission fee is normally accounted for, approximately, 10 to 15% of room rate according to the agreement between hotel and OTAs. Thus, the recommendations might be biased because of the commission fee to advertise some hotels. Moreover, in an online shopping, most customers tend to observe for a few choices from a list of all available choices whereas a choice presented on the top position of a list is more attractive (Tam and Ho, 2005). The importance of position effect on customer behavior and purchasing decision was investigated by many researchers (e.g., Cai and Xu, 2006; Diehl and Zauberman, 2005). Thus, the design of sorting mechanism has a significant impact on the booking intention and customer choice decision, resulting in the customer experience perceived from the service of hotel and OTAs.

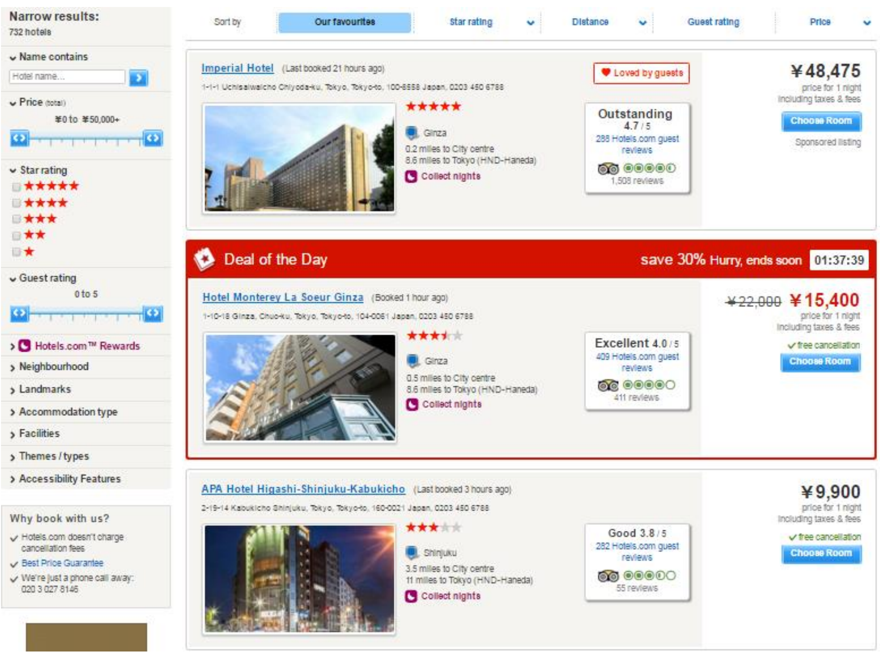
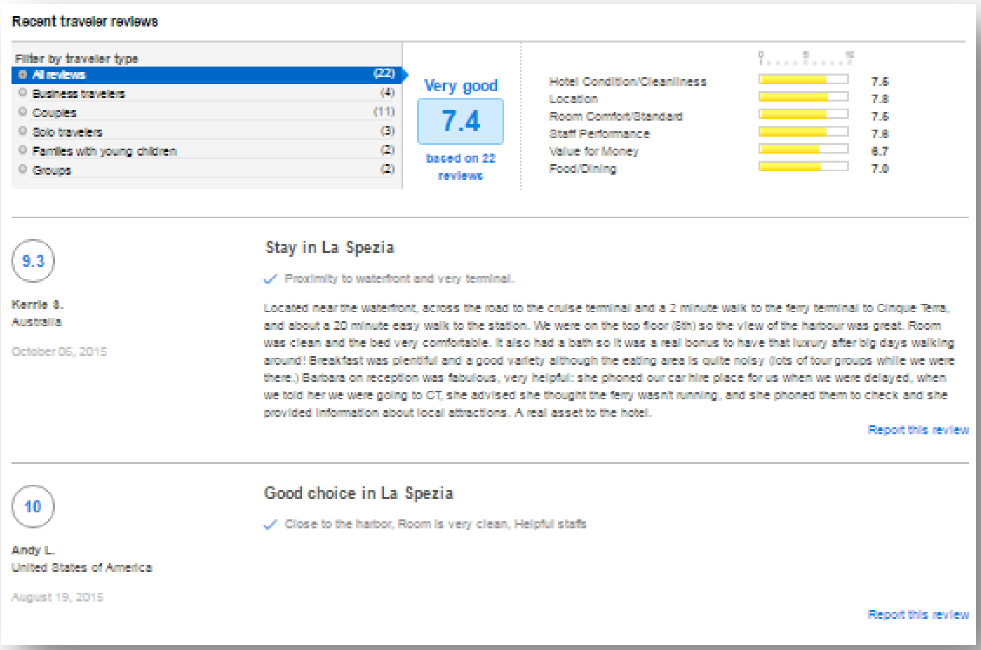


Fig.1.1. Website design and sorting mechanism of OTAs

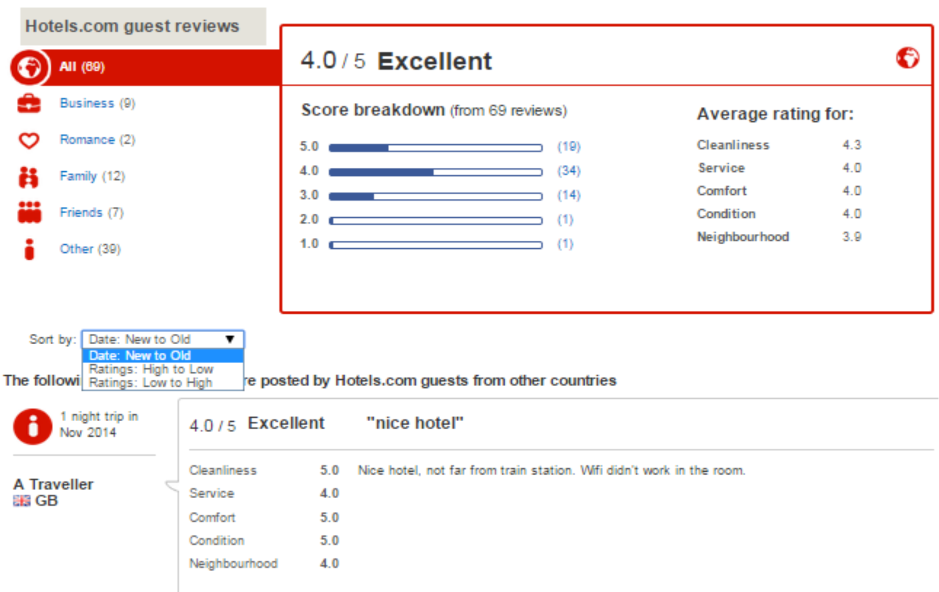
Online review is one of the most prominent characteristics of OTAs that enhances the online hotel booking experience. OTAs provide the information service with credible information content as they publish online review from past customers who booked a hotel room through their website and actually stayed at a hotel. Thus, most of online reviews reflect the actual experience with less unreliable reviews. Online review is one mechanism which represents the involvement of customers on a product or service. It creates the coordination between customers and hotels in such a way that a customer gives opinion on a hotel based on their experience. Accordingly, a hotel could improve the service performance regarding to the customer's complaint. With the emergence of the Internet, the customers rely on online review when make a hotel booking decision as the perception to reach a satisfactory hotel at the lowest perceived risk. It is reported that 97% of respondents read online reviews before making a booking decision whereas 58.1% of online reviews were observed from OTAs (Gretzel et al., 2007). Thus, online review plays an important role in the travel planning in the Internet era.

OTAs present online review in the form of overall review rating (given by overall customers), individual review rating, and individual text comments as shown in Fig. 1.2. The review rating, scored by a scale of 1 to 5 or 1 to 10 (based on the scale of OTAs), represents a summary of traveler votes on the service performance of hotel. Typically, the higher review rating represents the higher satisfaction level of customers (i.e., 1 = very poor, 3 = neutral, 5 = very excellent). A past customer who stayed at a hotel is allowed to evaluate the performance of hotel in various aspects (e.g., location, service, food, facilities, value for money, and cleanliness). Moreover, OTAs invite a customer to review a hotel, and write comments according to their actual experiences. The design of online reviews presented on the website is different among OTAs. For example, in Fig. 1.2 (a), Agoda.com presents overall review rating (scale by 1 to 10) in various review indicators (e.g., cleanliness, location, room comfort, staff performance, value for money and food), individual review rating and individual text comments. In Fig. 1.2 (b), Hotels.com presents overall review rating (scale by 1 to 5) in various review indicators (e.g., cleanliness, service, comfort, condition and neighborhood), individual review rating (on each review indicator) and individual text comments. In Fig. 1.2 (c), Booking.com presents overall review rating (scale by 1 to 10) in various review indicators (e.g., cleanliness, staff, location, free WIFI, facility etc.), individual review rating and individual text comments (classified to positive and negative aspects).

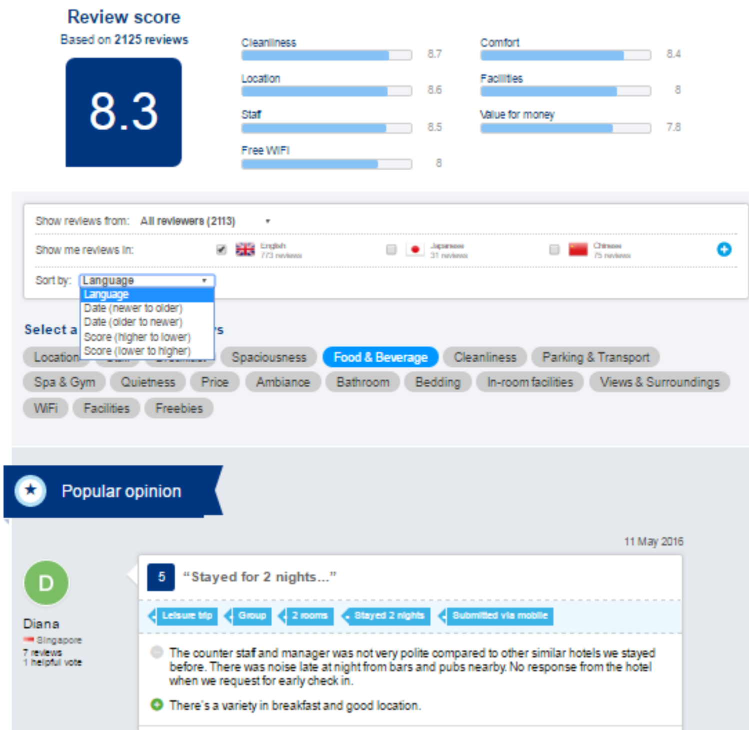
Moreover, a number of available online reviews are presented in a sorting feature, normally sorted by most recent reviews, highest review rating, lowest review rating, type of travelers and language. The default page of online reviews shows a number of online reviews sorted by the most recent reviews. Although online review is valuable source of information to evaluate a hotel, a large number of online reviews including unnecessary information (e.g., customer's complaint) influence the online booking experience.



(a) Online review presented on Agoda.com



(b) Online review presented on Hotels.com



(c) Online review presented on Booking.com

Fig. 1.2. Design of online review presented on OTAs

1.2. Research motivation

In this section, we determine the scope and direction of our research, and also point out the difference with other similar studies that might not relate to our concern as following.

This research is motivated by the effect of the website interface design, especially a design of product list (i.e., sequence of product choices), on the customer product choice in an online shopping environment. Online hotel booking through OTAs is considered due to its growing trend.

Accordingly, our research is designed as “the research on OTAs design for facilitating the searching process for overall customers”. As online review is the prominent feature on OTAs, one part of OTAs design incorporates the sequence of online reviews which considers the review rating and other basic review characteristics. On OTAs, a sequence of hotel choice is the prominent design characteristic which is normally sorted by single product characteristic dimension or single attribute (e.g., sorting by price, review rating, star rating, or distance). The current sorting mechanism of OTAs is somewhat limited when it comes to meet the expectations of customers as most of customers have multiple, highly specific preferences (e.g., consider overall price, star rating, review rating at the same time). The sorting position of hotels in the sequence as well has the effect on the booking intention because the hotels placed at the top positions are more attractive. Also, a customer evaluates the online product on the basis of the presentation of the product list and the information available on the website. Thus, the design for a sequence of hotel choices and online reviews is necessary to be studied, and suitably determined.

Drawing on previous literatures of eye-tracking, human-computer interaction, website interface design and customer’s choice decision in e-commerce, this research takes the view on how to design a list of products on the web site and how presentation of product in a sorting feature influences on customer’s choice decision.

Comparing with our focus on OTAs design for customer, there are various studies that might be close, but out of our concern, such as recommendation system for products or collaborative filtering system, sentiment analysis on review content and data mining. The main differences are that our OTAs design focuses on how to design the sequence of product choices with the concern of sorting effect to facilitate the searching process for overall customer, not recommend the best products for a specific customer like collaborative filtering system. Also, sequencing of online reviews is one part of OTAs design aiming to manage a number of online reviews to facilitate the realization of hotel choices and customer searching process. As we aim to show how to present online reviews instead of evaluating the quality and reliability of each review content, the sentiment analysis on review content is not our concern.

Considering as online market, a large number of customers come to use OTAs conveniently. Thus, the target customer of OTAs comprises of overall online customers around the world. Accordingly, sequencing of hotel choices needs to be suitably determined under the online market environments and uncertain condition of customers (e.g., arrival of customers and preference). Also, the sequence of hotels needs to be prepared optimally in advance to serve all possibilities of arriving customers. Thus, the problem of sequencing refers to the optimization problem of sequencing to find an optimal solution of sequencing. Similar to the characteristics of supply chain and production scheduling problems, we need to determine the optimal sequencing whereas several constraints and objectives (i.e., customer and hotel characteristics) are incorporated. The customer behavior is the detailed behavior and simulations of online hotel booking are necessary to reflect actual online booking mechanism. The motivation of adopting an optimization model comes with these reasons. With the application of optimization model, we can formulate the problem to set the detailed behavior of customers, perform a real simulation of online hotel mechanism and derive an optimal solution under all constraints at management decision. Especially, the application of a two-stage stochastic programming model (2SSP) can address the uncertain conditions under optimization problem.

Therefore, the present research focuses on the development of optimization model to address the OTAs design to improve customer experience in online hotel booking.

1.3. Problem statement

In this study, we investigate the customer behavior during the process of searching and booking a hotel through online travel agencies (OTAs). Most customers tend to rely on the hotel sorting mechanism and online review to reach a satisfactory hotel. However, the current situation of online hotel booking has faced many challenges arising from the multi-criteria decision of customers, information overload, complexity of choice and a lack of understanding on actual behavior of customers.

This research proposes the following current problems arising in an online hotel booking.

- Due to the complex choices with the intangibility of a tourism product during a booking stage, a customer must hold a perceived risk (e.g., time risk and performance risk) occurring from a poor booking decision that may lead to an unfavorable experience. The perceived risk may lose customer’s time and money during a trip period and thus damage the customer’s trust toward a hotel and OTAs.
- OTAs collect a number of hotels with useful information (e.g., hotel information, special deal, online review) that provide the opportunity to compare hotels conveniently. However, the information overload on OTAs increases search effort (e.g., search cost and time), makes confusion and leads to poor booking decision. Search cost and time are the major concerns for today’s society.
- The current sorting mechanism of OTAs (e.g., default sorting method by website’s favorite) might be biased because of the commission fee to advertise some hotels.
- The current sorting mechanism of OTAs (e.g., sorting by single attribute of price or review rating) has limitations to satisfy the hotel selection criteria of customers who have multidimensional preferences (e.g., price, review rating, star rating and reservation utility).
- According to the order effect of product choices in e-commerce, a customer prefers a product shown in the upper position of the sequence, and they will observe only a top few products due to the limitation of human cognition. Thus, ineffective sorting with a

long sequence of hotel choices not only increases the search effort but is a barrier for a customer to notice a satisfactory hotel if that hotel is placed at the bottom of a long sequence.

- An online hotel booking is a prominent case that online reviews and e-worth of mount play an important role to a customer's booking decision. Within a large amount of online review available on OTAs, there includes unnecessary information (e.g., customer's complaint) that disrupts the searching process. The evaluation of online review's usefulness (e.g., number of words, review target) is necessary but still has a gap to adopt in a practical way.
- In today's competitive market, a hotel that cannot compete with other competitors could not stand in a market. Thus, they have to adapt themselves while the service improvement is necessary, it requires trial and error at the large investment.
- A lack of understanding a customer's behavior influences on the customer satisfaction and service provider's profit. Moreover, there is a gap between the actual behavior of online hotel booking and theoretical research. Specifically, a framework that incorporates the usage of product sorting and online review mechanism is still unexplored. There is a limitation of the existing research to reflect overall framework of online hotel booking. A major challenge includes the uncertain condition of customers (e.g., arrival, search behavior and multi-criteria decision).

1.4. Research objectives

This research is designed to bridge the problem space arising in current mechanism of OTAs and the prior literatures. Moreover, we aim to provide the business implications for tourism industry. The specific objectives of this research include.

- To provide a mathematical model framework (Theoretical model framework***)*** to promote the understanding of profitable design of OTAs website. However, due to limitation of theoretical model, practical implementation of the model directly on OTA sorting mechanism is not our main expectation.
- To focus on the optimization of whole customer experience who uses OTAs for the information searching and hotel booking transaction.

- To propose a new approach that helps OTAs makes a better decision on the sequence of hotels and useful online review selection. This could increase the accuracy to match a hotel with the customer's expectation.
- To test the effectiveness of proposed approach with the existing mechanism of OTAs.
- To provide the direction of improvement for a hotel to compete in a competitive market.
- To propose a new framework to examine the findings from prior literatures regarding to the effect of online review on the booking intention and trust on a hotel.

1.5. Research questions

An examination of prior literatures reveals the absence of studies that incorporates the utilization of hotel sorting and online review mechanisms on OTAs to enhance the customer experience. Similarly, the non-existence of marketing analysis, that guides a hotel to increase the sales and compete with other hotels in current competitive market, has been evident. This research seeks to address these gaps and provides the contribution to tourism industry to deal with the current situations.

Thus, this dissertation under the title of "A Mathematical Model for Customer Experience by Optimizing the Multidimensional Sequencing of Hotel Rooms and Customer Reviews on Online Hotel Booking Sites" aims to response with the following research questions.

- How to incorporate the service value creation and optimize a service system for online hotel booking?
- What are the characteristics of hotel and online review that satisfy the customer's expectation?
- How can the website design of OTAs enhance the customer experience? And if so, how to do?
- How can a hotel create the competitive advantage over competitors?

1.6. Research design

This dissertation is designed on the basis of *service value creation for the customers*. We propose the research direction to service dominant logic (SDL) which concerns more on the role of customer and service value determined by a customer. In a practical term, that means, rather than maximize the profit of OTAs and hotel, we mainly focus on the whole optimization of customer experience from using OTAs.

The service system of online hotel booking through OTAs is studied and then the optimization of service system could be achieved using the proposed approach. A mathematical model approach is selected to represent the overall problem and then used to solve the problem optimally. As shown in Fig. 1.3, adapted from a model of service system proposed in Kosaka and Shirahada (2014), the main actors in our study include the online customers, service providers including hotels and OTAs, and collaboration among them. According to the service value creation, we aim to present the whole optimization of customer experience using OTAs for searching and booking transaction. In such a system, the service value of the information service derived from OTAs and the accommodation service derived from a hotel will be incorporated.

The optimization of service system will be achieved using three main approaches as mentioned in the service model following; (i) for the approach to analyze customers, the survey method using questionnaire is used to observe the customer's behavior and their requirement during a hotel booking transaction, (ii) for the approach to co-create service value with customers, this research do not directly develop but we take the advantage from online review to study how customers participate to create excellent service in service system. (iii) For the approach to optimize service, this research mainly focus on this part. Specifically, the optimization model approach is developed to design the hotel sorting and online review mechanisms to maximize the customer experience.

The first outcome from this research is a framework that could promote the understanding of customer's behavior and profitable design of OTAs. The second outcome is an effective approach that helps OTAs making the real simulation for a better decision on the basis of service value creation for customers.

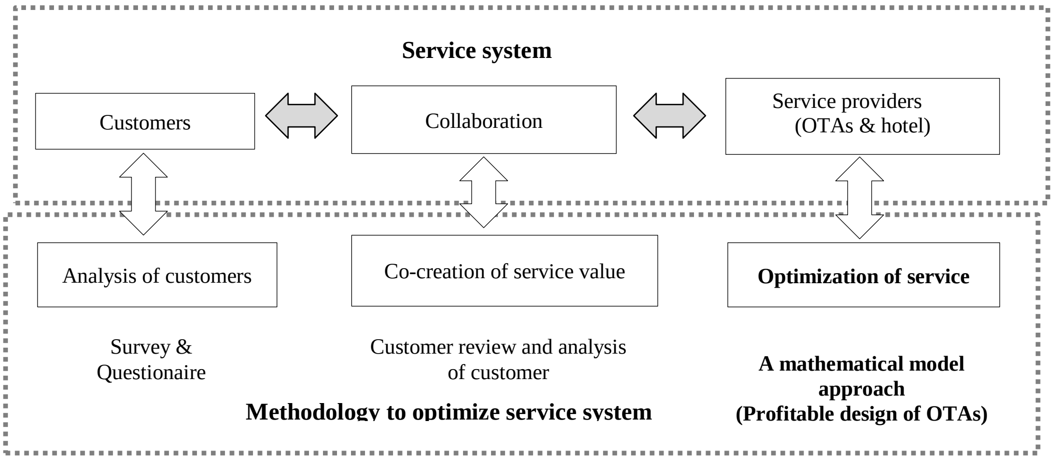


Fig. 1.3. Model of a service system for online hotel booking

1.6.1. Survey method

Survey method is conducted using questionnaire to understand the actual behavior and requirements of customers. The questionnaire is designed to cover the behavior and expectation of customers who use OTAs for information service and stay at hotel for accommodation service. The analysis of survey result is conducted to find the factors affecting on the customer's search behavior, hotel booking decision and overall satisfaction on a hotel. Also, the survey data is a source of customer data that will be used to develop a case study, and simulate with the proposed model.

1.6.2. The analysis of online review

In the part of co-creation of service value, this research does not directly deal with the co-creation value but we take the advantage from online review available on OTAs to study how customers participate to improve service value in a service system of online hotel booking.

1.6.3. A mathematical model approach

A mathematical model is applied to represent the problem as a whole picture. It is the main research methodology used to develop an efficient approach, for optimally designing the hotel sorting and online review mechanisms. Accordingly, the service system will be optimized to create the highest service value for a customer. The selection of approach is performed on the basis of (i) the application and reliability of approach in prior studies, (ii) the novelty of approach in the field of our study, (iii) the effectiveness of the approach to solve the stated problems, and (iv) the difficulty to adopt in the problem and practical application.

After a mathematical model is developed, a case study that simulates the process of online hotel booking using OTAs is investigated. The development of a case study considers a list of actual hotels presented on the selected OTAs, Hotels.com and Agoda.com. We take the advantage of actual data available on OTAs to evaluate the effectiveness of proposed approach with the current sorting mechanism of OTAs. This provides the opportunity to improve the proposed approach to better deal with the realistic cases. In a case study, we generate the customer profile from the survey data and simulate them to the situation of online hotel booking through the numerical experiments.

1.7. Significance and originality of the study

This research is important as it focuses on the understanding of customer's behavior in an online hotel booking transaction. It responses to the current situation and deals with the problem arising in e-commence and e-tourism. The main outcome from this study is a new framework that promotes the understanding of customers and profitable design of OTAs. Moreover, an effective approach that can deal with the problem of current OTAs mechanism is proposed. The actual customer data is observed through a survey and hotel information is collected from OTAs. Our proposed approach is tested with actual survey data to represent the realistic process of online hotel booking.

Interestingly, there are two main contributions made to the tourism industry. First, our findings provide the guideline for OTAs to manage the sequence of hotels and online reviews to response the customer's expectation. Second, our approach helps a hotel to evaluate their competitive position in current market and provides the direction of improvement to maintain competitive advantage over other hotels. This shows the application of our research in a practical way. Although our proposed model has carefully incorporated overall characteristics of online hotel booking through OTAs, it might not 100% reflect the reality behavior. However, none of the model in the research does cover 100% of reality. Thus, we believe that our study is far more advanced than prior researches and it is our belief that it closes to the realistic mechanism.

There are several unique points that set our study different from other prior literatures.

- Rather than optimizing the profit of service providers (e.g., OTAs and hotel), we mainly focus on the whole optimization of customer experience who uses OTAs for searching and online booking transactions. The multi-objectives based on the customer point of view are incorporated such as the minimum number of search steps, and the maximum utility gained from a selected hotel.
- An examination of prior literatures reveals the absence of studies that incorporates the utilization of hotel sorting and online review mechanisms on OTAs to enhance the customer experience. In this dissertation, we proposed a new approach, called a two-stage stochastic programming model, to deal with an optimal sequencing problem. This approach has been never applied in a similar problem but effectively deals with an uncertainty of customer in an online hotel booking.

To fulfill the gap of literatures, we develop an approach to design a sequencing of hotels and extend to design several situations such as sequencing with an optimal number of hotels and sequencing with online review selection.

- Prior literatures have some limitations to reflect the actual characteristics of online hotel booking. To fulfil the problem space of literatures, we incorporate various assumptions to propose a framework close to a realistic mechanism of online hotel booking. Specific details are discussed as following.
    - Most of prior sorting mechanisms ignored the number of choices which is necessary to response the human's cognition and decision process. Thus, an optimal number of hotel choices presented on OTAs is incorporated in our study. This idea provides a benefit to reduce search effort and facilitate the hotel booking decision.
    - The prior literatures ignored the customer's searching behavior. In our study, we adopt the assumption of search theory (e.g., sequential search behavior and non-sequential search behavior) to set the customer's searching process and hotel booking decision.
    - The impact of online review on the hotel booking intention was mentioned by several literatures. However, it is still unclear that how customers use the online review during the booking decision stage and which characteristics of online review can increase the customer's perception toward a hotel. Thus, this research aims to show the impact of online review, including its review rating and indicators, on hotel booking decision. Also, we propose a new framework to select a useful online review based on the customer-defined indicators (e.g., location, cleanliness, facility), which are never proposed up until now.

1.8. Structure of the dissertation

This dissertation is organized into eight chapters. This introductory chapter provides the research background, problem statement, research objective, research question, significance and originality of the study, research design and overview of the dissertation. The following chapters are structured as following.

Chapter 2 provides the summary of prior literatures on the customer's behavior on the online hotel booking through online travel agencies (OTAs). The related topics are listed and reviewed to find the problem space and reliable sources for our study.

Chapter 3 describes the outline of research methodology to show the overall framework of research conduction. Moreover, we provide the comparison of main ideas proposed in each chapter.

Chapter 4 analyzes the data obtained from questionnaires to study the customer behavior in an online hotel booking. The result of this chapter provides the guideline to develop a mathematical model and simulate through a case study of online hotel booking.

Chapter 5 investigates the design of the hotel sorting mechanism to enhance the customer experience comprising of search cost and utility gained from a selected hotel. The effectiveness of proposed model is confirmed through a case study using survey data and real information taken from OTAs. The interesting findings are discussed to derive the managerial insight and the practical implementation of the proposed model.

Chapter 6 presents the extension of Chapter 5 by designing the sorting mechanism of hotel and online review. The ideal online review management is adapted from the findings derived from prior researches. The effectiveness of proposed model is confirmed through a case study using survey data and real hotel information taken from OTAs. The proposed model in this chapter is developed to serve the website design of OTAs, such as Agoda.com, Expedia.com and so on, providing the standard feature of overall review rating, individual review rating and individual text comment.

Chapter 7 investigates the design of the hotel sorting mechanism and online review selection. The main objective of this chapter focuses on the minimum number of search steps when a customer performs a hotel booking transaction through OTAs. Specifically, we mainly concern the customer choice decision under a constraint of time. Also, the proposed model in this chapter is developed to serve the website design of OTAs, such as Hotels.com, providing the standard feature of overall review rating, individual review rating on various review indicators and individual text comment.

Chapter 8 summarizes the dissertation and highlights the findings. Also, we describe the contribution of research to tourism industry and academic field of knowledge science.

CHAPTER 2
LITERATURE REVIEW

The main content of this chapter is to summarize the prior literatures on the customer's behavior on the online hotel booking through online travel agencies (OTAs). Literature reviews are classified into six sections. Section 2.1 summarizes the factors that influence on the hotel booking decision and customer satisfaction. Section 2.2 discusses the characteristics of online review and its effect on customer's perception toward a hotel. Section 2.3 presents the application of optimization model in a common practice in e-commerce. Section 2.4 summarizes a two-stage stochastic programming (2SSP) approach proposed by prior literatures in many applications. Section 2.5 discusses the website interface design which is necessary for online shopping context. Section 2.6 reviews the approaches for a recommendation system. Section 2.7 provides the search theory and its application in customer choice model.

2.1. Hotel selection factor

In the context of hotel or accommodation service, the analysis of hotel selection factors has been widely investigated by many literatures as it provides the better understanding of customer's behavior in a hotel booking decision. Using the survey conducted at Tehran hotels, Sohrabi (2012) found that the protection and security, promenade and comfort, network services, staff and their services, news and recreational information, pleasure, cleanliness and room comfort, expenditure, room facilities and car parking are all perceived as the major attributes in a hotel selection. Lockyer (2005) studied the impact of price on the hotel selection decision through the survey of 42 participates. They found that price is one of hotel selection factors but it should not consider along with other attributes as it needs to do special consideration. Ekinci et al. (2003) studied the lodging service quality on the island of Crete using the modified SERVQUAL. They found that consumers perceive more value on the intangible service qualities than the tangible service qualities. Also, the location followed by the facilities, service quality, consumption prices, hotel reputation, exterior appearance and security are all the hotel selection criteria.

It is clearly found that the importance of hotel attributes on a hotel selection is perceived differently based on the customer's demographics such as the types of travelers (Yavas and Babakus, 2005), region (Li et al., 2013), and gender (McCleary et al., 1994). Types of travelers are commonly classified, on the basis of purpose and customer's profile, into five types of travelers, namely business, couple, family, friend or group and solo or leisure travelers. A number of researches investigated the hotel selection criteria of each type of travelers. Different types of travelers possess different preferences towards each hotel's attributes. For example, business travelers are extremely concerned on convenience of location and safety based on the survey of 150 Malaysia female business travelers (Hao and Har, 2014). Also, the study of Mccleary et al. (1993) indicated that cleanliness and location are perceived as the important attributes for business travelers. For the leisure travelers, it is found that the security, room rate and service quality of employee with personal interaction are the most concerned factors (Clow et al., 1994; Lewis, 1985; Parasuraman et al., 1988). The hotel selection criteria of couple are mainly determined by safety, quality of hotels and travel cost (Lee et al., 2010). Moreover, within the type of couple or romance traveler, two demographic variables of couple (i.e., age, and income), two travel characteristics (i.e., length of trip and budget), and three destination attributes (i.e., quality of hotel, nightlife entertainment and good place for shopping) are largely affected to a hotel choice decision for Taiwanese romance. Then, travelers who travel with family (family type) tend to more concentrate on "facility and safety" and "symbolic accessibility" than solo travelers based on a 1,996 survey of metropolitan Taipei, Taiwan (Lai and Graefe, 1999). Li et al. (2013) proposed a new technique, namely Choquet Integral (CI), to discover the preference of travelers through a case study of the Hong Kong hotel industry. They found that hotel selection criteria are varied among the types of travelers and countries. Divsalar et al. (2014) proposed a memetic algorithm to deal with a hotel selection problem. The proposed algorithm includes two levels; one focuses on determining a good sequence of intermediate hotel whereas six local searches deal with the selection and sequencing of vertices between the hotels. The effectiveness of proposed algorithm was shown through numerical experiments in term of computation time and quality of solution.

Several studies made a comparison of hotel selection criteria across the types of travelers, whereas business traveler and leisure traveler are the main types in comparison due to the large majority of potential travelers. Radojevic et al. (2015) studied the impact of hotel attributes, including star rating, convenience, and facility, on the satisfaction level across the types of customers. They found that solo traveler has higher baseline satisfaction level than family traveler. Using the survey method to Hong Kong tourists, Chu and Choi (2000) examined the perceived importance of six hotel attributes (i.e., service quality, value, business facility, room and front desk, food, and security) on hotel selection criteria between business and leisure travelers. The result reveals that both types of travelers have similar perception toward six hotel attributes whereas each attribute is perceived differently in an Importance-Performance Analysis (IPA) grid. However, in a hotel choice decision, room and front desk is the most important factor for business travelers whereas leisure traveler more concerns on the security of hotel. Yavas and Babakus (2005) found that general amenities of hotels are equally important for both business and leisure travelers. However, both travelers perceives differently on the importance of other attributes (i.e., core service, convenience, ambiance and room amenities). Specifically, business travelers are more concerned on convenience whereas leisure travelers are more concerned on core service as the second important factors.

Not only have the hotel selection criteria, a framework of customer satisfaction been studied based on the analysis of hotel attributes. Using the analysis of 540 survey results conducted from staying a hotel in Hong Kong, Choi and Chu (2001) examined the importance of hotel attributes on the satisfaction level and likelihood of returning to same hotels. They found that staff service quality, room qualities and value are the three most important factors to determine overall satisfaction and likelihood of returning to the same hotels. Using a text mining approach in an analysis of online reviews, Xu and Li (2016) found that types of hotels, including full-service hotels, limited-service hotels, suite hotels with food and beverage, and suite hotels without food and beverage, contribute to the customer satisfaction level. Anderson (2010) investigated on the hotel attributes that could determine the hedonic price of hotel rooms in Singapore’s market. They found that in-room safe, star rating, facility and amenities, food and convenience of location are all significant attributes to hedonic price. However, standard of room, facility, food, value for money, convenience of location are perceived as significant attributes based on customer feedback attributes. Deng et al. (2013) proposed a hotel customer index model (H-CSI) to estimate customer satisfaction toward international tourist hotels. Specifically, the proposed model incorporated the factors of consumption emotions into the prior model of American Customer Satisfaction Index (ACSI) model. Using the proposed H-CSI model, they found that service quality and perceived value are positively related to customer satisfaction, customer satisfaction is positively related to customer loyalty, and customer satisfaction is negatively related to customer complaints. Ren et al. (2016) investigated on the dimensionality of customer experience with budget hotel to determine the customer satisfaction using a mixed method of in-depth interviews and questionnaire. They found that tangible and sensorial experience, staff aspect, aesthetic perception, and location are all important factors contribute to customer satisfaction in a positive manner. Subramanian et al. (2016) studied the effect of operational capability and competitive market drivers to enhance customer satisfaction in the Chinese budget hotel. They found that all operational capability drivers (e.g., physical product, staff and services) highly contribute to innovative service satisfaction. For the marketing perspective, they suggest location and image should be priority factors to promote a hotel. For the business implication, they suggest that a budget hotel should mainly consider value drivers including physical product offering, selection of location, staff commitment, brand image and unique services. Brunner-Sperdin et al. (2012) examined the service factors that enhance the customer's emotional reactions and satisfaction in a hotel. They found that leisure experience, hardware and human ware influence on customer's emotional states in high-quality hotels resulting to customer satisfaction. Io (2016) conducted a survey of 500 casino-hotel visitors in Macao to examine their positive emotions with respect to their preference of hedonic activities and satisfaction at casino hotels. Using a discrete choice model, Román and Martín (2016) investigated the impact of hotel attributes (e.g., accessibility, food, security, room view, spa, check-in etc.) on the evaluation of hotel quality. The willingness to pay (WTP) and willingness to accept (WTA) were examined and estimated to forecast the customer choice decision. Using the survey of 400 respondents who stayed at hotel in Kuala Lumpur, Salleh et al. (2016) found the source of dissatisfaction toward a hotel service comparing the difference between the genders. The result reveals that gender play a significant effect to determine dissatisfaction. Specifically, female is more dissatisfied compared to male in the hotel attributes of receptionist, lobby except, guest room, rest room, restaurant, facility and hotel worker. However, male is more dissatisfied in the Wi-Fi services comparing to female.

2.2. Online review

Online review is a prevalent characteristic of online shopping representing the electronic word of mouth. For a hotel context, not only a hotel star rating, the service and quality of hotel can be evaluated by the customers who have actual experience on a hotel in forms of review rating, commonly scored by 1 to 5 or 10, and text comments to give the detail of experience (Fang et al., 2016). Nowadays, more and more travelers tend to read online reviews to make a better decision and reduce the perceived risk from unfavorable hotel experience (Gretzel and Yoo, 2008). It is reported that 97% of respondents looked at online review during a hotel booking decision whereas more than half of online reviews were observed from online travel agencies (OTAs) (Gretzel et al., 2007). Readers of online review perceive the importance of online reviews in the hotel booking decision. For example, reading the online review helps to enhance awareness of hotel, avoid unsatisfied hotels, and narrow down the hotel choices. Using the proposed eye-tracking approach, Noone and Robson (2014) found that a customer normally looks at hotel information (e.g., price, photo, star rating) and review rating during the process of hotel deliberation. Casaló et al. (2015) found that sorting a hotel by review rating has effect on the customer's booking attitude whereas a hotel presented at the top rating list are perceived higher booking intention than a hotel placed at the bottom of rating list. Moreover, review rating is perceived more useful and credible if observed from the well-known online travel communities such as Trip advisor. The extensive literature reviews related to online review of hotel can be found in Cantallops and Salvi (2014).

Online review has been perceived as the reliable source of travel information, and received attention by many researchers in the Internet era. A customer could evaluate a hotel on various attributes, commonly on value for money, location, staff service, room condition, and facilities. Overall review rating is perceived as the most important factor reflecting the hotel performance whereas review ratings for money value, location and cleanliness are the major attributes (Xie et al., 2014). Korfiatis and Poulos (2013) indicated that the different types of travelers (e.g., solo traveler, couple etc.) evaluate the indicators of online reviews (e.g., cleanliness, location, value, room, service, and sleep quality etc.) in different ways. This assumption was used to propose the recommendation approach of hotels based on a user-defined hierarchy of indicator importance. Liu et al. (2013b) analyzed the customer background and customer's expectation on the different trip modes using association rule mining. They found that some customers with the same backgrounds had different expectations of hotel factors when in different trip modes. For instance, older customers who did not care about money but wanted the best service had higher expectations of service when on business, but were less sensitive to it when traveling with family.

The hotel industry is well aware that online reviews have a strong impact on hotel booking decision. The effect of online review on the online travel sales was mentioned by many literatures. Singh and Torres (2015) indicated the positive relationship of review rating, number of review and online hotel sale. Öğüt and Taş (2012) found that a 1% increase in review rating could increase online hotel sale up to 2.68% in Paris and 2.6% in London. Ye et al. (2009) proposed a fixed effect log-linear regression model to determine the influence of online reviews (e.g., average rating, number of reviews, and variance of rating among reviews on first two pages) on the amount of online hotel sales. They found the relationship between online reviews and business performance of hotels. Torres et al. (2015) found that review rating, overall hotel ranking and number of online reviews could determine the online booking transactions and hotel revenue. Verma et al. (2012) indicated that positive ratings have a strong positive effect on a hotel booking intention.

The impact of online reviews on the booking intention has been studied with respect to review factors such as valence, target and content. It is commonly agreed that review-related factors are important, including the valence of reviews (e.g., Casaló et al., 2015), the volume of reviews (e.g., Ye et al., 2009), the target of review (e.g., Sparks and Browning, 2011) and the variation of reviews (e.g., Ye et al., 2009). The valance of reviews is essentially classified as positive review and negative review to show the nature of comments or opinions (Sparks and Browning, 2011). Valence sometimes refers to rating, scaled by 1 to 5 or 10, given by reviewers (Chevalier and Mayzlin, 2006). Positive valance is likely to be characterized by pleasant and vivid description of experience whereas negative valence is likely to included unpleasant experience and complaint (Anderson, 1998). Prior studies mentioned that the impact of positive valance and negative valence has been perceived differently by a customer (Sparks and Browning, 2011). Generally, the negative valence has the strong influence on booking decision than does positive valence (Casaló et al., 2015). Positive valence encourages the booking intention while negative valence creates the negative attitude of customer toward a hotel (Karakaya and Barnes, 2010; Lee et al., 2008). Sparks and Browning (2011) indicated that the positive valence enhances the booking intention and trust toward a hotel. However, a consumer is more influenced by early negative information, especially when the valence of reviews is negative. Also, they incorporated other reviews factors such as the target of review, framing of review and presentation of rating with written text. Casaló et al. (2015) conducted the experiments to examine the effect of positive and negative online review for travel product. They found more usefulness of negative review than positive review for a high-risk averse traveler. However, for positive review, expert reviewer, picture of travel product and well-known brand name are required to enhance the usefulness and reliability of positive review. Phillips et al. (2015) examined the characteristics of a hotel and online review (e.g. number of positive review) on the hotel performance.

Often times the focus of attention is the building a positive or useful online review using the analysis of online review characteristics. Elwalda et al. (2016) found that online review attributes, including perceived usefulness, enjoyment and understandability, influence on the customer's trust and booking intention. Liu and Park (2015) studied the factors affecting the perceived usefulness of online reviews in a travel product website. Two aspects of online information were examined including the characteristics of review providers (e.g., disclosure of personal identity, the reviewer's expertise and reputation), and reviews themselves including quantitative (e.g., star ratings and length of reviews) and qualitative measurements (e.g., perceived enjoyment and review readability). They found that the combination of the proposed aspects positively leads to the perceived usefulness of reviews. Qazi et al. (2016) analyzed the helpfulness of online reviews using the 1,500 reviews available on TripAdvisor.com across multiple hotels for analysis. They found that that the number of concepts contained in a review, the average number of concepts per sentence, and the review type contribute to the perceived helpfulness of online reviews. Specifically, review types and concepts have a varying degree of impact on review helpfulness.

2.3. Application of optimization model in e-commerce

In general, many optimization problems have been solved through a mathematical model approach, namely an optimization model. The application of optimization model is a common practice in the decision for e-commerce context mentioned by many theoretical and practical researches. Cooperation between a hotel and OTAs is prominent example in practice. In this case, the optimization model has been applied to make the optimal pricing decision for revenue management problem. An optimal decision on the unit commission to maximize the profit was determined through a pricing game model (Ling et al., 2014). Similarly, the economic game analysis was investigated to determine the unit commission fee on OTAs, and cash back value for a customer in order to maximize the OTA's profit (Guo et al., 2014). Also, the problem of dual-channel distribution systems (online and offline channels) require an optimization model to determine the optimal price and service level to generate the highest profit or lowest cost. Lu and Liu (2013) developed a competition model for a supplier who performs a dual channel distribution. The effect of several key factors, such as efficiency of e-channel, was examined and incorporated in a decision. Lau et al. (2010) developed a fuzzy location model to optimize the distribution system design in B2C e-commerce under the fuzzy variables (e.g., supply and demand). Furthermore, many approaches for a recommendation system were developed using an optimization model based on analysis of online review to find the best product to advertise for a customer (Nilashi et al., 2015). The maximum utility gained from a product was concerned in an online hotel recommender by Ghose et al. (2012). Kamiński and Szufel (2015) proposed an algorithm for the optimization of a simulation execution in the Amazon Elastic Compute Cloud (Amazon EC2) with a spot pricing mechanism. Using a proposed algorithm, the bidding strategy was analyzed to minimize the computation cost and time for running simulations on a system. This algorithm is ready for application to real life simulations executed on Amazon EC2.

2.4. Two-stage stochastic programming approach (2SSP)

Two-stage stochastic programming (2SSP) is a mathematical model approach to deal with the optimization problem under uncertainty parameters. A number of literatures from many research forums widely formulated the optimization problems as a two-stage stochastic programming model. Simic (2016) developed a multi-stage interval-stochastic programming model for planning end-of-life vehicles allocation. Uncertainties that are expressed as probability distribution and discrete interval are handled. The analysis of policies (e.g., economic penalties and system failure risk) was investigated. Shabani and Sowlati (2016) developed a hybrid, multi-stage, stochastic programming-robust optimization model to optimize the supply chain and reduce the cost for a forest-based biomass power plant. The uncertainty such as biomass quality was incorporated and handled. Valente (2016) proposed a configuration model to design reconfigurable robots for the high precision manufacturing industry. Accordingly, the production requirement is achieved by identification of robot architectures with the selection of type and number of robot module. Bagheri et al. (2016) proposed a stochastic programming model for the nurse scheduling problem (NSP) which deals with the uncertainties of demand and stay period of patient in a case study of Razavi hospital. The optimal scheduling was decided to minimize the overall assignment cost. Wang and Huang (2015) proposed a multi-level Taguchi-factorial two-stage stochastic programming (MTTSP) approach for the optimization problem of a water resource management. The decision deals with the parameter uncertainties and their interactions. Parisio and Jones (2015) applied a two-stage stochastic programming model for an employee scheduling problems under uncertainties of demand for staffs. Yeh et al. (2015) proposed a model for the analysis of new bio-refinery investment for an established timberlands supply chain at the maximum profit. The first stage deals with logistical decision around bio-refinery investment whereas the second stage deals with a bi-level timberlands model with parameter uncertainty.

2.5. Website interface design

The website design feature is a key factor determining the online hotel booking intention, customer satisfaction and e-Trust on OTAs. Utilitarian feature is a major component for a quality of website design which refers to the efficiency to support and fulfill what customer needs (Bilgihan and Bujisic, 2015).

A product sorting feature was mentioned within the website interface design by many literatures. The design of product list is the useful presentation on an online shopping website (Hong et al., 2004). The product list and web interface design plays an important role to the online shopping behavior as a customer evaluates the products based on information available on the screen of websites (Bettman et al., 1990; Tam and Ho, 2005). Most customers generally search for a few choices on a list of available choices in which a choice ranked on the upper position are more attractive (Tam and Ho, 2005). The importance of order effect (e.g. position effect & sorting effect) on the online retailing and search behavior was clearly examined (Cai and Xu, 2006; Diehl and Zauberman, 2005). Tam and Ho (2005) revealed that the presence of sorting could attract customer attention in which 37.50% of subjects were clicked when available on top sorting cue while only 15.19% of same subjects were clicked when available on without sorting cue. Also, the human attention is limited when facing with a long list of available choices.

Designing the number of available products presented on the Website is related to the human's cognitive load and decision process. It is important especially on OTAs collecting a million of hotels around the world. The suitable number of choices should be considered to response the limitation of human cognition. Diehl and Zauberman (2005) found that the order of choices and amount of search have effect on the quality of choices. Specifically, the declining order leads to the higher quality of choices when the amount of search is limited. Iyengar and Lepper (2000) found that customers were likely to purchase products when the number of available choices was small at six choices rather than up to thirty choices. Pan et al. (2013) proposed the eye tracking to examine the effect of the number of options and image on the human's attention and hotel booking decision. They found that the suitable number of hotel options and presentation of hotel image should be achieved.

2.6. Recommendation approach

The recommendation system is a useful tool to recommend the attractive choices. It facilitates the process of information, resulting in shorter lead-time for a booking and tailoring customer's preference (Nilashi et al., 2015). Senecal and Nantel (2004) found that online product recommendations influence customer choices and also that online retailer recommender systems have a greater effect on the potential choices than recommendations from human experts or other customers.

The development of recommendation system for online shopping has become a pressing issue, enabling an online customer addressing information overload. Several approaches have been developed to predict the customer's preferences whereas the most classical recommendation systems are based on user-generated content (e.g., social media and online reviews) and collaborative filtering (Ghose et al., 2012; Konstan and Riedl, 2012). Most of the existing approaches on the recommendation system concentrate on the multi-selection criteria and propose the utility or the satisfaction model to predict a good hotel. Liu et al. (2013a) proposed a novel recommendation algorithm based on the analysis of online reviews in a case of restaurant industry. In regard to research on tourism, Korfiatis and Poulos (2013) considered the different indicators of online reviews (e.g., cleanliness, location, service etc.) across traveler types. They proposed a demographic recommendation systems based on a user-defined preference criteria. Nilashi et al. (2015) incorporated the multi-criteria collaborative filtering techniques to enhance the predictive accuracy of the hotel recommendation systems. Ghose et al. (2012) proposed a new hotel ranking system by mining the user-generated and crowdsourced content to recommend the best value hotel. Ngai and Wat (2003) proposed the hotel advisory system using a fuzzy expert approach for the hotel selection. Nilashi et al. (2015) developed the multi-criteria collaborative filtering recommender system for hotel recommendation using Gaussian mixture model with Expectation Maximization algorithm and Adaptive Neuro fuzzy Interface System. Other approaches for developing a recommendation system can be found in Ładyżyński and Grzegorzewski (2015), and Vansteenwegen and Souffriau (2010). There is also the recommendation approach of Liu and Yang (2015) and Mao et al. (2015) which is mainly based on the ranking algorithms.

Moreover, the high volume of unnecessary online review makes confusion for an online customer to evaluate the best product. A mechanism to select the useful online review based on the user-preference criteria is necessary but still scare. While the main characteristics of useful online reviews have been analyzed extensively (for example, by Liu and Park, 2015), only one mechanism for ranking online reviews has been proposed (Ghose and Ipeirotis, 2007). However, this mechanism ignores user-preference criteria in the online-tourism context.

2.7. Search behavior

Search theory has a theoretical contribution to understand the customer behavior, motivated by many research forums of the marketing and human behavior. Search is a major activity before making a purchase decision. “Non-sequential search model” and “sequential search model” are commonly used to deal with the customer choice and search problem. The assumption of each model has its advantages and limitations. In the assumption of non-sequential search model, a searcher determines the fixed number of sample size, screen them, and decide the best one at the single period (Grosfeld-Nir et al., 2009; Stigler, 1961). The problem is to determine the optimal sample size at the linear search cost. A searcher can achieve a best-choice decision with the highest expected utility (or search offer). However, this model has limitations to adopt in a realistic search problem, especially when search cost is expensive, or when a searcher faces the constraint of time on decision (Morgan, 1983; Krishnan, 2007). Thus, the sequential search model is more appropriate as it makes an optimal decision on the balance of search cost (including time) and utility (search offer) based on each curriculum (Feinberg and Johnson, 1977; Lippman and McCall, 1976). Also, in an online hotel booking, some customers may not observe all hotels on the website and expect the best hotel with the highest expected utility, but simply make a satisficing decision under constraint of time (e.g., business traveler).

The assumption of “sequential search model” is commonly assumed in most search problems, such as shopping online (Chhabra et al., 2014; Zwick et al., 2003; Grosfeld-Nir et al., 2009), job search (Lippman and McCall, 1976), residential search (Phipps and Laverty, 1983), choosing a mate (Cheng et al., 2014), and other search problems (Müller, 2000; Mak et al., 2014). Accordingly, the use of this assumption has a justification, commonly discussed by mathematical theorems. Under this assumption, a single candidate is selected from a set of n candidate choices. Candidates are evaluated in random order in which a decision at each step is either to accept a candidate and receive a search payoff or continue to search and incur a search cost (Zwick et al., 2003). The problem with this approach is on determining an optimal control limit for an optimal stopping rule (e.g., reservation level). Using an experimental methodology for analysis of the actual search behavior in job search and apartment search problems, the results revealed that most of respondents tended to search sequentially in an optimal way as the search theory (Braunstein and Schotter, 1982; Phipps and Laverty, 1983). These results strongly supported the consistency of sequential search's assumption and actual search behavior. Specifically, the experiments conducted by Phipps and Laverty (1983) assumed that the subjects used the optimal utility cutoffs to terminate searching and choose an apartment. By analyzing the error from optimal stopping, the result revealed that most of subjects tended to decide a choice decision and continue searching in the optimal way. Feinberg and Johnson (1977) examined the superiority of "sequential search" over "non-sequential search" based on the distribution of search cost. The findings show the superiority of sequential search in term of net expected return, especially in the middle range of search cost.

Furthermore, the sequential search can simplify the model, and lead to an optimal decision within the acceptable computation time. These are the main reasons that the sequential search model has been adopted in many applications.

In general, it is difficult to conclude that which model is the best. As our setting for customer search behavior in the Internet, a sufficient number of similar literatures adopted the assumption of "sequential search behavior" as summarized following. In the study of Grosfeld-Nir et al. (2009), the fixed-sample size with sequential search was assumed to decide the optimal control limit (e.g. the highest price a searcher is willing to pay) with a sample size (optimal number of observed stores) used in a traditional online shopping. Chhabra et al. (2014) assumed that a searcher engaged in sequential search and adopted the reservation value to find a used car in the electronic marketplace. Zwick et al. (2003) investigated sequential search behavior in a generated-secretary problem in which searching an apartment over the online real estate websites was simulated.

To exemplify the sequential search behavior, a simple case that a searcher decides to terminate searching and choose one of n available choices is considered. In the searching process, it is common for a searcher to make a tradeoff between search cost and offer to maximize the expected benefit. The optimal stopping rule has been used and often determined by "a reservation strategy", where a searcher rejects all offers below a certain threshold (called reservation value or optimal cutoff point), continues searching at a cost, then terminates searching and accepts any offer above a certain threshold. The common example is the job search problem. A job searcher has to decide the time to stop interviewing and accept a job, otherwise, remains unemployment. That is, if a job searcher perceives that his ability is high, he will reject all offers below his expectation and remain unemployment. However, if the search cost is high, a searcher will limit the amount of his search activity. Under these assumptions, Lippman and McCall (1976) assumed that the optimal search policy for a job searcher is to reject all jobs that offers are below a critical value (reservation wage), and accept a job that offers are above this critical value.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter describes the outline of research methodology to show overall process of research conduction. The steps of research activities are summarized in Fig. 3.1 and detail description is provided in Section 3.1. In briefly, the research methodology applied in this research includes (i) the survey which aims to understand the actual behavior and requirements of customers, (ii) a mathematical model approach which is applied to represent the problem and develop an efficient approach to better deal with the current situation of online hotel booking. The development of case study from survey data is conducted to simulate the process of online hotel booking and test the effectiveness of proposed model.

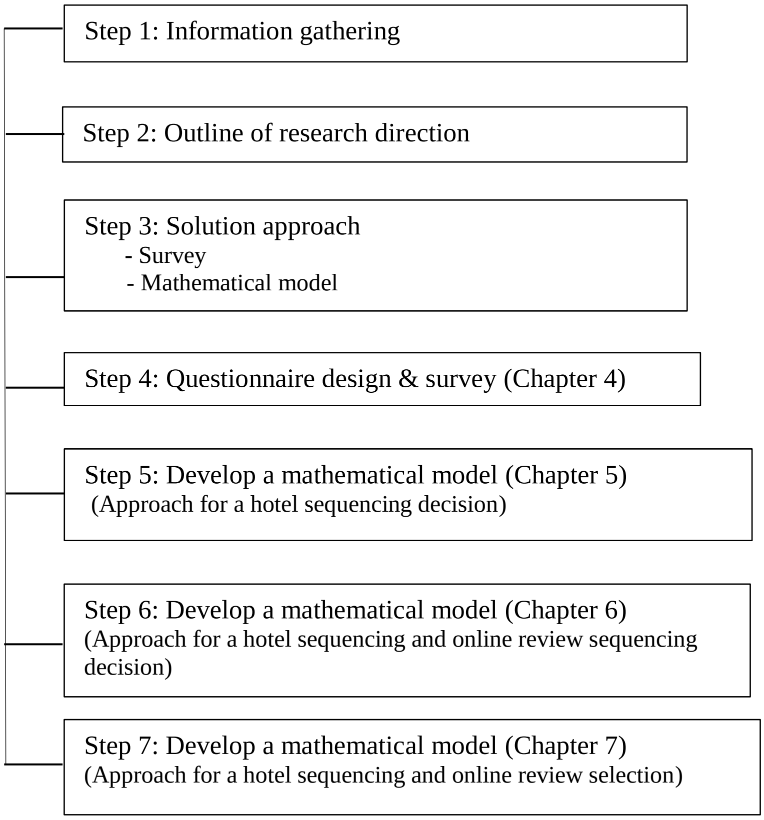


Fig. 3.1. Outline of research methodology

In this dissertation, the full utilization of hotel sorting and online review mechanisms is mainly concerned. The benefit in the viewpoint of customers (i.e., maximum utility from a selected hotel and minimum number of search steps) is focused. Accordingly, three models are proposed. The differences of three models are summarized in Table 3.1. The first model (Chapter 5) mainly focuses on a sorting approach for hotel choices. This is the main model covering the basic idea of this dissertation. The extension of Chapter 5 that aims to incorporate full scale of parameters, mainly on the parameters of online reviews, is presented in Chapter 6 and Chapter 7.

That is, the extension of first model by incorporating the sorting approach for online reviews is presented in the second model (Chapter 6). The third model (Chapter 7) incorporates the hotel sorting and online review selection mechanisms. It is observed that each OTA has specific feature to present online reviews. Thus, in Chapter 6 and 7, the decision of online review management is made on the basis of different perspectives. For instance, Chapter 6 considers the website design of Agoda.com whereas a sorting criterion of online review focuses on the characteristic of online reviews (e.g., target and valence). On the other hand, Chapter 7 considers the website design of hotel.com whereas a selection criterion of online review focuses on the review rating on each review indicator (e.g., cleanliness, location etc.).

Thus, three models share some similar characteristics while maintain unique points based on the purpose of study. Accordingly, the formulation of model and application are slightly different to response the website feature of different OTAs. For example, OTAs could adopt model presented in Chapter 5 to design the sequence of hotels and to improve the accuracy to match a hotel with customer’s expectation. However, if OTAs aim to manage the sequences of hotels and online reviews, the model presented in Chapter 6 and Chapter 7 could guideline the sorting strategy, depended on the sorting feature of OTAs. It is difficult to conclude that which model and assumption is the best, but we believe that three proposed models are far more advanced than most models proposed in the literatures. In summary, this dissertation provides a new perspective of profitable design of OTAs.

Table 3.1
Outline of three proposed models

Content	Chapter 5	Chapter 6	Chapter 7
Decision	(i) Hotel sorting decision	(i) Hotel sorting decision	(i) Hotel sorting decision
	-	(ii) Online review sorting decision	(ii) Online review sorting decision
Sorting criteria of hotel	Multidimensional preferences of customers	Multidimensional preferences of customers	Multidimensional preferences of customers
Sorting criteria of online reviews	-	Characteristics of online review: Framing, valence, target, variation,	Review rating on customer-defined indicators (e.g., location, cleanliness etc.)
Feature of OTAs	Hotel information and overall review rating (e.g.,Agoda.com, Hotels.com)	*Hotel information* *Online review board:* Overall review rating, individual review rating, individual text comments (e.g., Agoda.com)	*Hotel information* *Online review board:* Overall review rating, individual review rating on various indicators (e.g., location, cleanliness, food), individual text comments (e.g., Hotels.com)
Main objective of customers	Maximum utility of hotel Minimum search cost Minimum ranking position of a selected hotel	Maximum utility of hotel Minimum search cost Minimum ranking position of a selected hotel	Minimum number of search steps

3.1. Research activities

Step 1 Information gathering

Step 1.1 Collecting the information

The related information from various sources (e.g., OTAs, statistics, and news) is observed to understand the background and current situation of online hotel booking.

Step 1.2 Classifying and summarizing prior literatures

The topic of online hotel booking has been widely discussed over a last few decades. A number of prior literatures are reviewed and then classified into a category of similar topic. The content of study and interesting findings from prior literatures are summarized to capture the overall existing studies and limitations of researches.

Step 2 Outline of research direction

Step 2.1 Defining the research topic, problem statement and objectives

Firstly, a tentative title of dissertation is proposed according to the research interest as

“A Mathematical Model for Optimizing Customer Experience through the Multidimensional Sequencing of Hotel Rooms and Customer Reviews on Online Hotel Booking Sites”

Under this title, the mathematical models are developed to response the research questions which are (i) an optimization model for designing a sequence of hotels on the website, (ii) an optimization model for designing the sequence of online review.

Secondly, the problem statements are defined to reflect the current situation of online hotel booking under the scope of the study. Then, the research objectives are set to find the suitable approach to achieve such a goal.

Step 3 <u>Problem criteria and solution approach</u>

To find the suitable approach, we need to understand the elements of problem and objectives of research. The problem criteria are mainly classified into customers and website design.

(i) The problem of customers, needed to be considered, includes the searching behavior, preferences, expectation, budget and time constraints and hotel booking decision process.

(ii) The problem of Web site design, needed to be considered, includes the sequence of hotels and online reviews, number of hotels shown on the website.

Solution approaches are selected to deal with the problem criteria including a survey and a mathematical model approach.

(i) Survey method is conducted to understand the actual behavior and requirements of customers from their online hotel booking experience. Also, it collects the customer data used to test a mathematical model approach. The steps of survey will be described in Step 4.

(ii) A mathematical model is applied to represent overall problems. The strategy to map a problem is adopted from prior literatures. Using a mathematical model, an efficient approach is proposed to decide the website design optimally (e.g., sequencing of hotels and online reviews, number of hotels). The steps to develop a mathematical model will be described in Step 5.

Step 4 <u>Questionnaire design and survey</u>

We use the survey method as one of the research approaches to collect the information related to the online hotel booking experience. The objectives of survey are to observe the customer's behavior and find the factors affecting on the online hotel booking decision. The questionnaire is distributed to Thai customers. According, the analysis of data is conducted using SPSS statistic tool. The detail of questionnaire (English version) is provided in Appendix A, and the analysis of data is summarized in Chapter 4.

Step 5 <u>Model development: A mathematical model for designing the sequence of hotels (Chapter 5)</u>

This step describes an optimization model approach to decide an optimal sequencing and number of hotels. This model mainly focuses on the recommendation mechanism of hotels.

Step 5.1 <u>Literature review about an approach for sequencing and recommendation of product choices</u>

The recommendation approach and sequencing model in online hotel booking and e-commerce are reviewed in details.

Step 5.2 <u>Propose an approach "Two-stage stochastic programming model (2SSP)"</u>

The selection of approach is performed on the basis of (i) the application and reliability of approach in prior studies, (ii) the novelty of approach in the field of our study, (iii) the effectiveness of the approach to solve the stated problems, and (iv) the difficulty to adopt in the problem and practical application. As a result, we decide to apply a two-stage stochastic programming model to solve the stated problems as it satisfies our criteria.

Step 5.3 <u>Formulate the problem as a mathematical model</u>

Step 5.3.1 Actor and framework

We draw the model framework to summarize the whole picture of online hotel booking transaction. In our study, the main actors include a number of hotels, OTAs and customers. These actors are incorporated in the model under the conditions to represent the realistic mechanism. For example, a number of hotels are presented on OTAs in the sorting feature with the hotel information and online review. The sequence of hotels is presented on OTAs before the customers who have specific requirements come at the site. A number of customers come in a random order and a customer coming first has a priority to book first.

Step 5.3.2 Parameter and decision variable

The elements of each actor are represented by the notations classified into an input parameter and decision variable. Note that a parameter represents input data while decision variable represents the expected output. For example, the input parameter of hotel includes price, star rating, review rating and supply of rooms while its decision variable includes the ranking positon that will produce the good solution.

Step 5.3.3 Assumption and constraint of model

The behavior of actors under a realistic mechanism is managed using assumption and constraint. For example, the customer's booking decision is controlled by the assumption that a customer will observe a hotel in a list sequentially and book a hotel that all attributes satisfy with their requirements. A nature of inquires during booking decision is controlled with the constraint. For example, a customer has budget constraint and expectation; a hotel holds limitation of rooms and one sorting position on OTAs will present only one hotels.

In summary, we incorporated the assumption of non-sequential and sequential search behavior to manage the searching and booking behavior of customers in our study. Also, we stated the essential constraints classified to (i) customer constraints and (ii) sequencing constraints.

Step 5.3.4 Objective

The objective of model is stated to find the optimal solution. In this model, three objectives are incorporated into one term, called a composite score.

Objective function: Minimum of composite score (Lowest is preferred)

(1) Minimum search cost

(2) Maximum utility gained from a hotel above the reservation price

(3) Minimum position of hotel selected by customers (good hotel is recommended in the top position)

Step 5.3.5 Stage of decision

Following the realistic mechanism, the sequence of hotels is prepared in advance on OTAs before a customer comes. Then, the customers will observe a hotel and make a booking decision based on the presentation of a given sequence. Thus, the stage of decision is divided into two stages;

(1) First-stage decision: includes a decision on sequence of hotel and number of hotels on the website.

(2) Second-stage decision: includes a decision on customer choice.

Step 5.4 <u>Develop a case study</u>

The case study is developed to simulate the process of searching and booking a hotel using OTAs. We develop a case study by considering the actual hotels located in Chachengsao province, Thailand. The hotel information and a list of hotels sorted by current mechanism of OTAs were taken from OTAs, Hotels.com. We take the advantage of actual data (e.g., number of hotels, a list of hotel sorted by OTAs) available on OTAs to evaluate the effectiveness of proposed approach with the current sorting mechanism of OTAs. This provides the opportunity to improve the proposed approach to better deal with the realistic case. In the case study, we generate the customer profile from the survey data and simulate them into the situation of online hotel booking. We expect that the numerical results derived from a case study may provide the managerial insight to tourism industry.

Step 5.5 <u>Code the model in the optimization software</u>

The optimization software, namely IBM ILOG CPLEX version 12.6, is applied to solve the problem optimally. The coding process requires two main parts which are model file and data file. The model file includes the codes of input parameters, decision variables, objective function, and constraint to represent a model of research. The data file includes the codes that links the input data in specific excel worksheet with the optimization solver. After completed coding, the problem can be solved optimally. The testing of model is required to check the correction of result and effectiveness. The program source code is provided in Appendix B-1.

Step 5.6 Conduct the numerical experiments

We used the information of a case study to conduct the numerical experiments. The customer profile and requirements were generated from survey data by Monte Carlo sampling method. The hotel information taken from OTAs was used to simulate the customer's booking decision. After verify the model, we design the numerical experiments mainly on; (1) To find the optimal sequence of hotels with an optimal number of hotels shown in the website. (2) To show the effectiveness of proposed model compared with the current sorting mechanism of hotel. (3) To find the managerial insight that can promote the understanding of profitable design of OTAs. (4) To adopt an approach in the practical implication.

Step 5.7 Solution analysis

The solution is analyzed in following aspects.

(i) Minimum composite score (defined by objective function)

(ii) Computation time (second)

The results from the proposed approach are compared with the existing OTAs mechanism.

Step 5.8 Outcome

The main outcome derived from these steps is an effective approach that helps OTAs designs the optimal sequence with number of hotels. Also, this approach provides the application to guide the direction of improvement to maintain competitive advantage to a hotel. It provides a framework that promotes the understanding of customer's behavior and profitable design of OTAs as a whole.

Step 6 Model development: A mathematical model for designing the sequence of hotels with available sequence of online reviews (Chapter 6)

The sequence model with the number of hotels (in Chapter 5) is extended to incorporate the sequence of online reviews. Thus, this study focuses on the hotel recommendation and online review mechanisms. The steps to develop the approach are described as following.

Step 6.1 Literature review about the online review management

An examination of prior literatures reveals the absence of studies that designs a mechanism of online review. Most of literatures examined the effect of online review on booking decision and online sale. Thus, we adopt the findings from prior literatures, mainly from Sparks and Browning (2011), to design our online review mechanism. This investigation provides a new framework to examine the findings of prior literatures whether it is correct.

Step 6.2 Propose the mathematic model approach

We selected the approach on the basis of criteria described in step 5.2. As this approach is the extended version of the first model, we incorporate another mathematical approach, called goal programming model to solve the problem. Thus, the mathematical model techniques for this study includes

(1) Two-stage stochastic programming model (2SSP)

(2) Goal programming model

Step 6.3 Formulate the problem as a mathematical model

The formulation of this model is similar to the one described above.

Step 6.3.1 Actor and framework

Step 6.3.2 Parameter and decision variable

In this model the parameters of online reviews are added into the previous version (e.g., target and valence of online review). The ranking position of online reviews is the additional decision variable.

Step 6.3.3 Assumption and constraint of model

We incorporate the assumption of non-sequential and sequential search behavior to manage the searching and booking behavior of customers in our study. Also, we state the essential constraints classified into (i) customer constraints, (ii) sequence constrains of hotels and online review constraints.

Moreover, we mainly adopted the findings from Sparks and Browning (2011), to set as the desired goal of the ideal online review mechanism. The assumptions of online review mechanism incorporate (i) target of review, (ii) frame of review, (iii) valence of review, (iv) variation from overall rating. The details are provided in Chapter 6.

Step 6.3.4 Objective

The objective of model is stated to find the optimal solution. In this model, five objectives are incorporated into one term, called a composite score.

Objective function: Minimum of composite score (Lowest is preferred)

(1) Minimum search cost

(2) Maximum utility gained from a hotel above the reservation price

(3) Minimum position of hotel selected by customers

(4) Minimum deviation from desired goal of ideal review mechanism

(5) Maximum review rating of online reviews selected to show on the website

Step 6.3.5 Stage of decision

Following the realistic mechanism, the stage of decision is divided into two stages

(1) First-stage decision: a decision on the sequence and number of hotels, and sequence of online reviews

(2) Second-stage decision: a decision on the customer choice.

Step 6.4 Develop a case study

We develop a case study by considering the actual hotels located in Kanchanaburi province, Thailand. The hotel information, a list of hotels and online review sorted by current mechanism of OTAs were taken from OTAs, Agoda.com. The customer profile is generated from the survey data. The online hotel booking is simulated using the information of the case study.

Step 6.5 Code the model in the optimization software

The optimization software, namely IBM ILOG CPLEX version 12.6, is applied to solve the problem optimally. The program source code is provided in Appendix B-2.

Step 6.6 Conduct the numerical experiments

Step 6.7 Solution analysis

The solution is analyzed in following aspects.

(i) Minimum composite score (defined by objective function)

(ii) Computation time (second)

Step 6.8 Outcome

The main outcome derived from these steps is an effective approach that helps OTAs designs the optimal sequencing of hotel and online review. Also, this approach provides the direction to examine the findings from prior literatures.

Step 7 Model development: Mathematical model for designing the sequence of hotels with online review selection (Chapter 7)

This model mainly focuses on the recommendation mechanisms for hotel and online review. The steps of model development are quite similar with the steps described in Step 5. The program source code is provided in Appendix B-3.

CHAPTER 4
FACTOR AFFECTING ON ONLINE HOTEL BOOKING DECISION

This chapter investigates the main factors that influence the hotel booking decision through online travel agencies (OTAs). The survey is conducted to Thai customers who have the experience on online hotel booking. The analysis of survey result is conducted to find the factors affecting on the hotel booking intention, and to collect the customer data for a case study used to test the proposed model. This chapter guides the design of the website to satisfy the customer behavior.

4.1. Introduction

With the emergence of the Internet, a number of customers tend to use online travel agencies (OTAs) for information searching process and hotel booking transaction. A quality of hotel information content along with the website interface design has been the critical aspects that could increase the hotel booking intention. It is essential for any OTAs to understand the customer behavior and the hotel selection criteria. Accordingly, OTAs could customize the hotel information along with the friendly website design to match with the customer's preferences.

4.1.1. Stage of customer behavior

In this chapter, we consider the customer behavior in the process of information searching and hotel booking decision. Thus, the description of customer behavior is divided into two terms. In the first term, customer behavior study is based on the "*customer's search behavior"*, which the customers search for hotel information through OTAs, and use OTA's functionality (e.g., sorting mechanisms of hotels and online reviews) during searching process. In this point of view, we design the questionnaires to observe how customers use OTA's sorting mechanisms during searching process, which elements customer searching for, and how much amount of search activity. In the second term, customer behavior study is based on the "*customer's hotel booking decision*" or customer's choice decision, which describes how the customers compare and evaluate the hotels and how they make a hotel booking decision. In this point of view, we design the questionnaires to observe how customers evaluate the hotels and what factors are important on a hotel booking decision.

4.1.2. Target customers

Considering as the online market, a large number of online customers around the world come to use OTAs conveniently. Thus, the target of customers for OTAs is the group of online customers whereas most of them vary in preference and expectation. Accordingly, it is essential for OTAs to capture the characteristics of customers as a whole so that provide service meeting the expectation of overall online customers. Thus, our customer behavior study is mentioned on basis of overall customer behavior and types of traveler, rather than the individual customer behavior.

In this study, we aim to find the factors affecting on hotel booking decision through OTAs. Apart from the prior literatures, we incorporated the customer attitude toward online reviews and sorting design of hotel lists and online reviews. This study was conducted through survey method, and the analysis of results was used to suggest OTAs for their website design.

The following sections of this chapter are organized as following. The research methodology is shown in Section 4.2. The analysis of result is reported in Section 4.3. We conclude the findings in Section 4.4.

4.2. Research methodology

4.2.1. Questionnaire design

The questionnaire was designed to observe the customer’s behavior and find the major factors affecting on the online hotel booking decision. Also, the customer data was used to develop a case study for the numerical experiments.

The questionnaire consisted of twenty-six questions classified into five main parts.

- In the first part (Personal background), the respondents were asked to provide their general information.
- In the second part (Hotel selection criteria), the respondents were asked to indicate the factors affecting on the hotel booking decision.
- In the third part (Hotel booking experience using OTAs), the questions on the experience of hotel booking using online travel agencies were designed. Only the

respondents who have the experience were asked to complete the questions, otherwise they can skip and go to the fourth part.

- In the fourth part (Recent hotel booking experience), the respondents were asked to provide the information related to their recent trip. Specifically, they were requested to evaluate their recent experience on a hotel.
- In the fifth part (Attitude toward online review), the respondents were asked to express their attitude toward the online reviews available on OTAs.

The choices in the questionnaire (e.g., hotel attributes, online review indicators, element of the website) were adapted from prior literatures and from online travel agencies such as Agoda.com and Hotels.com. Moreover, we adapted the standard measurement scales to evaluate the respondent's opinion. That is, the respondents were requested to indicate the level of importance on the hotel attributes and review indicators using a five-point Likert-type scale (1 = Very unimportant, 2 = Unimportant, 3 = Neutral, 4 = Important, 5 = Very important). Moreover, the respondents rated a score to evaluate a hotel using a five-point Likert-type scale (1 = Very poor, 2 = Poor, 3 = Neutral, 4 = good, 5 = Very excellent).

The detail of questionnaire (English version) is provided in Appendix A, the analysis of result is summarized in Section 4.3, and case study using the survey data will be developed in Chapter 5.

4.2.2. Data collection

The number of questionnaires were distributed via online and offline channel to collect the information, mainly, from Thai customers during November 3 to 19, 2014. Specifically, the online survey was conducted with a wide range of Thai people over the social network during November 8 to 19, 2014. Also, the questionnaires were hand distributed to the employees of TMB bank at Chatuchak headquarter and Kasikorn Bank at Empire Tower branch, Thailand during November 3 to 9, 2014. Then, Forty–nine questionnaires were completed from online survey and seventy-one questionnaires were collected from offline survey. Thus, the total of 120 questionnaires was used for our analysis of results.

4.3. Analysis of survey results

The survey was conducted to Thai customers whereas total of 120 questionnaires were completed. The respondents, who participated in this study, included females (60.8%) and males (39.2%). Ages varied from 20 to more than 50 years old. The majority of respondents graduated bachelor degree (71.2%) and master degree (24.6%). Most of respondents (31.6%)

have average monthly income less than 20,000 Baht whereas 27.2% of respondents have average monthly between 20,000 to 39,990 Baht. According to the purpose of travel or type of travelers, most of respondents were family (43.57%) and friend (32.96%) whereas couples, solo traveler and business traveler were accounted for 15.08%, 5.59% and 2.79%, respectively. The 39.8% of respondents use the Internet less than 3 hours per day. More than half of the respondents (52.5%) reported the online hotel booking experience through OTAs whereas most of respondents (69.8%) used the online travel agencies for searching and booking transaction one to two times per year. The demographic characteristics of respondents are summarized in Table 4.1.

Table 4.1
The demographic characteristics of the respondents.

Variable	Range	%	Variable	Range	%
Gender	Male	39.2%		Family	43.57%
	Female	60.8%		Couple	15.08%
			Type of Traveler	Friend	32.96%
	20-30	33.33%		Solo traveler	5.59%
Age	31-40	17.1%		Business	2.79%
	41-50	29.91%			
	Above 50	19.66%		< 3 hours	39.8%
			Internet usage	3-5 hours	31.4%
	High school	0.8%	(per day)	6-8 hours	16.9%
Education level	Collage certificated	2.5%		> 8 hours	11.9%
	Bachelor degree	71.2%			
	Master degree	24.6%	Online hotel booking experience	Yes	52.5%
	Doctoral degree	0.8%		No	47.5%
	< 20,000Baht	31.6%		1-2 times	69.8%
Monthly income (Baht)	20,000-39,990 Baht	27.2%	Using the online travel agencies (per year)	3-4 times	15.9%
	40,000-49,990 Baht	8.8%		5-6 times	9.5%
	50,000-69,999 Baht	16.7%		> 9 times	4.8%
	≥ 70,000 Baht	15.8%			

In this part, the respondents were asked to indicate the purposes of using OTAs service. According to Table 4.2, the respondents show that searching for the hotel information

(81.7%) and making an online hotel booking transaction (50%) are the main purposes of using OTAs service. Also, 44.2% of respondents read the online reviews available on OTAs when searching the hotel information.

Table 4.2
Purpose of using online travel agencies

Transaction	%
Search information	81.7%
Online booking	50%
Read review	44.2%
Review a hotel	10.8%
Others (e.g., find promotion)	2.5%

The elements of OTAs site have effect on the online shopping intention. In this part, the respondents were asked to indicate the important level of website elements on the booking intention, using a five-point Likert-type scale (1 = Very unimportant, 3 = Neutral, 5 = Very important). As shown in Table 4.3, the respondents normally agreed with the importance of all proposed elements with the mean score of importance higher than 3.5. Specifically, the convenient usage, variety of hotel choices and hotel information are the top elements of OTAs which contribute to the online booking intention. Also, sorting the hotels plays an important role on online booking intention with the mean score of importance at 4.00.

Table 4.3
Elements of website on online hotel booking intention

Element	Mean	Std.dev
Hotel information and photo	4.22	0.83
Variety of hotels	4.22	0.77
Sorting methods	4.00	0.79
Online review	3.90	0.79
Convenience	4.40	0.74
Required information for booking transaction	4.18	0.79

The hotel selection criteria play an important role to determine the customer choice decision. In this part, the respondents were asked to indicate the important level they perceived on the hotel attributes when making a hotel booking decision, using a five-point Likert-type scale (1 = Very unimportant, 3 = Neutral, 5 = Very important). According to Table 4.4, the respondents normally agreed with the importance of all proposed hotel attributes on the hotel choice decision at the mean score of importance higher than 3.5. Specifically, the security, cleanliness, location and service are the top attributes to indicate the hotel selection criteria with the mean score of importance at 4.62, 4.47, 4.32, and 4.25 respectively.

Currently, the number of available hotels is shown on the website in the sorting feature. A customer can sort the sequence of hotels based on the criteria of price, distance, review score, star rating, Website's favorite and ascending order of hotel name. In this part, the respondents were asked to indicate the preferable sorting method when searching a hotel choice. According to Table 4.5, most of respondents (72.5%) indicated sorting a hotel by price as the most preferable sorting method when searching for hotel information.

Table 4.4
Hotel selection criteria

Hotel attribute	Mean	Std.dev
Security	4.62	0.79
Cleanliness	4.47	0.86
Location	4.32	0.78
Service	4.25	0.75
Environment	4.21	0.93
Facilities	4.20	0.84
Booking condition	3.94	1.09
Food	3.87	1.06
Price	3.84	0.97
Review	3.82	0.94
Hotel reputation	3.52	0.88
Room type	3.34	0.94

Table 4.5
Hotel sorting method on OTAs

Sorting method	%
Price	72.5%
Promotion	59.2%
Distance from destination	53.3%
Review score	40.8%
Popularity	40%
Hotel star	37.5%
Website's favorite	19.2%
Hotel name (A-Z)	10.8%

In this study, we investigated the customer attitude toward online reviews. The respondents were asked to indicate the important level they perceived on online review indicator when evaluating a hotel, using a five-point Likert-type scale (1 = Very unimportant, 3 = Neutral, 5 = Very important). As shown in Table 4.6, the respondents normally agreed with the importance of all proposed review indicators on the hotel evaluation at the mean score of importance higher than 4. Specifically, the cleanliness, location and service are the top review indicators to indicate the performance of hotels with the mean score of importance at 4.45, 4.32, and 4.29 respectively.

Table 4.6
Importance of online review indicators

Online review	Mean	Std.dev
Worth money	4.17	.772
Location	4.32	.705
Facility	4.16	.757
Service	4.29	.710
Cleanliness	4.45	.689
Food	4.03	.798

The review rating, scored by 1 to 5 or 1 to 10, is used to represent the satisfaction level of customer on the hotel performance. In this part, the respondents were asked to indicate their minimum acceptable review score on the hotel attributes, using ten-point Likert-type scale (1= Very poor, 10 = Very excellent). According to Table 4.7, the minimum acceptable review score of candidate hotel is at an average 7.36 out of 10 whereas the most sensitive review indicator is cleanliness which requires on average 7.77 out of 10 as minimum acceptable level.

Table 4.7
The minimum acceptable review score

Review factor	Mean	Std.dev
Cleanliness	7.77	1.94
Service	7.52	1.83
Location	7.40	1.89
Worth money	7.26	1.96
Food quality	7.17	1.88
Average	7.36	1.83

On OTAs site, the number of hotels is presented with available online reviews to help the customers evaluate the hotel performance. The number of individual online reviews is normally shown in the sorting feature. A customer can sort the sequence of online reviews based on the criteria of type of travelers, most recent review, and individual review rating from the highest to lowest review score and from lowest to highest review score. In this part, the respondents were asked to indicate the preferable sorting method when read the online reviews. According to Table 4.8, most of respondents indicated that sorting an online review by most recent review is the most preferable sorting method when reading online reviews.

Table 4.8
Sorting methods of online review on OTAs

Sorting method	%
Type of travelers	33.3%
Recent review	47.5%
Highest to lowest score	45%
Lowest to highest score	8.3%

To find the relationship between the hotel attribute and expected utility gained from a hotel, the respondents were asked to evaluate the expected values of their recent hotel experience. Multiple regression analysis was then performed between the expected utility as a dependent variable (*y*) and seven independent variables (*x*) comprising of (1) hotel price, (2) star rating, and review rating on five review indicators (i.e., (3) location, (4) comfort, (5) service, (6) cleanliness, and (7) hotel condition). As shown in Table 4.9, the regression analysis shows that our survey data fits the multiple regression model with an adjusted R^2 of 0.86. In our analysis, stepwise regression was used to select the significant variables. That is, two out of seven variables were selected to be the final model. Thus, 86% of the variation in expected utility is explained by two variables of price and review rating on the service indicator.

Table 4.9
Multiple regression results, dependent variable: expected utility.

Variable	B	β	t-value	Standard error
Constant	–1,134.27		–3.79	298.97
Price	1.144^{**}	0.91	27.95	0.041
Service rating	249.98^{**}	0.11	3.26	76.88
R^2	0.864			
Adjusted R^2	0.862			
Standard error of estimation	901.461			

Note: $^{**}p<0.01$; Ordinary least squares (OLS) regression is used with total number of observations of 120.

4.4. Discussion

This study has the potential implication for online travel agencies (OTAs) and hotel by providing the guideline to manage the website design to meet with the customer behavior. The result shows that the customers tend to use OTAs mainly for information searching and booking transaction. The convenient process and a quality of hotel information are the main elements of the website that can promote the online booking intention. We found that most customers prefer to sort a hotel by price (i.e., from lowest to highest price) when searching for hotel information. The security, cleanliness, location and service of hotel are the top attributes in a hotel choice decision. In the evaluation process, most of customers read online reviews whereas the cleanliness, location and service are the top review indicators observed by customers. The minimum acceptable review score of the candidate hotel is expected at an average 7.36 out of 10 whereas the most sensitive review indicator is cleanliness which requires on average 7.77 out of 10 as minimum acceptable level. Also, sorting an online review by most recent review is the most preferable sorting method when observes available online reviews. The price and review rating on service indicator can determine the expected utility gained from a hotel.

In an online shopping, most of customers have decided a purchasing decision based on the presentation of product choices on the website (e.g., product description, e-worth of mouth, ranking position). According to the findings, we suggest that the hotel with a higher review rating on cleanliness, location and service should be placed on the upper position of the list of hotel choices. Also, a hotel that fails to satisfy the minimum acceptable review rating should be placed at the bottom of the list or cut out from the recommendation list to speed up the searching process. Moreover, the hotel managers need to take a look at online review and improve the service performance according to customer's complaint because online review has effect on the hotel booking intention and reputation of hotel (i.e., e-word of mouth). A hotel fails to sale the rooms should consider to improve its price and service as they determine the customer perception on hotel. Moreover, a hotel also can consider improving security, cleanliness, location and service as they influence the hotel selection criteria.

In the future study, we aim to develop a model that helps OTAs designing the website to respond the customer's behavior. The survey data will be used to represent the customer's behavior in the simulated mechanism. Also, we will determine the direction of improvement for a hotel to increase the reservation rate in today's competitive market.

CHAPTER 5
MULTIDIMENSIONAL SEQUENCING OF HOTEL ROOMS

This chapter focuses on the usage of a hotel sorting mechanism of OTAs as the tool to present a number of hotels to customers. Our study develops a new approach, based on a stochastic programming model, to design an optimal sequence of hotels. The proposed approach incorporates the appropriate elements, including the multidimensional preference of customers (e.g. price, expected star, review rating) and the optimal number of hotels selected to show on the website. These are the main features of the proposed model that is superior to the sorting mechanism used by OTAs. These considerations encompass the overall system from a customer to service providers (e.g., hotel and OTAs). The service value derived from information service provided by OTAs and accommodation service provided by hotel could be successfully achieved in viewpoints of customer. The case study of online hotel booking is developed to simulate the realistic mechanism in the proposed model. In this study, customer data is collected using the survey method and hotel information is taken from selected OTA. After implemented our proposed model, we expect that a customer can find a satisfactory hotel at the minimum search cost and maximum utility gained from a hotel. The effectiveness of the proposed model is confirmed in a case study, and tested through the numerical experiments.

5.1. Introduction

Online travel agencies (OTAs) provide the information service to help online travelers search for a satisfactory hotel whereas provide the advertising service to increase the reservation rate for a hotel. A quality of information content along with website design and functionality of OTAs are the critical aspects which can add the value to online booking experience, and thus increase the reservation rate. The hotel sorting mechanism of OTAs is one of the useful functionalities widely adopted by a customer during a searching process. Developing a hotel sorting mechanism has become a pressing issue for many researchers in recent years. This mechanism is necessary to deal with information overload and improve the accuracy to match a hotel with customer’s expectation.

The current sorting mechanism of OTAs commonly sorts a sequence of hotels on the basis of single dimensional sorting criteria. The single dimensional sorting criteria is sorting a sequence of hotels by concerning on one attribute of hotel such as sorting by price (from lowest to highest price), review rating (from highest to lowest review rating), star rating from highest to lowest review rating), and distance (from nearest to farthest). Although the existing sorting mechanism of OTAs is efficient in timely aspect, the presentation of hotels in a sequence (i.e., website's favorite) might be biased because of the advertising fee to promote some hotels. Also, sorting by one attribute has limitation when is adopted to satisfy the multidimensional preferences of actual customers. The sequence of hotels sorted by different sorting methods has the impact on the customer choice decision resulting in the online hotel booking experience. A customer prefers a hotel placed on a top position. Thus, a customer may fail to notice a satisfactory hotel if that hotel is placed in the bottom of a long sequence. It is essential for OTAs to improve the sorting mechanism of hotel so that it can serve most of customers more effectively.

Various approaches for developing a sorting mechanism can be found in prior researches. However, most of them ignored the set size of choices which have effect on the cognitive load and the decision process of customers. According to human's cognition, the set size of choices is important, especially for OTAs as they collect a hundred numbers of hotels. In addition, most of prior studies ignored the customer's searching behavior while it is important to understand how customers use a sorting mechanism to reach a satisfactory hotel. To the best of our knowledge, our study is the first attempt to incorporate both the customer's searching behavior and the optimal number of hotels in the sorting feature through an optimal sequencing model. These issues could promote the profitable design of OTAs that could enhance the customer experience from using OTAs.

In this study, we developed a service coding framework of online hotel booking based on a mathematical model approach. The main focus is on the profitable design of a hotel sorting mechanism to enhance online hotel booking experience of customer. The website feature and hotel sorting mechanism under the scope of study are presented in Fig. 5.1.

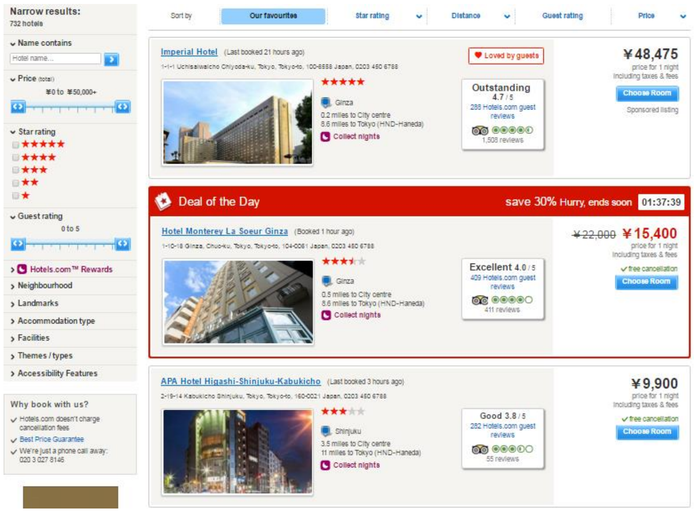


Fig.5.1. Website design and hotel sorting mechanism of OTAs

There are four unique points that set our work apart from prior literature. (i) We proposed a new approach, namely a stochastic programming model to deal with the optimal sequencing problem under the uncertain condition of customers (e.g., arrival and preferences). (ii) We incorporated the optimal number of hotel presented on the website with the position effect through the optimal sequencing decision. (iii) Our sorting model was developed on the basis of multidimensional preferences of customers (e.g., price, star rating, review rating, reservation price) and search theory (non-sequential search and sequential search behavior). The customer data was collected using a survey method, and hotel information was taken from OTAs so that our model and numerical results close to a realistic case of online hotel booking. (iv) Our model incorporated multi-objectives in the view of customers, which include the minimum search cost, maximum utility gained from a selected hotel, and a hotel placed at an appropriate sorting position. We conducted numerical experiments using survey data and showed the effectiveness of our proposed model comparable to existing sorting mechanism of OTAs. This study provides the contributions to knowledge science and tourism industry. Firstly, we present a framework to promote understanding of profitable design of OTAs sorting mechanism and customer's behavior. OTAs can practically adopt the proposed model to design the sequence of hotels responding to the customer's expectation. Secondly, we provide the guidelines of improvement for a hotel to increase its reservation rate and maintain a competitive advantage.

The following sections of this chapter are organized as following. The research method is shown in Section 5.2. The overall mechanism of service system is described as the problem description in Section 5.3. In Section 5.4, the problem is formulated into a mathematical model. The development of a case study using survey method and observation on OTAs is described in Section 5.5. The numerical result derived from the proposed model is shown in Section 5.6. We conclude the findings and practical implications in Section 5.7.

5.2. Research method

5.2.1. Service coding framework

This study focuses on the usage and design of a hotel sorting mechanism of OTAs to maximize the customer experience (or customer value) from using OTAs. The customer experience from using OTAs is created from information service provided by OTAs and accommodation service provided by hotel. We establish a framework to represent overall service system of online hotel booking, using a coding method of mathematical model approach. According to our selection criteria, a two-stage stochastic programming (2SSP) model is selected to apply in this study.

The overall process of using a mathematical model is summarized in Fig. 5.2. That is, we need to understand the scope of study by identifying problem and collecting information from actual mechanism. After that, the suitable approach in a mathematical model is selected (a two-stage stochastic programming model, for example). We formulate the problem into a mathematical model whereas the standard mapping processes include the identification of parameters related to all actors, decision variable, assumption of model, objectives, and constraints. After a problem is appropriately formulated into a mathematical model, an optimal decision mechanism is made optimally using optimization software. The optimal solution is analyzed to provide the managerial insight for practical implication.

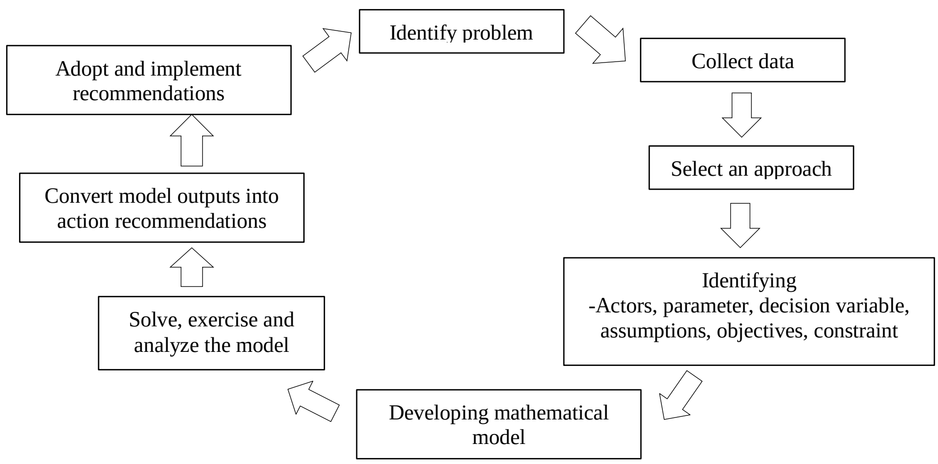


Fig. 5.2. Schematic of modeling process

5.2.2. Survey and modeling process

To develop a service coding framework, our research uses an optimization model and survey method. We make use the capacity of a mathematical model to represent framework of online hotel booking mechanism and then solve for an optimal decision. To develop a model, we need to combine input parameter representing online booking mechanism. Accordingly, we make use survey method by two main objectives. Firstly, we do survey and literature review to find the important parameters for developing a model. Secondly, we collect survey data and perform analysis of survey data to derive the distribution of customers. The analysis of data is used to generate sample data for online booking simulation.

As shown in Fig. 5.3, we formulate the problem into a mathematical model whereas the standard mapping processes include the identification of parameters related to all actors, decision variable, assumption of model, objectives and constraints. All of assumptions and parameters are adopted from several literatures and our observation. Specifically, the model incorporates standard parameter and adequate assumption which can differentiate customers and cover overall characteristic of different customers (e.g., business traveler, solo traveler, family traveler) in the realistic situation. Even though our model has carefully incorporated various parameter, environment factors and assumptions, it might not 100% reflect the reality mechanism of online hotel booking but none of the model in the research covers all mechanism of reality. However, our proposed model is the most simplified version but far more advanced than prior literatures. Thus, it is our belief that the proposed model is a closest proxy of real mechanism of online hotel booking. After a problem is appropriately formulated into a mathematical model, we simulate the usage of online hotel booking service using a case study. We develop a case study using hotel information taken from OTAs and analysis of survey data for the sample of customers. An optimal decision on a hotel sorting mechanism is made optimally using optimization software, namely IBM ILOG CPLEX version 12.6. The numerical experiments using the case study are conducted to derive the outputs. Also, the findings from numerical analysis are then discussed to provide the managerial insight for practical implication. Using the ILOG CPLEX software for determining optimal solution is briefly described in Appendix B-4.

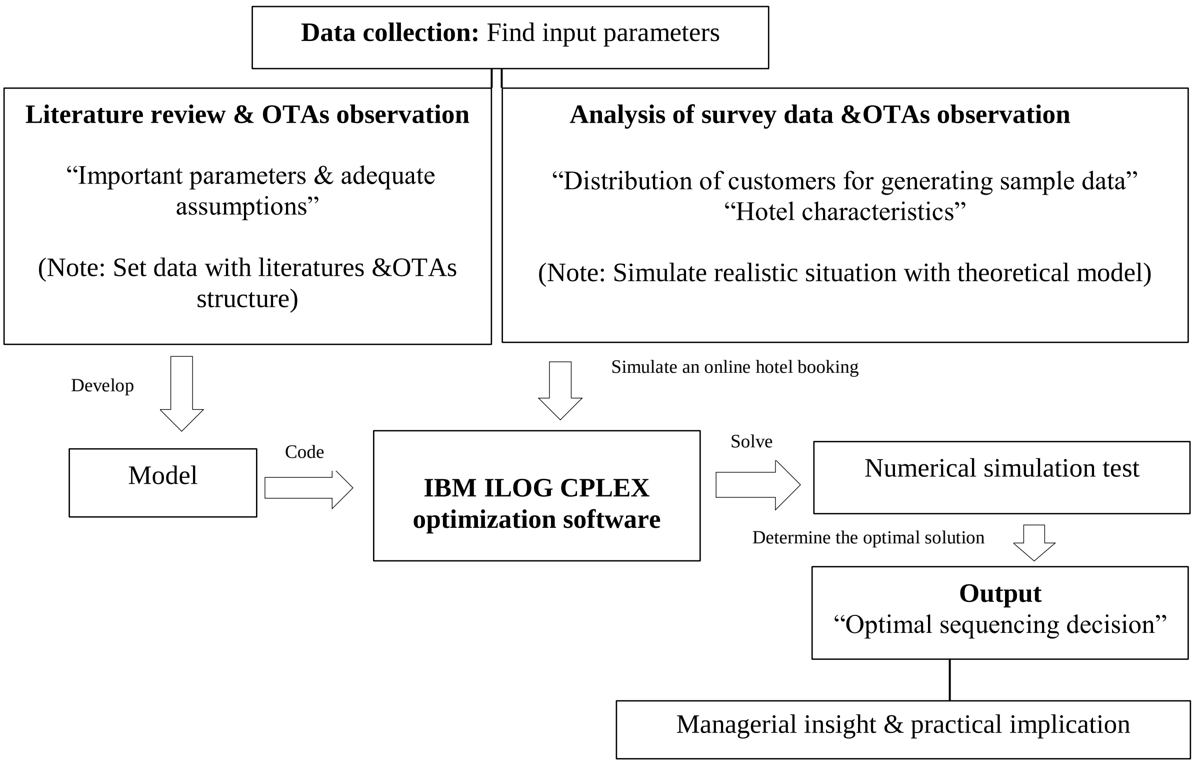


Fig. 5.3. Schematic of survey and proposed model

In the proposed model, we collect the hotel information (e.g., price, star rating, review rating, supply of room) from a specific OTA and use it as input information to represent hotel characteristics. For the customer review, we consider review rating to represent a hotel quality evaluated by actual customers. The review rating is normally scaled by 1 to 5 (i.e., 1 = very poor, 3 = good, 5 = very excellent). As other hotel information, we collect review rating on various indicators (e.g., service, location, cleanliness) from a selected OTA and directly used them in the proposed model as a given hotel information. The adoption of review rating without analysis of other review contents is adequate as most literatures including our observation found the usage of review rating in a hotel searching process and booking decision. For example, it is observed that the hotels presented in the best review rating list are perceived higher booking intention (Casaló et al., 2015).

Moreover, we estimate the expected utility on hotel according to each customer. The value of expected utility is estimated by willingness to pay (WIP: unit in monetary value of Thai Baht) collected by survey method. That is, to estimate the expected utility gained from a hotel, the respondents were asked to give value (in monetary value (Thai Baht)) of their recent hotel service experience (this method is called "self-stated WTP"). For example, how much you are willing to pay for the hotel (Thai Baht)? Accordingly, we perform a regression analysis to find relationship between hotel attributes (e.g., review rating, star rating, and price) and expected utility. This method of self-stated WTP is widely mentioned in research on measurement of willingness to pay (Jedidi and Zhang, 2002). Similarly, we consider reservation price of customer. In theoretical definition, reservation price is simply the threshed vale at which the customer is indifferent between buying and not buying the product. Accordingly, in customer's choice decision, a customer will select a hotel if the net utility of hotel is greater than personal reservation price. The value of reservation price in our study is estimated in monetary unit by survey method. For example, reservation price will be estimated by the question as how much you are expected to book for the hotel (Thai Baht)? This method is widely mentioned in researches on measurement of self-stated reservation price (Jedidi and Zhang, 2002) and sequential search behavior (Lippman and McCall, 1976).

5.3. Problem description

We consider a customer who searches for hotel information and make a hotel booking decision through OTAs. According to Fig.5.4, OTAs present a sequence of hotels with the hotel information (e.g., price, star rating, and available rooms) and online review (e.g., review rating). In the searching process, a typical customer searches for a hotel from top to bottom of a sequence sequentially. The position of hotels placed on the sequence influences on the customer's perception toward a hotel whereas the hotel placed on the upper position seems more attractiveness (Tam and Ho, 2005; Xu and Kim, 2008). The current sorting mechanism of OTAs sorts a number of hotels by single attribute such as sorting by price, star rating, review rating, and website's favorite. However, according to reality, we assume that the customers have multidimensional preferences (e.g., budget, expected review rating, star rating, and number of booking rooms, reservation price) and these preferences will vary depending on the types of customers and, sometime, on individual customer (e.g., business traveler, solo traveler, family, couple and friend). A customer searches all hotels presented in the sequence and select the candidate hotel that all attributes satisfy with their expectation at the highest utility. Customers spend search time and, thus, they incur search cost per hotel.

In the service system of online hotel booking, a customer considers multi-objectives (e.g., utility gained from a selected hotel and total search cost). The sequence of hotels thus needs to be decided such that it meets the multidimensional preferences of customers and multi-objectives from using OTAs. If we know a customer's preference, we can recommend the best candidate hotels for a customer at the maximum utility and minimum search cost. However, the arrival and multidimensional preferences of customers are random. Thus, we need to prepare an optimal sequence with the optimal number of available hotels to serve all customers suitably. Our three objectives for sequencing decision include (i) minimum search cost from the optimal number of hotels shown on the website, (ii) maximum utility gained from a selected hotel above the reservation price, and (iii) presentation of the most preferred hotel at the top position.

Also, the supply of hotel rooms is limited and customers are allowed to book if room is available. The customers who arrive first have priority to book and later customers can book if rooms are available. Each customer is assumed to arrive first equally. Thus, OTAs makes a sequence decision of hotel choices so that it can be effectively served all possible cases of customers.

Key questions that can be answered with an appropriate model are listed as following.

- How many hotels should be presented on the website?
- Which hotel should be presented on the website? And at which ranking position?
- Which hotel a customer will book? How much utility does customer get from the hotel experience?

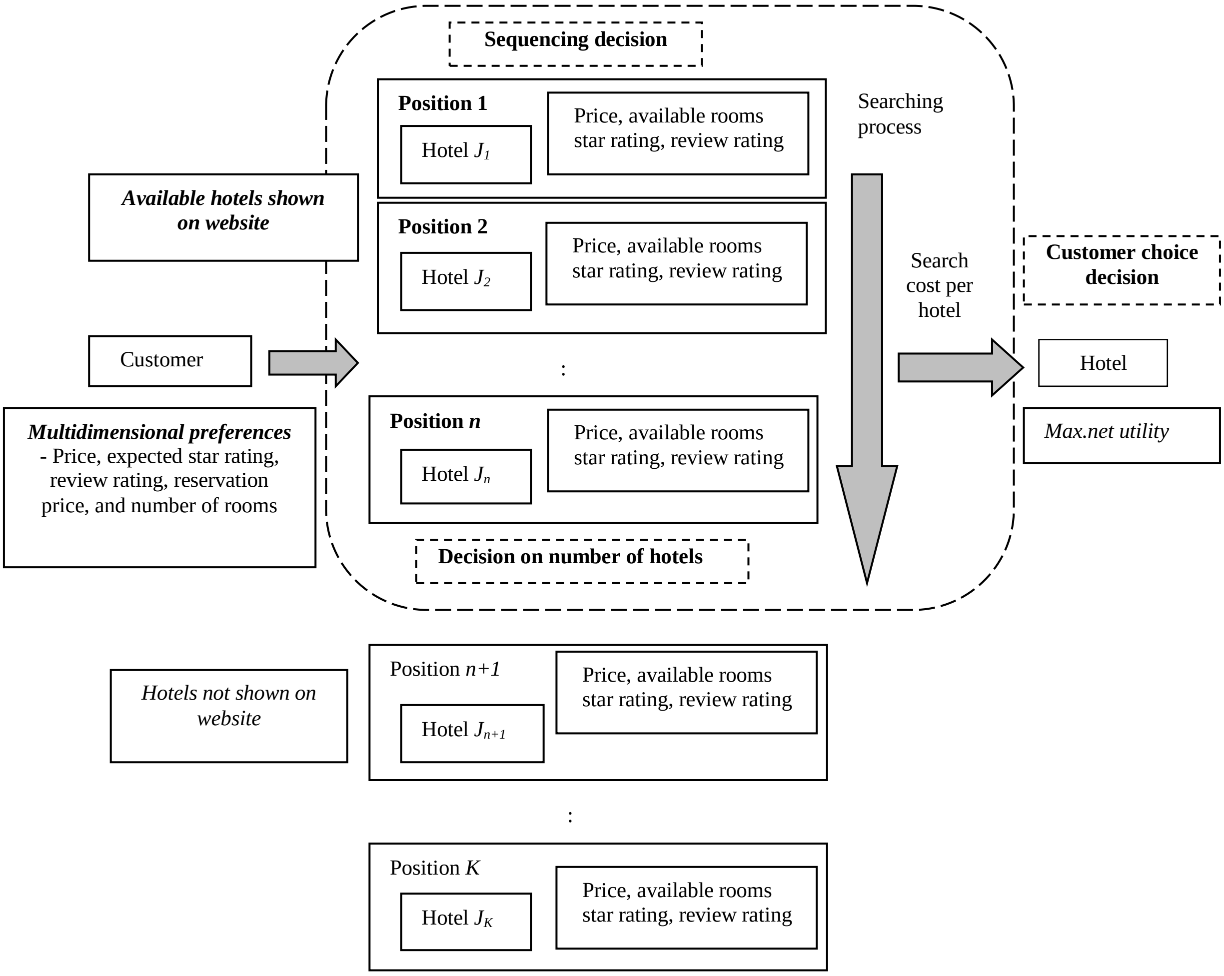


Fig. 5.4. Framework for service system of online hotel booking

5.4. Mathematical model approach

To solve the stated problem, the overall service system is formulated into a mathematical model with the multi-objectives to maximize the customer experience. The mathematical model approach is selected under the criteria of (i) the application and reliability of the approach in prior studies, (ii) the novelty of the approach in the field of our study, namely a sequencing problem (iii) the effectiveness of the approach to solve the stated problems, and (iv) the difficulty to adopt in practical application. In this dissertation, the proposed model is developed on a basis of a two-stage stochastic programming (2SSP) model approach.

5.4.1. Formulation of a two-stage stochastic programming model (2SSP)

Two-stage stochastic programming (2SSP) is a framework for modeling optimization problems that involve uncertainty. Many optimization problems taking uncertainty and randomness, such as production scheduling, transportation network design, nurse scheduling, vehicle and resource allocation, environmental protection, supply chain management, has been suitably modeled with 2SSP (e.g., Simic, 2016; Valente, 2016; Shabani and Sowlati, 2016; Wang and Huang, 2015; Parisio and Jones, 2015; Yeh et al., 2015). The basic ideal is that the (optimal) decision should be based on data available at time the decisions are made and should not depend on future observations (Shapiro and Philpott, 2007). In general, 2SSP corresponds to have two stages in a decision making process. Thus, the decision variables are partitioned into two sets. The first-stage decision variables are decided in advance (before the actual realization of the uncertain parameters is known). After the random events are known, further decisions can be made at a certain cost, known as the second-stage decision variables (Sahinidis, 2004).

In this study, the proposed model is developed on the basis of 2SSP. 2SSP can be suitably applied in our study by referring to the optimization problem of sequencing decision under the uncertain condition of customers (e.g., preferences, arrival). To formulate the stated problem into a mathematical model, we define all actors (e.g., customer, hotel, OTAs) in the service system including their elements as input parameters and decision variables. The notations and descriptions used to make a decision are shown in Table 5.1 and 5.2. With 2SSP, the decisions under the stated problem are divided into two-stage decision, and thus, decision variables are classified into two sets. The separation of decisions based on the decision time basis closes to the realistic mechanism. A diagram of the decision stages is presented in Fig. 5.5.

- *First-stage decision:* In the first-stage decision, the sequence of hotels $x_{j,k}$ with the decision to determine number of hotels presented on the website z_n needs to be prepared and posted on OTAs in advance before knowing the customer's preference. Accordingly, the sequence of hotels needs to be prepared to serve all possible cases of customers because each customer is equally likely to arrive first.

  In this stage, we generate many possible scenarios of customers (e.g., preferences and reservation price) to make a sequence decision to satisfy the future demand of actual customers.
- *Second-stage decision:* In the second-stage decision, after an actual customer comes to the website, the preference of customer is realized. A customer makes a hotel booking decision $y_{i,j,k}$, from a given sequence of hotels prepared in the first-

stage decision. Then, the ranking position of hotel selected by customer i, s_i, is determined.

Table 5.1
Index variables

Notation	Description
i	Customer index and $i \in$ Set i ={1,…,N}
j	Hotel index and $j \in$ Set j ={1,…,K}
k	Ranking position index and $k \in$ Set k ={1,…,K}
n	Total number of hotels selected to show on the website and $n \in$ Set n = {1,…,K}
m	Number of arriving customers and $m \in$ Set m ={1,…,M}
K	Total number of ranking positions which reflect to total number of available hotels
N	Total number of customers
M	A threshold number of customers arriving at the website to re-optimize the sequence

Table 5.2
Input parameters and description

Notation	Description	Notation	Description
t	Average search cost per hotel	w_1	Weight of search cost
ξ_i	Reservation price of customer i ($\xi_i = u_{i,j,at\ booking} - p_j$)	w_2	Weight of utility
$u_{i,j,at\ booking}$	Estimated utility on hotel j according to customer i at the booking stage	w_3	Weight of ranking position
$u_{i,j}$	Expected utility on hotel j according to customer i		
$\overline{Ub}$	Maximum number of hotels shown on the website	$\overline{Lb}$	Minimum number of hotels shown on the website
B_i	Budget of customer i	p_j	Price of a room at hotel j
EQ_i	Expected star rating required by customer i	Q_j	Star rating of hotel j
Er_i	Expected review rating required by customer i	r_j	Overall review rating of hotel j
D_i	Number of rooms required by customer i	S_j	Available rooms at hotel j
$O_{i,j}$	1 if hotel j satisfies all requirements (budget, star rating, review rating, availability of rooms) for customer i, 0 otherwise $\left(O_{i,j} = RoundDown\left[Minimun\left[\frac{B_i}{p_j}, \frac{Q_j}{EQ_i}, \frac{r_j}{Er_i}, \frac{S_j}{D_i}\right]\right] \ \forall\ i, \forall j\right)$		

Decision variables and auxiliary decision variables are as follows.

First-stage decision variables

$x_{j,k}$ = 1 if hotel j is placed at ranking position k in the sequence; 0 otherwise

z_n = 1 if n is the last ranking position in the sequence selected by all customers; 0 otherwise

Second-stage decision variables

$y_{i,j,k}$ = 1 if customer i selects hotel j placed at ranking position k in the sequence; 0 otherwise

s_i = The list position number of the hotel selected by customer *i*

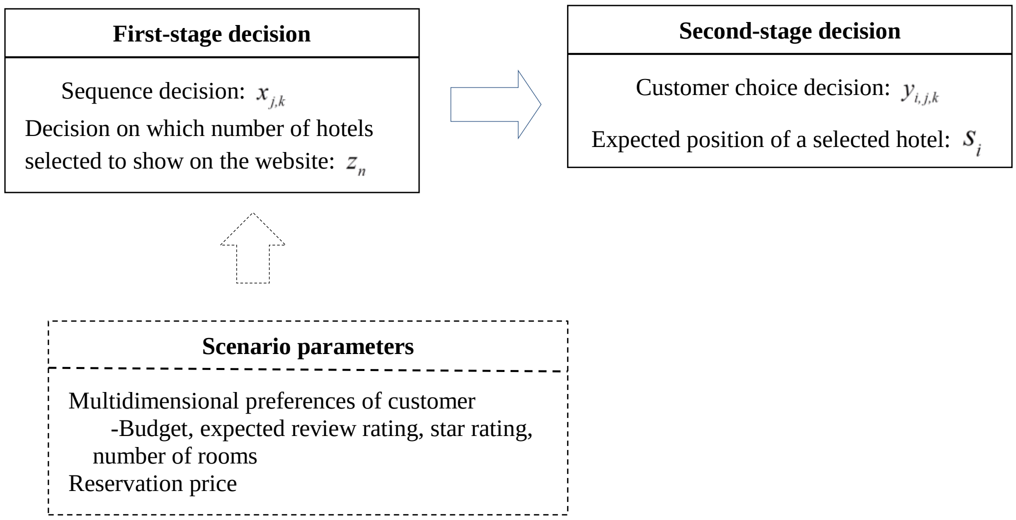


Fig. 5.5. A diagram of stages of decision.

5.4.2. Customer choice model

We consider the customer's searching behavior and hotel choice decision process. A customer has multidimensional preferences (e.g., price, expected star rating, review rating, number of rooms, reservation price) whereas these preferences are different depending on the individual and on the types of customer (e.g., solo traveler, family and business etc.).

Moreover, the utility gained from each hotel is perceived differently among customers. Note that, in our study, the value of utility is estimated as willingness to pay for a hotel (WTP) equivalent to monetary value (Thai Baht) using survey method. The utility gained from a hotel is assumed at the booking stage and after the staying stage. At the booking stage, a customer estimates the utility gained from a hotel using hotel information available on the website (before staying at hotel and knowing actual utility). According to this estimated utility, a customer decides to book a hotel if he or she is willing to accept the estimated utility gained. It is equivalent to say that a customer determines the minimum expectation as criteria to accept a hotel at the booking stage, called reservation price ξ_i. That mean, reservation price ξ_i is determined by $\xi_i = u_{i,j,at\ booking} - p_j$, where $u_{i,j,at\ booking}$ is the estimated utility at the booking stage and p_j is the actual price of hotel. After staying at the hotel, a customer evaluates the expected utility gained from hotel with the actual price.

To simulate the online hotel booking, we assume that a customer searches available hotels shown in a given sequence of hotel choices, and will select a satisfactory hotel with the highest utility gained above the reservation price (net utility gained) while all constraints of price, star rating, review rating, and room availability are satisfied to personal expectation. The customer choice model is presented in Fig. 5.6.

Customer choice model:

Objective: Max. utility gained from hotel above reservation price

$$\sum_{i=1}^{N}\sum_{j=1}^{K}\sum_{k=1}^{K}\left(u_{i,j}-p_j-\xi_i\right)\times y_{i,j,k}$$

Select a hotel if

All hotel attributes satisfy with personal expectation

$$y_{i,j,k}\le O_{i,j} \qquad \forall i, \forall j, \forall k$$

Utility gained from a selected hotel exceeds personal reservation price

$$\left(u_{i,j}-p_j-\xi_i\right)\times y_{i,j,k}\ge 0 \qquad \forall i,j,k$$

Fig. 5.6. Customer choice decision

For the objective of customer, similar meaning to the word that a customer aims to maximize the net utility gained from a selected hotel $\left(u_{i,j}-p_j\right)\times y_{i,j,k}$, but we added a term of ξ_i in $\left(u_{i,j}-p_j-\xi_i\right)\times y_{i,j,k}$, to be consistent with the theoretical theory of utility and reservation price. Specifically, adapted from the model of Jedidi and Zhang (2002) and Lippman and McCall (1976), a customer *i* will select a product *j* if the net utility of product is higher than personal reservation price $\left(u_{i,j}-p_j-\xi_i\right)\times y_{i,j,k}\ge 0$, and if consuming product *j* gives him the maximum surplus from what he gets (net utility after staying) and what he expects (reservation price at booking stage) over any other hotels. Accordingly, we define the objective of customer that a customer aims to maximize the net utility gained from a selected hotel above the reservation price. In practical term, a customer needs to gain the maximum surplus from personal expectation.

5.4.3. Second-stage decision: Approximated customer choice model

In the second stage, the random event (i.e., a customer with a given preference arrives) occurs. In this stage, we know the preferences of the next customer and therefore we know which hotel and which hotel position will be selected (on the basis of the sequence set earlier in the first stage) using the consumer choice model described above. However, this hotel choice selected by the customer occurs with an equal probability of $1/N$. Therefore, in the second stage, the model will firstly try to maximize the expected utility gained of the next customer (due to its larger weight w_2 in the objective function compared to the other weights) to represent the optimal choices of the next customer. This is the first goal of the second-stage model.

Moreover, a customer normally searches for the first few products in a list while the products placed in the upper position are more attractive. Thus, OTAs need to understand this customer's perceptions and assign a popular hotel in the upper ranking position without any bias to advertise some hotels. Accordingly, the suitable ranking position of hotels provides the benefit for customers as customers could find a satisfactory hotel that provides the highest expected utility in the top ranking position of a sequence (i.e., the minimum ranking position of a selected hotel).

To find the optimal sequence that ranks the popular hotels on the top of the list, the second-stage model needs to record the expected number of positions of hotels selected by the next customer.

For example, suppose there are two customers: customer A and customer B. If customer A comes first (with probability = 0.5), she will select a hotel at position 3. If customer B comes first (with probability = 0.5), he will select a hotel at position 2. The expected number of positions selected by the next customer will be $(0.5\times 3)+(0.5\times 2)=2.5$. To set up a good sequence, this expected step should be as small as possible because it means that the hotel selected by the next customer under any scenario is ranked mostly at the top of the list. Therefore, the second stage will record this expected step in the objective function as the second goal and pass this to the first stage to minimize while deciding the sequence.

2nd stage model

Minimize composite score =

$$-w_2\times\frac{1}{N}\times\sum_{i=1}^{N}\sum_{j=1}^{K}\sum_{k=1}^{K}\left(u_{i,j}-p_j-\xi_i\right)\times y_{i,j,k}+w_3\times\frac{1}{N}\times\sum_{i=1}^{N}s_i \tag{1}$$

Eq. (1) represents the composite score that combines two goals. The first goal aims to maximize the expected utility gained from the hotel above the reservation price and the second goal aims to minimize the expected position of hotels selected by the customer. The objective function aims to minimize the composite score so that both goals are satisfied.

The first term in Eq. (1), $-w_2\times\frac{1}{N}\times\sum_{i=1}^{N}\sum_{j=1}^{K}\sum_{k=1}^{K}\left(u_{i,j}-p_j-\xi_i\right)\times y_{i,j,k}$, serves as the expected utility gained by the next customer weighted by the importance factor w_2. The second term in Eq. (1), $w_3\times\frac{1}{N}\times\sum_{i=1}^{N}s_i$, represents the expected positions of hotels selected by the next customer weighted by the importance factor w_3. As the sequence is not set up in the second stage, the term $w_3 \times \frac{1}{N} \times \sum_{i=1}^{K} s_i$ will be minimized by the first-stage decision. However, the second-stage model will work as expected only when the customer choices of hotel solved from the consumer decision model are exactly the same as the customer choices of hotels solved from the second-stage model. Potential differences could occur due to the difference in objective functions (from the second goal of the second-stage model). To minimize this effect, the weight w_3 should be set relatively very small compared to w_2. With a very small value of w_3 compared to w_2, the objective function of the second-stage model closely represents the objective function of the consumer choice model. In our numerical experiment, w_3 selected is tested with 80 customers and 10 replications such that w_3 is small enough to ensure the customers choices from the customer choice model and the second-stage model are identical.

5.4.4. First-stage decision: Sequencing model and two-stage stochastic programming model

According to the customer choice decision, if we know which customer comes first, we can arrange the optimal sequence of available hotels to satisfy all goals of the customer. However, in practice, we don’t know which customers will come first, so each customer is assumed to arrive first with equal probability. Therefore, in the first stage, we need to decide the optimal number of available hotels with the optimal sequence to serve all of the possible requirements of the next customers. The sequence should also put the popular hotels (selected by the majority of next customers) on the top of the list (to minimize the term $w_3 \times \frac{1}{N} \times \sum_{i=1}^{N} s_i$). The two stages are combined into one two-stage stochastic programming (2SSP) model as shown in Section 5.4.5.

5.4.5. Two-stage stochastic programming (2SSP) model

Minimize composite score =

$$w_1 \times t \times \sum_{n=1}^{K} n \times z_n - w_2 \times \frac{1}{N} \times \sum_{i=1}^{N} \sum_{j=1}^{K} \sum_{k=1}^{K} \left(u_{i,j} - p_j - \xi_i\right) \times y_{i,j,k} + w_3 \times \frac{1}{N} \times \sum_{i=1}^{N} s_i \tag{2}$$

Subject to:

First-stage constraints: Sequencing constraints

$$\sum_{n=1}^{K} z_n = 1 \tag{3}$$

$$\sum_{n=1}^{K} n \times z_n \le \overline{Ub} \tag{4}$$

$$\sum_{n=1}^{K} n \times z_n \geq \overline{Lb} \tag{5}$$

$$\sum_{k=1}^{K} x_{j,k} = 1 \quad \forall j \tag{6}$$

$$\sum_{j=1}^{K} x_{j,k} = 1 \quad \forall k \tag{7}$$

Second-stage constraints: Customer choice constraints

$$\sum_{j=1}^{K} \sum_{k=1}^{K} y_{i,j,k} \leq 1 \quad \forall i \tag{8}$$

$$y_{i,j,k} \leq O_{i,j} \quad \forall i, \forall j, \forall k \tag{9}$$

$$\left(u_{i,j} - p_j - \xi_i\right) \times y_{i,j,k} \geq 0 \quad \forall i, j, k \tag{10}$$

$$y_{i,j,k} \leq x_{j,k} \quad \forall i, \forall j, \forall k \tag{11}$$

$$y_{i,j,k} \leq (1 - z_n) \quad \forall i, \forall j, \forall k, \forall n = 1,..,k-1 \tag{12}$$

$$s_i = \sum_{j=1}^{K} \sum_{k=1}^{K} k \times y_{i,j,k} + (1 - \sum_{j=1}^{K} \sum_{k=1}^{K} y_{i,j,k}) \times K \quad \forall i \tag{13}$$

Given a sequence of available hotels, a customer searches all hotels presented on the web site, and selects the hotel that all attributes satisfy their personal expectation with the highest utility gained above the reservation price. Eq. (2) represents a composite score comprised of three main goals, namely (1) to minimize search cost from searching hotels shown on the website, (2) to maximize the utility gained from a selected hotel above the reservation price, and (3) to minimize the ranking position of hotels selected by customers. Therefore, the objective function is to minimize the composite scores so that all goals are satisfied. Eqs. (3) to (7) are the first-stage constraints to decide the hotel sequencing and the number of hotels shown on the website. Eq. (3) determines which number of hotels selected to show on the website. Note that only one z_n (from Set n = {1,…, K}) can be 1 so that one optimal number of hotels is selected. Eqs. (4) to (5) set up the upper and lower bounds of the number of hotels shown on the website.

Eqs. (6) to (7) assign the ranking position of each hotel in the sequence. Eq. (6) states that each hotel can be assigned to only one position. Eq. (7) states that each position can be assigned by only one hotel. Eqs. (8) to (13) are the second-stage constraints to decide the customer choice. Eq. (8) states that the customer can either book a hotel or leave without booking. Eqs. (9) to (10) set the criteria to select a hotel. Eq. (9) states that a customer will select a hotel if all attributes (price, star rating, review rating, availability) are satisfied with the minimum expectation. Eq. (10) states that a customer will select a hotel if the net utility gained from the hotel exceeds the reservation price. Eq. (11) states that the customer can select a hotel shown in the sequence at the given ranking position. Eq. (12) states that customers can select a hotel shown on the website. Eq. (13) calculates the position of a hotel selected by each customer (if not selected, the position K is assigned).

After the two-stage model is run, the optimal sequence is found for the next customer and it remains optimal until the availability of the hotel rooms changes. As the availability of rooms is limited, customers are allowed to reserve a room if it is available. Customers who arrive or decide first have priority to book and later customers can book if there are still rooms available. After a booking by a customer, the sequence should be re-optimized, but re-optimizing after every booking transaction takes up too much computation time to be practical. In our proposed method, we propose re-optimizing the sequence every M^{th} customer's arrival where $1 \leq M \leq N$. For example, If M = 10 and the total number of customers (N) = 50, it means that we run the model to decide an optimal sequence every 10^{th} customer's arrival. In other word, the sequence will be re-optimized after 10^{th}, 20^{th}, 30^{th}, 40^{th} and 50^{th} customers arrive at the website. The appropriate value of M will be tested in our numerical experiment. In summary, we propose that the optimal sequence be re-optimized for the next customer every M^{th} customer's arrival. The methodology of the proposed model is summarized in Table 5.3.

Table 5.3
Steps showing the main concept of the sequence of proposed model

Step 1	Initialize customer counter m = 0
Step 2	In the first stage, make decisions on the sequence of n available hotels. Solve for $x_{j,k}, z_n$
Step 3	In the second stage, make decisions on the customer choice using the model Given the solution of $x_{j,k}, z_n$, solve for $y_{i,j,k}$
Step 4	After every customer's arrival, update the availability of hotel room and the customer counter. After a customer at the website, increase customer counter m by 1 or let $m = m+1$. Then, update the availability of a hotel room. If the room is already sold out, remove it from the current sequence and shift up to next one. Then, provide the updated sequence of hotels to the next customers.
Step 5	Check if the number of customer's arrival reaches M. If the customer counter $m = M$ where $1 \leq M \leq N$, go to Step 1. Otherwise, go to Step 4. Repeat Step 5 until reaching all customers N.

5.4.6. Discussion on the optimization model

We proposed the optimization model that aims to design the sequencing features of OTAs to facilitate the searching process for customers. To achieve such a goal, the model incorporates three components (i.e., for search cost, expected utility, and sorting effect) as the composite score in the objective function. However, the model cannot fully guarantee the best optimal solution in every case but will provide the optimal solution to satisfy some natures under management decision. In other words, the optimization will be achieved depend on manager or management decision. Accordingly, a manager could determine the management decision and then heuristically adjust the weight of importance on composite score to achieve the optimal solution under their concern. As the theoretical model framework, OTAs can get the new idea and heuristically add their options to make the simulation through the proposed model.

5.5. Case study

As the present research proposes the theoretical model approach, true precise value is not matter to use in the simulation of online hotel booking and customer's behavior. However, to make the simulation closely with the realistic situation, we adopted the important input parameters from the literatures and generated the input data using the data obtained from the hotel information on OTAs (i.e., hotel characteristics) and from customer survey (i.e., customer characteristics). Accordingly, we developed a case study using the real data set (i.e., hotel characteristics and customer's profile) to simulate the customer's behavior in an online hotel booking in Chachoengsao Province, Thailand. The data set of customers was collected using survey method and the hotel information was taken from OTAs. Accordingly, the case study was simulated through the numerical experiments to derive the managerial insight and show the effectiveness of proposed model.

The sample data of hotel characteristics and customers in a selected area were collected from a popular OTA, Hotels.com, which is ranked number 524 in the eBizMBA ranking with 16,000,000 estimated unique monthly visitors (eBizMBA, 2015).

5.5.1. Hotel characteristics

Our selected area was Chachoengsao Province, Thailand. Chachoengsao Province is located to the east of Bangkok in Thailand's central region. It is a tourist attraction representing traditional culture and old history of Thailand. Within the province, the traditional markets and temples, such as Talat Khlong Suan and Wat Sothon, have been located (Barrow, 2015). Also, many industrial parks are located within Chachoengsao Province.

Chachoengsao Province was selected as a case study to conduct the numerical experiments because the number of hotels and booking transactions made by various types of travelers are large but its size is still manageable to create a data set manually. Hotel information related to Chachoengsao Province, Thailand for the check-in dates of February 11 to 12, 2015, were considered. A total number of 42 available hotels on Hotels.com were collected and used as input data for the numerical experiments. Hotel characteristics including price (in Thai Baht), star rating (scaled by 1 to 5), number of room availability, overall review rating (scaled by 1 to 5), and review rating (scaled by 1 to 5) based on service indicator were collected. Also, the existing sequences sorted by the website (sorting by star rating, price, review rating, website's favorite) were collected to compare the effectiveness of sorting method with that by our proposed model. The descriptive data of the subject hotels is summary in Table 5.4.

Table 5.4
Descriptive data of the subject hotels located in Chachoengsao Province

Hotel attributes	Mean	Std.dev	Min	Max
Price (Baht)	1,228.1	1,013.57	361	5,760
Star rating	3.31	0.53	2.5	5
Supply (Room)	5.74	3.25	1	9
Overall review rating	3.58	0.41	2.8	4.6
Review rating based on service indicator	3.76	0.46	2.5	4.8

Note. Data source: http://www.hotels.com
Total number of hotels = 42 hotels; Location: Chachoengsao Province, Thailand; Check-in date: February 11 to 12, 2015

5.5.2. Customer characteristics in the selected area

We assumed the historical ratio of customers in Chachoengsao Province, Thailand from the history of online reviews from all hotels available on Hotels.com. Table 5.5 provides a ratio summary of customer types, namely, solo traveler, couple, business traveler, family, and friend. We generated an independent customer set based on the ratio of customer types, where the arrival of customers is random and each customer is equally likely to arrive first.

Table 5.5
Estimated ratios of customers.

Type of customer	Ratio
Solo traveler	32.46%
Couple	26.96%
Business traveler	20.37%
Family	14.23%
Friend	5.96%

5.5.3. Search cost of customer

Anderson (2011) reported that customers spend an average of five minutes on each OTA page to search hotels. We assume that customers incur a search cost per hotel. Customer incomes were extracted from our survey and time value was converted into the equivalent monetary value (in Thai Baht). The search cost per hotel at 0.3484 Baht was adopted to conduct the numerical experiment.

5.5.4. Customer characteristics

We generated a set of customers using the survey data conducted in Chapter 4. These data will be used in the simulation of online hotel booking with the proposed model. In this section, we will summary the relevant data that is used to generate the customer profile for a case study.

With the data analysis, we aim to observe the characteristics of overall customers that faithfully represent online customers in Thailand. Table 5.6 provides the characteristics of customers classified by type of customer whereas Table 5.7 provides the characteristics of overall customers. In practical term, all types of customer share some similar characteristics. Using survey data, we generated a set of customers by Monte Carlo sampling. Customers were classified by type of customers using the proportions in Table 5.5. For each customer, on the basis of his or her type, the parameters (e.g., budget, expected star rating, review rating) were generated using a normal distribution with the mean and standard deviations in Table 5.6. Table 5.7 shows the number of searched hotels, reservation price, and demand for all types of customers. Customers were randomly assigned in the numerical experiment using a normal distribution with the mean and standard deviation in Table 5.7.

Table 5.6
Summary statistics of variables classified by customer type.

Type of customer		Budget (Baht)	Expected star rating	Expected review rating
Solo traveler	Mean	2,294.44	2.6	3.69
	Std.dev	2,323.31	0.7	0.87
Couple	Mean	2,035.71	2.86	3.61
	Std.dev	1,298.14	0.58	0.88
Business traveler	Mean	1,860	2.6	3.28
	Std.dev	879.20	0.55	0.74
Family	Mean	2,151.30	2.91	3.71
	Std.dev	1,042.367	0.67	0.79
Friend	Mean	1,983.93	2.86	3.72
	Std.dev	1,196.09	0.72	0.82

Table 5.7
Summary of statistics of customer variables.

	Variable	Mean	Std.dev	Min	Max
All types of customer	Number of searched hotels	6.24	4.68	2	30
	Reservation price	199.24	983.69		
	Demand (room)	2.02	2.44		

To estimate the expected utility gained from a hotel, respondents were asked to give values of their recent hotel service experience (self-stated valuation). Multiple regression analysis was then performed between the expected utility as a dependent variable and seven independent variables including hotel price, star rating, and review rating on five indicators (location, comfort, service, cleanliness, and hotel condition).

Table 5.8 shows the results of regression analysis showing that our survey data fit the multiple regression model with an R-squared of 0.86 and an adjusted R^2 of 0.86. In our analysis, stepwise regression was used to select or remove variables, and two out of seven independent variables were selected to be in the final model. Thus, 86% of the variation in expected utility is explained by two independent variables (i.e., price and review rating on service indicator). Also, in order to estimate the effect or magnitude of each independent variable on dependent variable, Beta and B values were presented in the regression analysis. In the interpretation, B is the unstandardized coefficient which indicates the direction (plus and minus) and number of units of change in the dependent variable due to a one unit change in each independent variable (measured in original unit of each variable such as Thai Baht and rating). Therefore, the regression equation was formulated as following.

Expected utility = -1,134.27 + 1.144(Price) + 249.98(Service rating)

Moreover, Beta is the standardized coefficient which indicates the effect of units of change in the dependent variable due to a one unit change in each independent variable (measured in unit of standard deviation). The use of Beta coefficient facilitates comparisons among independent variables since they are all expressed in standardized unit.

We used this regression to generate a data set with information on the level of utility gained from each hotel, and these varied based on the different perceptions of individual customers. With a normal distribution, we used the standard error of estimation equal to 901.46 to randomly assign each customer the expected utility gained from each hotel.

Table 5.8
Multiple regression results, dependent variable: expected utility.

Variable	Coefficients			t-value
	Unstandardized Coefficients		Standardized Coefficients	
	B	Standard error	Beta	
Constant	–1,134.27	298.97		–3.79
Price	1.144^{**}	0.041	0.91	27.95
Service rating	249.98^{**}	76.88	0.11	3.26
R^2	0.864			
Adjusted R^2	0.862			
Standard error of estimation	901.461			

Note: $^{**}p<0.01$; Ordinary least squares (OLS) regression is used with total number of observations of 120.

5.6. Numerical experiment

In this section, the numerical experiments were conducted to design the sequence of hotels with the number of hotels selected to show on the website. As a case study of online hotel booking, 42 hotels (K = 42) located at Chachoengsao Province were chosen, as described in Section 5.5. The numerical experiment aims to determine the effectiveness of the proposed model and discuss the managerial insight that arose from doing them. The problem is solved optimally by using an optimization solver (namely, ILOG CPLEX 12.6) on a PC with a 64-bit Intel(R) Core(TM) i3-2348M CPU, 2.30 GHz clockspeed, and 8.0 GB of RAM.

5.6.1. Example of results derived from the proposed model

In the first experiment, 80 scenario customers were generated, and used to decide the optimal sequence of hotels along with the optimal number of hotels shown on the website. This is an example of the optimal decisions derived from our proposed model under a case study of online hotel booking in Chachoengsao Province. As shown in Table 5.9, five hotels out from 42 available hotels (as shown in the highlight) are selected to present on the website at a given ranking position in the sequence.

Table 5.9
Example of results for the hotel sequencing decision and the number of hotels shown on the website

Ranking position	Hotel
1st	Kriss Residence
2nd	Nest Boutique Resort
3rd	The Phoenix Hotel Bangkok
4th	BS RESIDENCE Suvarnabhumi
5th	Aranta Airport Hotel
6th	Paeva Luxury Serviced Residence
7th	Avion Apart-Hotel
:	:
42nd	Novotel Suvarnabhumi Airport

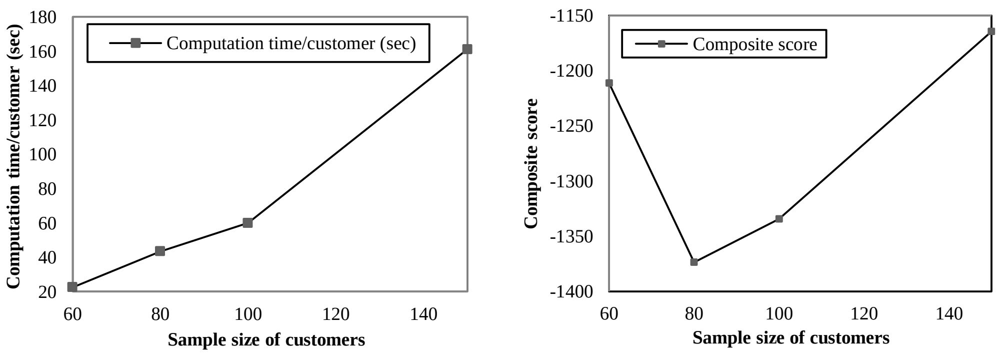
5.6.2. Analysis of numerical results

We randomly generated different customers with the varying total number of customers, N, where $N \in \{60, 80, 100, 150\}$, to design a sequence that would satisfy the various characteristics of independent customers. The sequence is re-optimized every time a new customer (independently selected from the customer pool) arrives. As a result, the sequences are selected to optimally fit these sets of customers. To test the sequence, we randomly generated another five independent customers following the same procedure. Then, a sequences of hotels designed using the varying total number of customers $N \in \{60, 80, 100, 150\}$ were tested with these five independent customers. (In other words, the sequence was re-optimized five times per test.) The larger sample size required longer computation times but provided a slightly different composite score, as shown in Table 5.10 and Fig. 5.7 (a) to (b). We found that the sample size of 80 provides the lowest composite score within the acceptable computation time per customer. The computation time will increase significantly with the number of independent customers and with the problem size, so in this study we adopted the sample size of 80 customers to make our sequencing decision.

Table 5.10
Sample size of customers for making a sequence of hotels.

Sample size of customer	Total search cost	Avg. utility/customer	Total position of all booked hotels	Composite score (Lower preference)	Computation time/customer (sec)
60	19.51	1,230.79	17	–1,211.11	22.54
80*	17.42	1,391.21	27	–1,373.50	43.48
100	13.92	1,348.52	25	–1,334.34	60.01
150	9.41	1,174.05	14	–1,164.50	161.20

* Note: The sample size of 80 is used in all subsequent numerical experiments.



(a) (b)

Fig. 5.7. Effect of sample size on computation time and composite score.

Figs.5.8 and 5.9 (a) to (d) show the sorting criteria to design the sequence of available hotels. These numerical results highlight the importance of ranking position of product placed in the sequence. Specifically, the most attractive hotel should be presented in the upper ranking position. In this numerical experiment, we fixed the number of hotels selected to show on the website (*n)* at 30 hotels which are placed in 30 ranking positions. Note that the number of 30 hotels is selected from the survey data as most customers will search hotel between 2 to 30 hotels. We conducted numerical experiment with three replications using three different sets of customers. Three sets of 80 customers were generated to design the sequence, and the average results from three replications were analyzed. The results show that the hotel that is able to attract more customers is assigned at the top position, as shown in Fig. 5.8. Fig. 5.9 shows the characteristics of the hotel in each position. From the decreasing linear trends observed in Fig. 5.9(a) to (d), we can see that not only the number of potential customers (shown in Fig. 5.8) determines the ranking position but also other hotel attributes such as net utility, review rating, star rating, and price. These results show that the ranking position of a hotel in a sequence is designed on the basis of multidimensional criteria to satisfy the multidimensional preferences of customers. In summary, a hotel with higher net utility, review rating, star rating, and price are suggested to be placed in the upper ranking positions of the sequence.

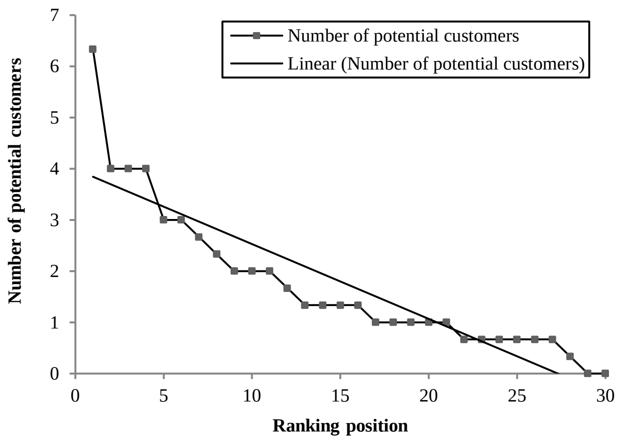
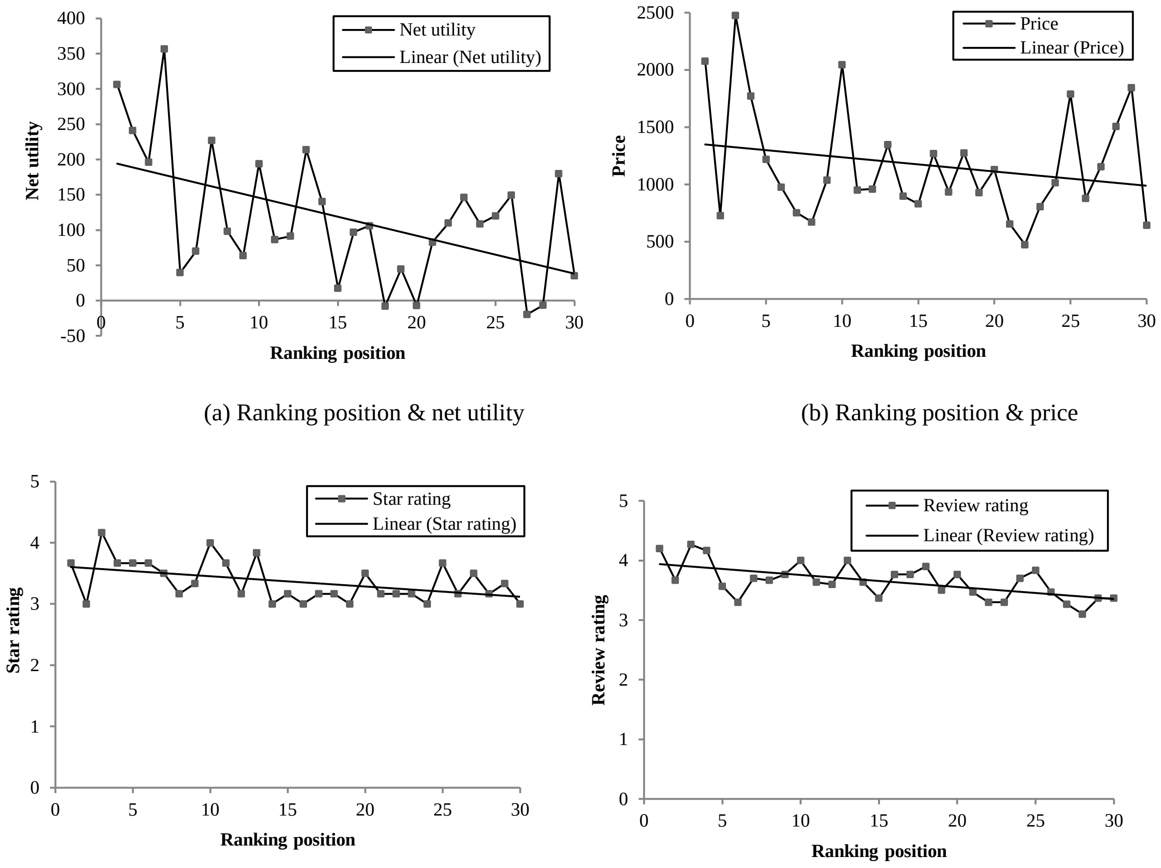


Fig. 5.8. Relationship between the ranking positon and number of potential customers



(a) Ranking position & net utility

(b) Ranking position & price

(c) Ranking position & star rating

(d) Ranking position & review rating

Fig. 5.9. Relationship between the ranking position and hotel attribute.

Table 5.11 reports the impact of the number of hotels on the composite score of the customer. We varied the number of hotels selected to show on the website $n \in \{10, 20, 25, 30, 35\}$. Fifty customers were randomly generated to test each of them. The results show that both the average utility per customer and the search cost increased along with the number of hotels. The larger number of hotels increased the probability to match a hotel with the customer's preferences but caused a higher search cost. Thus, OTAs need to balance increased search cost and utility gained from the hotel. Our results demonstrate the need for a suitable number of hotels to balance the utility and search cost. For example, to obtain the lowest composite score, the suitable number of hotels selected to show on the website is 25.

Table 5.11
Impact of the number of hotels, presented on the website, on the composite score.

Number of hotels	Total search cost	Avg. utility/customer	Total position of booked hotel	Total sold rooms	Composite score (Lower is preferred)
10	191.62	1,085.73	320	67	–890.91
20	348.40	1,263.91	445	70	–911.06
25	435.50	1,413.10	573	72	–971.87
30	522.60	1,417.50	492	72	–889.98
35	609.70	1,457.31	642	72	–841.19

Fig. 5.10 shows the composite score from different sorting methods and the number of hotels selected to show on the website. The different sorting methods, including our proposed model, price, review rating, star rating, and website's favorite, were compared. We varied the number of hotels selected to be shown on the website, $n \in \{10, 15, 20, 15, 30\}$ for each sorting method, each of which was run by three replications with three different customer sets. That is, three sets of 50 independent customers were generated and we recorded on the average. The results show that the number of hotels influences the composite score. There is a certain number of hotels that produce an optimal solution to each sorting method. For instance, the sequence sorted by price will reach an optimal solution (i.e., the lowest composite score) when considering 25 hotels shown on the website whereas the sequence sorted by star rating will reach an optimal solution when considering 15 hotels. Sorting by our proposed model generates the lowest composite score when considering 25 hotels. Also, the sorting methods have the significant impact on the composite score. Sorting by our proposed model generates the lowest composite score in every case of number of hotels compared to other OTA sorting methods. These results provide managerial insight to consider the number of available hotels shown on the website and the sorting method to use in the online shopping context.

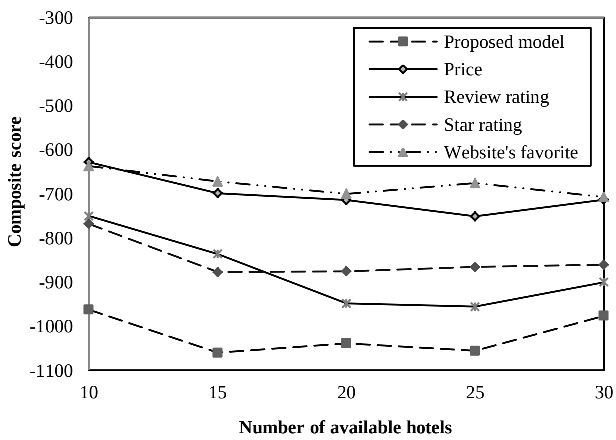


Fig. 5.10. Comparison of composite scores of different sorting methods and numbers of hotels shown on the website.

In the numerical experiments, we selected the same value for weight w_1, w_2, and w_3 at 1 as the base case. The reason is that we assume that a customer concerns every objective equally. However, the weight of each objective can be adjusted according to the main concern of customers in the case study. If we can capture the accurate expectation of customer, we can estimate the weight of each objective suitably.

Table 5.12 shows the effect of changing in the weight of search cost (w_1) on the composite score. In this experiment, we fixed the weight of expected utility (w_2) and the weight of expected ranking position (w_3) to be 1 but vary the weight of search cost, $w_1 \in \{0.5, 1, 3, 5\}$. Note that higher weight represents a case that a customer concerns more on search cost. The result indicates that changing in weight of search cost may change in the average number of hotels selected to show on the website. That is, the number of hotels selected to show on the website is continuously reduced with the higher weight on search cost. While small number of hotels reduces search cost significantly, the choices of hotel are limited and thus reduce the opportunity to find the hotel with higher net utility. The result suggests that OTAs need to consider all objectives of customers to make the sequence balancing between search cost and net utility gained from a selected hotel

Table 5.12
Impact of weight of search cost on the composite score

Weight of search cost (w_1)	Avg. no of hotel (*n**)	Total search cost	Avg. utility/customer	Total position of booked hotel	Composite score (Lower is preferred)
0.5	14.3	249.106	1344.305	346	-1,091.74
1	10.4	181.168	1256.19	287	-1,072.15
3	3.5	60.97	555.05	136	-492.72
5	2	34.84	373.39	85	-337.70

5.6.3. Effectiveness of the proposed model

To compare the result from the proposed model with that of realistic case, we performed the numerical experiment using a case study of online hotel booking in a selected area. Specifically, we compared the sequence sorted by our model and realistic sequences sorted by a specific OTA to show how the proposed model is effective. In the comparison, we simulated the sets of customers to search a hotel from different sequences sorted by each sorting methods. Using criteria of composite score, the result validates the superiority of our sequence comparing to any other sequences sorted by OTA.

Table 5.13 compares the effectiveness of sequence sorted by our proposed model with that offered by the website function. We performed this numerical experiment to determine the suitable number of available hotels shown on the website and compare the effectiveness of sequences sorted by different methods. Each sequence method was tested using three replications with three different customer sets. That is, three sets of 50 independent customers were generated, and the average result from three replications was recorded. We divided the numerical experiment into two parts. First, our sequence model decided the optimal number of n hotels in the sequence and the sequence was re-optimized every time a new customer arrives, or M = 1. Thus, 50 sequences were generated for every replication. The average number of hotels from three replications was 9.31 hotels, which is lower than the maximum number of ranking positions (n = 30) because most customers will pick hotels in the top ranking positions.

If all 30 hotels were to be included in the sequence, the net utility would increase marginally but the search cost of all customers would be much higher. To reflect this, in the second part, we fixed the number of hotels selected to show on the website (n) at 30 hotels for all sequence methods. The results show that our model with the optimal number of 9.31 hotels provides the highest utility gained from hotels above the reservation price, lowest search cost, and lowest position from a selected hotels, resulting in the lowest composite score (as lower is preferred). However, with the fixed 30 hotels, our model provides a higher utility and higher number of booking rooms, resulting in a lower composite score compared to other sequences sorted by the website. The numerical result validates the superiority of our proposed method relative to default sorting method (e.g., website's favorite) and any other sorting methods of OTAs.

From the survey data, we found that sorting a hotel list by price (from lowest to highest price) is the most preferable sorting method of most respondents when searches for hotel choices. However, the numerical result from a case study reveals that sorting by price has the lowest effectiveness when considers three goals of the proposed model (composite score). The survey result reflects that price is the main factor in the hotel booking decision. However, in the realistic of hotel characteristics, a more quality of hotel normally comes with higher price. With the sorting effect of online product list, if customers sort a list of hotel by price, it is possible that they may fail to notice a satisfactory hotel if that hotel has higher price and is placed at the bottom of a long list. Accordingly, when a customer has multidimensional preferences (e.g., consider both service quality and room facility), a cheaper hotel but lower quality influences on the utility gained from a selected hotel. These behaviors lead to the lowest composite score resulting to the lowest effectiveness of sequence sorted by price.

Table 5.13
Comparison of sequence effectiveness by our proposed model with that by the website function.

Number of hotels	Sequence method	Total search cost	Avg. utility/customer	Total position of booked hotels	Composite score (Lower is preferred)	Total sold rooms
Optimal *n* $n^*=9.31$	Proposed model	162.12	1,539.31	229.67	–1,374.89	66.67
Fixed *n=30*	Proposed model	522.60	1,460.75	833.00	–932.20	66.67
	Price	522.60	1,301.22	677.33	–770.29	60
	Review rating	522.60	1,456.96	711.67	–927.58	66
	Star rating	522.60	1,409.54	892.00	–879.82	66
	Website's favorite	522.60	1,434.65	595.00	–903.13	60

Table 5.14 shows the impact of time (period) to re-optimize the new sequence on the composite score and computation time. We compared the computation time to re-optimize the sequence every M^{th} customer's arrival, $M \in \{1, 5, 10, 20, 50\}$. 50 independent customers were randomly generated to test each of them. From the numerical result, the sequence should always be re-optimized to match a number of hotels with the uncertain condition of customers (e.g., preference, arrival), as good result providing lower composite score. However, the time to re-optimize should be optimally determined because it greatly affects the computation time. Specifically, the more often a sequence is re-optimized, the longer the computation time is taken. In our numerical experiment, we decided to re-optimize the new sequence every time that new customer arrives at the website ($M = 1$), because it provides the lowest composite score, and also every arrival of five customers ($M = 5$), because it provides good solution at an acceptable computation time.

Table 5.14
Impact of time to re-optimize the new sequence on the composite score and computation time.

Re-sequence (every M^{th} customer's arrival)	Composite score (Lower preferred)	Number of sequences	Computation time/customer (sec)
1*	–1,341.66	50	28.68
5*	–1,057.30	10	6.69
10	–930.48	5	4.14
20	–850.17	3	1.90
50	–798.52	1	0.91

* Note: Re-optimizing the sequence every 1th and 5th customer's arrival is selected in the numerical experiment

5.6.4. Practical implementation

In today's competitive market, it is essential for any companies to create competitive advantage over other competitors. In this numerical experiment, we show that the proposed model can suggest the possible ways for a hotel to improve the performance resulting to increase in the reservation rate. This highlights the usefulness of our proposed model in terms of creating a competitive advantage as the practical implication. Table 5.15 provides the information of a sample hotel used to consider the performance improvement. In our assessment, this hotel failed to get any bookings. Our model analyzed the competitive position of this hotel under the current market. As a result, this hotel was ranked number 23 out of 42 hotels in a selected area. According to Table 5.16, our model suggests that, under the current characteristics of hotel, this hotel should consider to reduce price, specifically, to less than 1,100 Baht to attract more customers.

However, an improvement of just one attribute (e.g., price, star rating, or review rating) may not be enough to remain competitive in the current market. Thus, the model suggests improving two attributes at the same time, as shown in Table 5.17. For example, a hotel should reduce price to 700 Baht and improve its service quality in order to gain a review rating of at least 3.8 to get the booking of four rooms; otherwise, they have to reduce the price to 700 Baht and improve the facilities in order to gain a hotel star rating of at least 4.5.

In our viewpoint, we suggest that a hotel should improve two attributes of price and review rating first because review rating can probably increase by improving hotel service quality (e.g., staff service, cleanliness and food) to satisfy the customers. On the other hand, two attributes of price and star rating can be improved but enhancement of star rating requires evaluation by specific organization. Also, it needs large investment at long lead time. However, the effective strategy of improvement is varied on the basis of the current situation and resource of each hotel. Since our model suggests improvements on the basis of an analysis of the current market situation (e.g., the selected area, possible competitors, and characteristics of potential customers), this strategy has a lot of potential to create a competitive advantage. This will help hotel managers plan the direction of improvement that is most practical for the hotels.

Table 5.15
Selected hotel characteristics.

Hotel information	
Price	1,291
Star	3
Review rating	3.4
Available room	9
Sold room	0
Ranking position	23

Table 5.16
Suggestion for performance improvement based on one attribute.

Number of sold rooms	Price (Baht)					Star rating					Review rating				
	500	700	900	1,100	1,291	3	3.5	4	4.5	5	3.4	3.8	4.2	4.6	5
	9	3	2	2	0	0	0	0	0	0	0	0	0	0	0

Table 5.17
Suggestion for performance improvement by two attributes.

Review rating	Number of sold rooms										
	Price (Baht)					Star rating	Price (Baht)				
	500	700	900	1,100	1,291		500	700	900	1,100	1,291
3.4	9	3	2	2	0	3	9	3	2	2	0
3.8	9	4	3	3	0	3.5	9	3	2	2	0
4.2	9	5	5	3	0	4	9	3	2	2	0
4.6	9	7	5	3	0	4.5	9	4	2	2	0
5	9	7	5	3	1	5	9	4	2	2	0

5.7. Findings and implications

This study provides the interesting findings for business implication as discussed following.

1. *The importance of sequence*

   We found that the sequence of hotel choices plays an important role on the online hotel booking intention. According to the numerical result under a case study, the sequence of hotels sorted by different sorting method produces different value of composite score (i.e., search cost, utility gained from a selected hotel and ranking position of a selected hotel). That mean, a customer tends to select different hotel choices when searching through different sequences. Thus, it is probable that an effective sequence could contribute to improve the hotel experience for customer as customer is noticed to observe and select a good hotel within the suitable search effort.

   Moreover, the sequence of hotels sorted by price, star rating and review rating, and distance will be the same for every period. Our study suggests that the sequence of hotels should always be re-sequenced at the suitable period to response with the changing situation (e.g., the changing price of hotels in some period, supply of room, special deal, and uncertain condition of customer preferences). As the result, every good hotel has an opportunity to be observed by a customer and presented in the first page of website.

2. *Multidimensional sorting criteria*

   The current sorting mechanism of OTAs sorts the sequence of hotels by using single dimensional sorting criteria. Single dimensional sorting criteria is the sorting method that sorts a sequence of hotels by concerning on single attribute of hotel (e.g. sorting by price (from lowest to highest price), review rating (from highest to lowest review rating), star rating (from highest to lowest review rating), and distance (from nearest to farthest). This sorting method has limitation to satisfy customer's need as most of customers concern many attributes of hotels (e.g., all attributes of price, review rating, star rating). Our study suggests using multidimensional sorting criteria which sorts a sequence of hotels by concerning on many attributes of OTAs (e.g., concerning all attributes of price, review rating, star rating). This sorting method could better respond the customer's need as most customers concern various attributes of hotel when make a hotel booking decision, called multidimensional preferences of customer. From the numerical results, our model provides the guidelines to sort a sequence of hotels using multidimensional sorting criteria or multidimensional sequencing of hotels. That is, the hotels with higher net utility, review rating, star rating, and price should be placed in the upper positions of the sequence.

   However, when considering single dimensional sorting criteria, the sorting by review rating (from highest to lowest review rating) produces the results close to the optimal solution derived by multidimensional sorting criteria. That is, a hotel with higher review rating should be considered in the upper position.

3. *The optimal number of choices shown on the website*

   We found that the number of choices have the significant impact on the human cognition and booking decision. The optimal number of choices shown on the website should be decided strategically to balance the quality of choices and search cost. Instead of providing a full list of hotels, our proposed model suggests to select only the hotels likely to be selected by the customers to be available on the website.

4. *Strategy to create the competitive advantage*

   The competitive advantage is a key to survive in the competitive market, especially in the era of e-commerce. There are many ways to improve a hotel to increase the number of booking rooms. We suggests that a hotel should improve main attributes such as price, star rating, and review rating to make hotel more attractive than other hotels. However, the decision that which attribute should be improved is based on the current conditions of hotel, market, potential customers in the area and competitors. Thus, our model can be practically adopted to make these directions.

This study provides several contributions to the e-commerce, tourism industry and academic researches as following. We proposed a new approach, called a two-stage stochastic programming (2SSP) model for solving the optimal sequence problem under the uncertain condition of customers. This methodology has never before been applied to this problem. We collected actual customer data through a survey and actual hotel information from OTAs. The multidimensional preferences and heterogeneity of customers were realistically captured. Using survey data, we found that the numerical results closely represent the results to be expected from actual usage of the model. Unlike other methods, the optimal number of hotels shown on the website was decided to reduce the search cost while maintaining the high utility gained from available hotels.

For the practical application, this study provides a new perspective to enhance the understanding of profitable design of OTAs and customer's behavior. Accordingly, the proposed model is to be run by OTAs to generate optimal sequence satisfying customer's expectation. Also, our model helps the hotel managers understand how customers evaluate their hotel compared to other hotels. It can analyze a hotel's competitive position in the current market and is able to provide useful guidelines to improve the hotel performance. Also, our proposed model can be applied to other types of online products which it is not limited to hotels.

CHAPTER 6
MULTIDIMENSIONAL SEQUENCING OF HOTEL ROOMS AND ONLINE REVIEWS

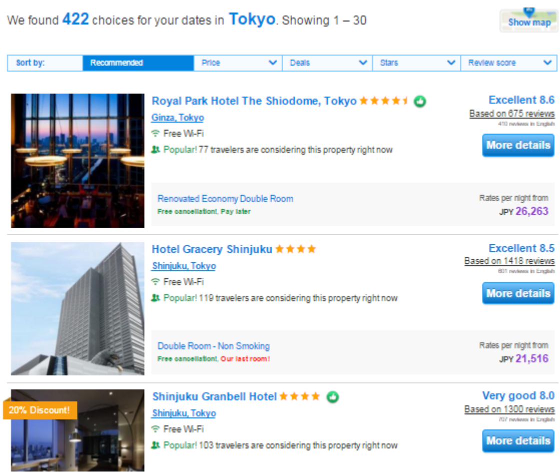
This chapter presents the extended version of the proposed sequencing model mentioned in Chapter 5. It incorporates the design of sequence of hotels and sequence of online reviews to enhance customer experience. The impact of online review is examined, and then the sequence of online reviews is designed on the basis of the findings derived from prior literatures. Specifically, the sequence of online review is designed on the basis of four independent variables; mainly (i) framing of reviews (what come first: positive or negative information), (ii) the target of review (core or service), (iii) overall valence of a set of reviews (ratio of positive or negative review), (iv) variation from overall review rating. The decision on online review sequencing is the main difference from previous chapter.

However, at the current status, we aim to present the idea of the proposed model but the findings will be discussed in the future work.

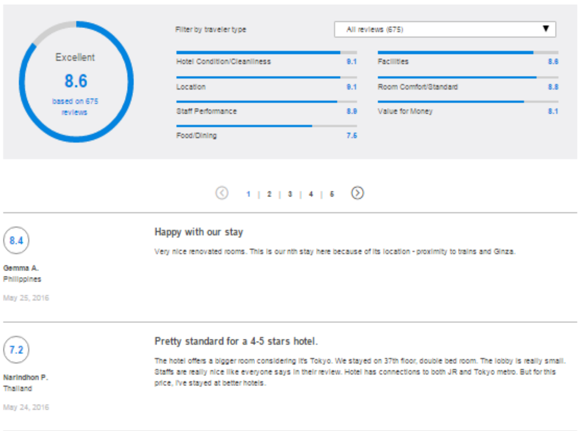
6.1. Introduction

With the Internet, the customers easily access the global searching space and share the comments, resulting in a new form of electronic word of mouth (e-WOM). Online review (e.g., review rating, individual text comments) has become an important element on OTAs and other social media forums, supporting a hotel booking decision. The current mechanism of OTAs presents overall review rating and individual review rating, scored by 1 to 5 or 1 to 10, and a number of individual comments in a sorting feature. However, a growing number of online reviews make confusion and incur search effort to an online customer. Several researches found the effect of online reviews on a hotel booking intention whereas some of them analyzed the characteristics of useful online reviews. Accordingly, several findings were derived from the data analysis, commonly supporting the relationship between online reviews and online hotel booking in many points of view. However, prior literatures ignored the application of findings to be used in online review management. Specifically, the selection and sorting design of online reviews have not been incorporated up until now.

To the best of our knowledge, a sorting design of online reviews was incorporated to present online reviews more effectively. The main contribution of this study is to develop a new framework to examine the findings derived from survey studies. Specifically, we proposed a new approach, a stochastic programming model, to design the sequence of hotels and online reviews. The design of online review expects to select useful reviews matching with customer's expectation. The website feature and sorting mechanism (for hotels and online reviews) under the scope of study are presented in Fig. 6.1(a) and (b). According to the study of Sparks and Browning (2011), the sequence of online reviews was designed on the basis of four independent variables; mainly (i) framing of reviews (what come first: positive or negative information), (ii) the target of review (core or service), (iii) overall valence of a set of reviews (ratio of positive or negative), (iv) variation from average rating. The case study was developed using actual information from OTA, Agoda.com. The numerical experiments were conducted to show the effectiveness of proposed approach and derived the managerial insights for the tourism industry.



(a) Sorting mechanism of hotels



(b) Sorting mechanism of online reviews

Fig. 6.1. Website design and sorting mechanism of Agoda.com

The following sections of this chapter are organized as following. The research method is shown in Section 6.2. The overall mechanism of service system is described as the problem description in Section 6.3. In Section 6.4, the problem is formulated into a mathematical model. The development of a case study using survey method and observation on OTAs is described in Section 6.5. The numerical result derived from the proposed model is shown in Section 6.6. We conclude the chapter in Section 6.7.

6.2. Research method

6.2.1. Service coding framework

Similar to the research method conducted in Chapter 5, this study develops a framework to represent overall service system of online hotel booking, using a coding method of a mathematical model approach. The customer experience is created from using a sorting mechanism to sort both of hotel choices and online reviews. The minimum search cost and maximum utility gained from a satisfactory hotel are mainly concerned. The problem is formulated as (i) a two-stage stochastic programming approach (2SSP) whereas goal programming approach is incorporated. Specifically, a two-stage stochastic programming approach (2SSP) is applied to deal with uncertain condition of customers, and goal programming model approach is adopted to make a sorting decision to achieve a desired goal of online review management.

6.2.2. Application of findings derived from prior literatures

This study aims to design the sequence of online reviews to meet with customer's behavior and expectation. We reviewed a number of literatures on the impact of online reviews and characteristics of useful online reviews. To examine the findings derived from prior literatures, the study of Sparks and Browning (2011) is selected to demonstrate the applicability of proposed model, and to guide the sorting strategy for online reviews. In practical term, the sequence of online reviews is designed on the basis of four independent variables; mainly (i) framing of reviews (what come first: positive or negative information), (ii) the target of review (core or service), (iii) overall valence of a set of reviews (ratio of positive or negative), (iv) variation from overall review rating. Even though these findings might not 100% guarantee to adopt in a practice, it can serve as a sorting strategy to decide online review management. Also, none of the research developed a sorting approach to select and manage online reviews. Whether the findings are correct or not, it is our belief that the proposed new framework provides the contribution for tourism sector to bridge problem space between realistic mechanism and theoretical research. Also, it provides a new perspective of online review management.

6.2.3. Mapping a model

We formulate the problem into a mathematical model whereas the standard mapping processes include the identification of parameters related to all actors, decision variable, assumption of model, objectives, and constraints. Moreover, the findings derived from Sparks and Browning (2011) are interpreted into the constraints to achieve the desired goal of ideal sorting design of online reviews. The desire goal will be described in Section 6.3.

After a problem is appropriately formulated into a mathematical model, we can simulate the usage of a sorting mechanism in an online hotel booking and an optimal decision can be made optimally using optimization software, namely IBM ILOG CPLEX version 12.6. We develop a case study using actual data from survey data and information taken from OTA, Agoda.com. The numerical experiments are conducted using a case study to show the effectiveness of the proposed model.

6.3. Problem description

In this study, we present a novel model that incorporates online review management into design of OTAs, i.e., sequencing of online review. This model includes the main actors of service system of OTAs such as customer, hotel and OTAs. According to Fig. 6.2, the sequence of hotels is presented on the website along with hotel information (e.g., price, star rating, and number of rooms) and online reviews (e.g., overall review rating, individual review rating and individual text comment). A customer searches for a hotel from top to bottom of sequence. Also, a customer looks at the online review to better make a booking decision. At the board of review, online review is presented in the forms of overall review rating (overall review rating scored by overall customers), and individual review rating with text comments given by individual customers. A customer can use a sorting mechanism of online reviews to sort the presentation of online reviews given by individual customers. Currently, the sequence of online reviews can be sorted by the most recent review, the highest to lowest review rating and the lowest to highest review rating. We assume that a customer has multidimensional preferences (e.g., budget, expected review rating, star rating, and number of rooms) and their preferences are varied among the types of customers and individual customers. Also, the impact of online reviews is perceived differently across individual customers. Given a sequence of hotels with available sequence of online reviews, a customer will select a satisfactory hotel that all attributes satisfy their personal expectation and provide the highest expected utility.

The sequence of hotels with available reviews needs to be prepared to satisfy most of customer's preferences. In practical term, as a sorting mechanism, a good hotel with good review should be presented on the upper position. Also, a hotel that fails to meet the customer's expectation should cut out from the sequence to speed up the booking decision process. Moreover, the sequence of online reviews needs to be presented suitably to help customers evaluating a hotel more accurately. In this study, the useful characteristics of online review in the design of online reviews are adapted from Sparks and Browning (2011). That is, the sequence of online reviews is designed on the basis of four independent variables; mainly (i) framing of reviews (what come first: positive or negative information), (ii) the target of review (core or service), (iii) overall valence of a set of reviews (ratio of positive or negative), (iv) variation from overall review rating. Specifically, the ideal sorting mechanism of online reviews should be achieved as it influences on the hotel booking intention and the perception of trust toward a hotel. The ideal sorting design of online reviews is determined as desired goal of online review management, including four characteristics as summarized following.

- Framing of reviews

In our study, framing of reviews represents the information (e.g., individual review rating) that is presented first in the sequence. Note that the type of information is evaluated as positive information (+), negative information (-) and neutral information (^{m}) using review rating given by an individual customer. According to Agoda.com, we classify review rating into three intervals based on the rating scored by 1 to 10. The review rating falling on interval of 0 to 3.4 is classified to be negative information (-), on interval of 3.5 to 6.9 is neutral information (^{m}) and on interval of 7.0 to 10 is positive information (+).

In the desired goal of ideal sorting design of online reviews, the positive framing is preferred to motivate a booking intention. Specifically, the first and second ranking positions in the sequence prefer the positive information (+) of online review (individual review rating on interval of 7.0 to 10).

- Target of review (core or service)

In the text comments given by individual customer, target of review is classified into two main categories, which are service and core feature. Some comments include both categories. Service-targeted review (S) relates to the service of staff, check-in, and food whereas the common phases are as helpful staff/unhelpful staff and great/poor service. Core-targeted review (C) relates to facility, location, room condition whereas the common phases are as convenient/inconvenient location and clean/dirty rooms.

In the desired goal of ideal sorting design of online reviews, service-targeted review (S) is preferred to enhance the perception of trust toward a hotel.

- Overall valence of a set of reviews (ratio of positive or negative information)

The valence of review is determined by ratio of type of information. Predominance of valence is operationalized by varying the ratio of review information; 42% of review information (can be positive or negative), 25% of review information (can be positive or negative) and the remaining review of 33% is neutral review information.

In the desired goal of ideal sorting design of online reviews, the positive valence, or predominantly positive, is preferred. Specifically, for example, the set of total 12 online reviews should contain five positive (42%), three negative (25%) and four neutral (33%) review information.

- Variation from overall review rating

The review rating given by individual customers is varied among the customers based on the type of customer, preference and trip period. Some of customers give extremely review rating (either positive or negative) or made unbiased review, consequently, variation of individual review rating from overall review rating is large.

In the desired goal of ideal sorting design of online reviews, the variation of useful individual review from overall review rating should be small in order to select a review closely representing overall customer reviews.

According to the findings from the prior literatures, OTAs makes sequence decisions of hotels and online reviews to response multi-objectives of customers and desired goal of online review mechanism. The overall problem is presented in Fig. 6.2.

Key questions that can be answered with an appropriate model are listed as following.

- How many hotels should be presented on the website?
- Which hotel should be presented on the website? And at which ranking position?
- Which hotel a customer will book? How much utility does customer get from the hotel experience?
- Which online review should be presented on the website? And at which ranking position?

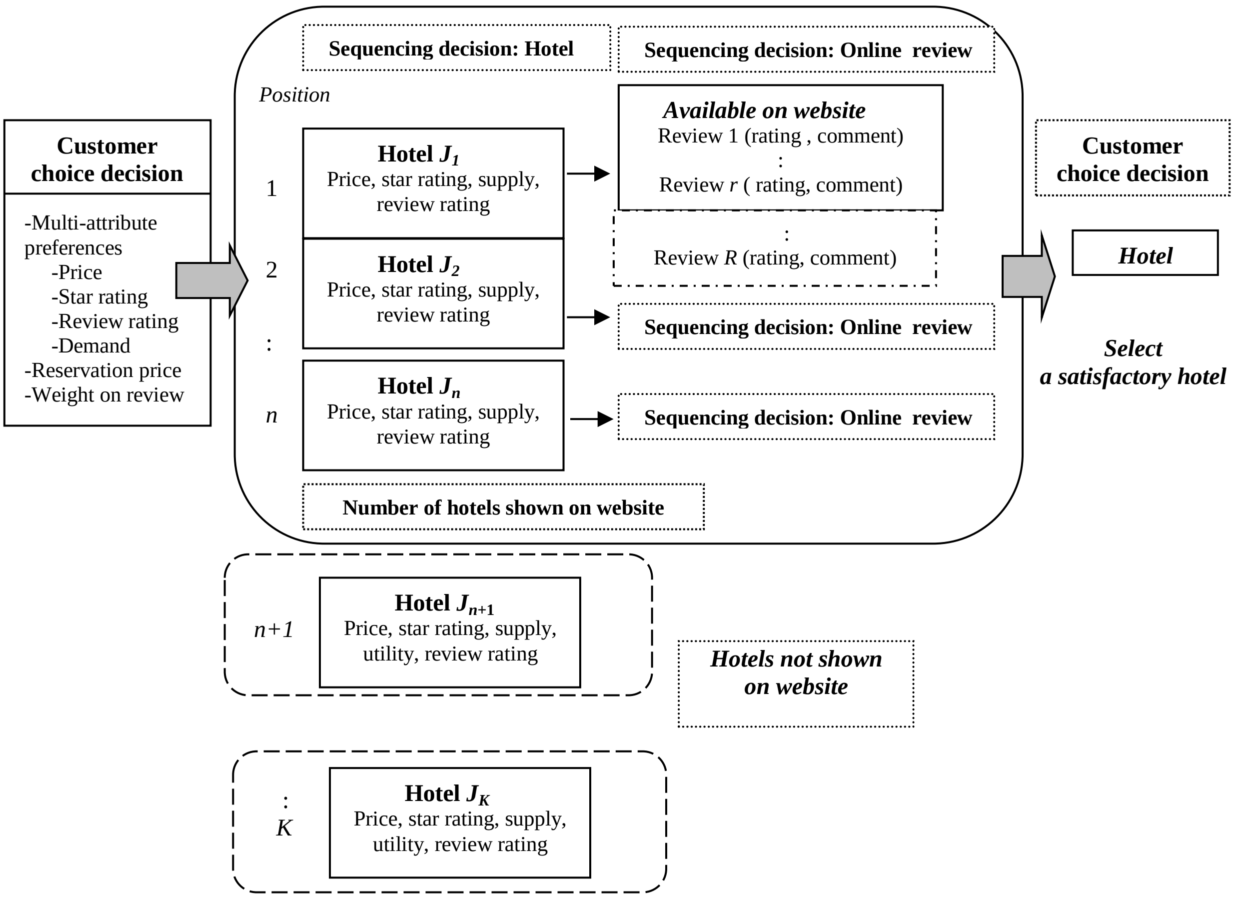


Fig. 6.2. Sequencing of hotels and online reviews on OTAs

6.4. Mathematical model approach

This study is the extended version of the proposed model mentioned in Chapter 5. To solve the stated problem, the overall service system is formulated into a mathematical model with the multi-objectives to maximize the customer experience and minimum variation from desired goal of online review sorting mechanism. In this study, the proposed model is developed using a two-stage stochastic programming (2SSP) model and goal programming model.

To formulate the problem into mathematical model, we define all actors (e.g., customer, hotel, OTAs) including their elements as input parameters and decision variables. The notations and descriptions used to make a decision are shown as following**.**

Table 6.1
Index variables

Notation	Description
i	Customer index and $i \in$ Set I ={1,…,N}
j	Hotel index and $j \in$ Set j ={1,…,K}
r	Individual review index and $r \in$ Set r ={1,…,R}
k	Ranking position index of hotel and $k \in$ Set k ={1,…,K}
b	Ranking position index of review and $b \in$ Set b = {1,…,R}
n	Total number of hotels presented on the website and $n \in$ Set n = {1,…,K}
K	Total number of ranking positions of hotels which reflects total number of hotels
N	Total number of customers
R	Total number of individual online reviews
d	Total number of individual online reviews presented on the website, $d \in$ Set d = {1,…,R}

Table 6.2
Input parameters

Notation	Description	Notation	Description
p_j	Price of a room at hotel j	B_i	Budget of customer i
Q_j	Star rating of hotel j	EQ_i	Star rating required by customer i
$Avgr_j$	Overall review rating at hotel j	Er_i	Review rating required by customer i
S_j	Available room at hotel j	D_i	Number of room required by customer i
$u_{i,j}$	Expected utility of hotel j perceived by customer i	ξ_i	Reservation price of customer i
		w_i	Weight of customer i perceived on effect of online review
$o_{i,j}$	1 if hotel j is satisfied all requirements (price, star rating, review rating, availability) for customer i; 0 otherwise $\left(o_{i,j} = RoundDown\left[Minimun\left[\frac{B_i}{p_j}, \frac{Q_j}{EQ_i}, \frac{Avgr_j}{Er_i}, \frac{S_j}{D_i} \right] \right] \forall\, i, \forall j \right)$		
w_1	Weight of search cost	$Pr_{j,r}$	1 if review r of hotel j is positive (7-10 rating); 0 otherwise
w_2	Weight of utility	$Mr_{j,r}$	1 if review r of hotel j is neutral (3.5-6.9 rating); 0 otherwise
w_3	Weight of ranking position of hotel	$Nr_{j,r}$	1 if review r of hotel j is negative (0-3.4 rating); 0 otherwise
w_4	Weight of achievement of desired goal of online review sequencing	$Sr_{j,r}$	1 if review r of hotel j is service-targeted review; 0 otherwise
w_5	Weight of ranking position of reviews	$review_{j,r}$	Review rating of hotel j at individual review r
t	Average search cost per hotel	$+C$	Positive information on core-targeted review
$\overline{Lb}$	Minimum number of hotels shown on the website	$-C$	Negative information on core-targeted review
$\overline{Ub}$	Maximum number of hotels shown on the website	^{m}C	Neutral information on core-targeted review
L	The large number	$+S$	Positive information on service-targeted review
Np	Number of positive reviews shown at a hotel	$-S$	Negative information on service-targeted review
Nn	Number of negative reviews shown at a hotel	^{m}S	Neutral information on service-targeted review
Nm	Number of neutral reviews shown at a hotel		

Decision variables and auxiliary decision variables are shown as following.

First-stage decision variables

$x_{j,k}$ = 1 if hotel *j* is presented at ranking position *k* in the sequence; 0 otherwise

z_n = 1 if *n* is the last position in the sequence selected by all customers; 0 otherwise

$R_{j,r,b}$ = 1 if individual review *r* posted on hotel *j* is presented at ranking position *b* in the sequence of reviews; 0 otherwise

Second-stage decision variables

$y_{i,j,k}$ = 1 if customer *i* selects hotel *j* presented at ranking position *k* in the sequence; 0 otherwise

s_i = Ranking position of hotel selected by customer *i*

$U_{i,j,k}$ = Net utility of customer *i* gained from hotel *j* presented at ranking position *k*

Goal programming decision variables

$d^+_{1,j}$ = Deviation variable (positive sign) stated if valence of positive reviews at hotel *j* does not fit the desired goal

$d^-_{1,j}$ = Deviation variable (negative sign) stated if valence of positive reviews at hotel *j* does not fit the desired goal

$d^+_{2,j}$ = Deviation variable (positive sign) stated if valence of neutral reviews at hotel *j* does not fit the desired goal

$d^-_{2,j}$ = Deviation variable (negative sign) stated if valence of neutral reviews at hotel *j* does not fit the desired goal

$d^+_{3,j}$ = Deviation variable (positive sign) stated if valence of negative reviews at hotel *j* does not fit the desired goal

$d^-_{3,j}$ = Deviation variable (negative sign) stated if valence of negative reviews at hotel *j* does not fit the desired goal

$d^+_{4,j}$ = Deviation variable (positive sign) stated if service-targeted review at hotel *j* does not fit the desired goal

$d^-_{4,j}$ = Deviation variable (negative sign) stated if service-targeted review at hotel *j* does not fit the desired goal

$d_{5,j}^{+}$ = Deviation variable (positive sign) stated if last ranking position of review at hotel *j* does not fit the desired goal of positive framing

$d_{5,j}^{-}$ = Deviation variable (negative sign) stated if last ranking position of review at hotel *j* does not fit the desired goal of positive framing

$d_{6,j}^{+}$ = Deviation variable (positive sign) stated if first two ranking positions of review at hotel *j* do not fit the desired goal of positive framing

$d_{6,j}^{-}$ = Deviation variable (negative sign) stated if first two ranking positions of review at hotel *j* do not fit the desired goal of positive framing

$d_{7,j}^{+}$ = Deviation variable (positive sign) showing variation of average individual review rating from overall review rating at hotel *j*

$d_{7,j}^{-}$ = Deviation variable (negative sign) showing variation of average individual review rating from overall review rating at hotel *j*

6.4.1. Formulation of two-stage stochastic programming model (2SSP)

In 2SSP, the decisions are divided into two stages of decision.

- *First-stage decision:* In the first stage, the sequence of hotels $x_{j,k}$ with the number of hotels shown on the website z_n needs to be decided before a customer comes to OTAs. Also, the sequence of online reviews available for each hotel $R_{j,r,b}$ is prepared based on the findings of prior literatures. Note that goal programming approach is applied to set a desired goal of an ideal online review mechanism.

  In the first stage, we generate many possible scenarios of customers to make a sequence decision to satisfy the future demand of actual customers.

- *Second-stage decision:* In the second stage, given a sequence of hotels with available sequence of online reviews, a customer selects a hotel $y_{i,j,k}$, to satisfy their expectation. The ranking position of hotel selected by customer *i*, s_i, is determined.

6.4.2. Formulation of goal programming model

Goal programming (GP) is a framework to model the multi-objective optimization problem (MOOP). The model incorporates the deviation variables between the achievement of desired goal (ideal setting) and achieved objective of model (actual solution). GP aims to make a decision to minimize the unwanted deviation variables of the desired goal. In practical term, the achieved objective is expected to be consistent with the desire goal as much as possible. Thus, the deviation variables representing the positive sign and negative sign are incorporated to make such the consistency. The application of GP in the real life decision problems has been widely investigated such as supplier selection and order allocation (Jadidi et al., 2015), airport logistics center expansion plan problems (Tu and Chang, 2016), hub location-allocation problem (Ghodratnama et al., 2015), and renewable energy production problem (Zografidou et al., 2016).

In this study, we apply goal programming approach to deal with the sequencing decision of online reviews. The desired goal of sequencing is defined as the sequencing constraints, based on the findings derived from prior literatures. As shown in Fig. 6.3, it is our belief that these findings serve as sorting strategy to create an ideal sequence of online reviews (desired goal) to enhance the hotel booking intention. In the proposed model, the deviation variables, d^- and d^+, are incorporated to make the consistency between the desired goal and achieved objective. Accordingly, the objective of sequencing model under GP is to minimize the unwanted deviation from desired goal. For example, if a hotel has characteristics of review closing to the desired goal, online review of that hotel is presented to meet such a goal, otherwise it will be presented as close as possible at the unwanted deviation variables. Note that unwanted deviation variable will be computed by adding or deducing value (i.e., positive and negative sign) to satisfy the desired goal. Thus, the proposed sequencing model is designed to satisfy an ideal sequencing mechanism as much as possible. The two stages of decision incorporating with the desired goal of ideal review mechanism are presented in Fig. 6.3.

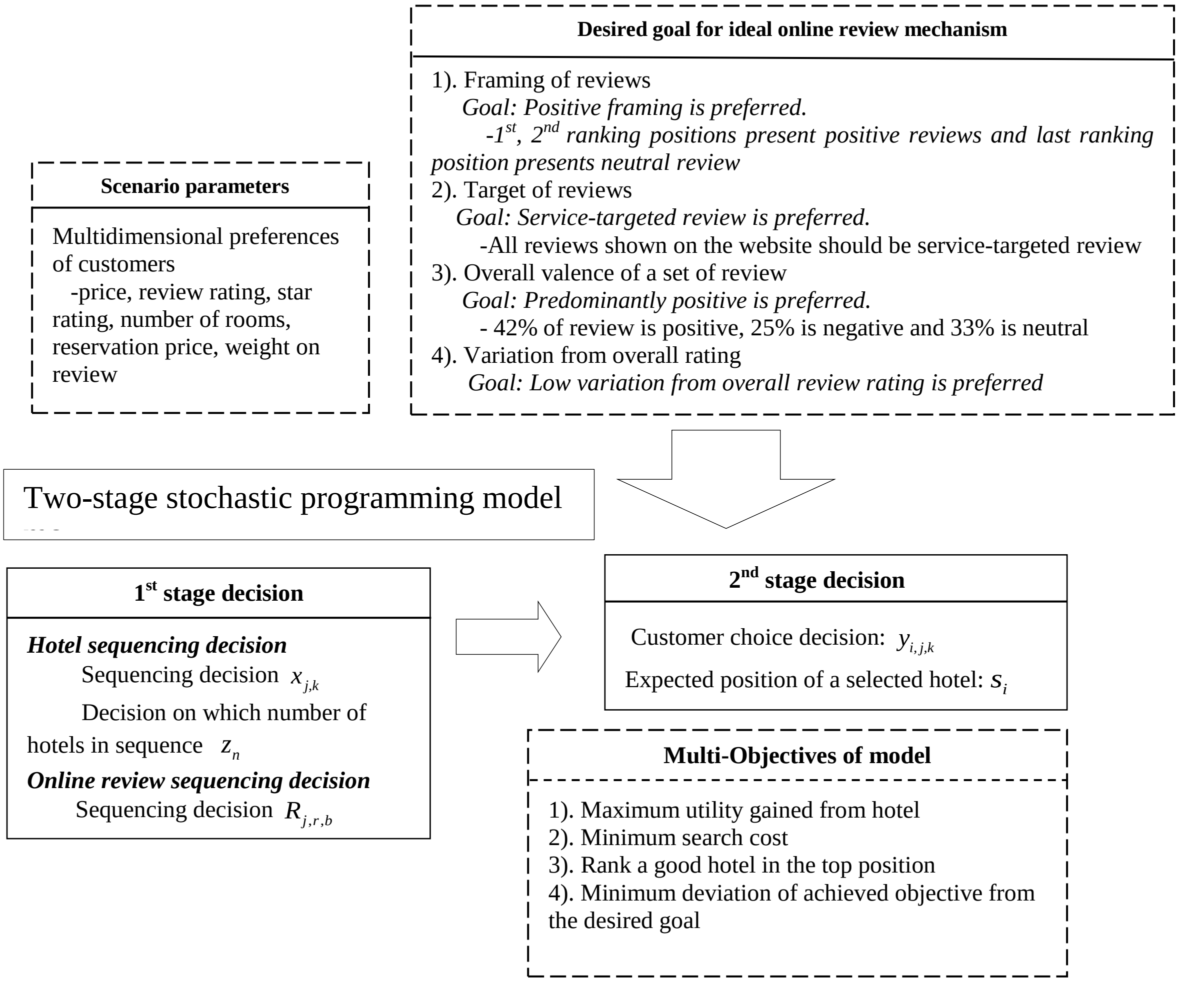


Fig. 6.3. Diagram of two-stage decision with the desired goal

6.4.3. The proposed model

The proposed model is developed using a two-stage stochastic programming (2SSP) and goal programming model as following.

Minimize composite score =

$$w_1 \times t \times \sum_{n=1}^{K} n \times z_n - w_2 \times \frac{1}{N} \times \sum_{i=1}^{N}\sum_{j=1}^{K}\sum_{k=1}^{K} U_{i,j,k} + w_3 \times \frac{1}{N} \times \sum_{i=1}^{N} s_i$$
$$+ w_4 \times \sum_{j=1}^{K} (d_{1,j}^{+} + d_{1,j}^{-} + d_{2,j}^{+} + d_{2,j}^{-} + d_{3,j}^{+} + d_{3,j}^{-} + d_{4,j}^{+} + d_{4,j}^{-} + d_{5,j}^{+} + d_{5,j}^{-} + d_{6,j}^{+} + d_{6,j}^{-} + d_{7,j}^{+} + d_{7,j}^{-}) \qquad (1)$$
$$+ w_5 \times \sum_{j=1}^{K}\sum_{r=1}^{R}\sum_{b=1}^{R} b \times R_{j,r,b} \times review_{j,r}$$

Subject to:

First-stage constraints:

Hotel sequencing constraints

$$\sum_{n=1}^{K} z_n = 1 \qquad (2)$$

$$\sum_{n=1}^{K} n \times z_n \leq \overline{Ub} \tag{3}$$

$$\sum_{n=1}^{K} n \times z_n \geq \overline{Lb} \tag{4}$$

$$\sum_{k=1}^{K} x_{j,k} = 1 \quad \forall j \tag{5}$$

$$\sum_{j=1}^{K} x_{j,k} = 1 \quad \forall k \tag{6}$$

Review sequencing constraints

$$\sum_{b=1}^{R} R_{j,r,b} = 1 \quad \forall j, r \tag{7}$$

$$\sum_{r=1}^{R} R_{j,r,b} = 1 \quad \forall j, b \tag{8}$$

$$d_{1,j}^{-} - d_{1,j}^{+} + \sum_{r=1}^{R}\sum_{b=1}^{d} R_{j,r,b} \times Pr_{j,r} = Np \quad \forall j \tag{9}$$

$$d_{2,j}^{-} - d_{2,j}^{+} + \sum_{r=1}^{R}\sum_{b=1}^{d} R_{j,r,b} \times Mr_{j,r} = Nm \quad \forall j \tag{10}$$

$$d_{3,j}^{-} - d_{3,j}^{+} + \sum_{r=1}^{R}\sum_{b=1}^{d} R_{j,r,b} \times Nr_{j,r} = Nn \quad \forall j \tag{11}$$

$$d_{4,j}^{-} - d_{4,j}^{+} + \sum_{r=1}^{R}\sum_{b=1}^{d} R_{j,r,b} \times Sr_{j,r} = d \quad \forall j \tag{12}$$

$$d_{5,j}^{-} - d_{5,j}^{+} + \sum_{r=1}^{R} R_{j,r,b} \times Mr_{j,r} = 1 \quad \forall j, b = d \tag{13}$$

$$d_{6,j}^{-} - d_{6,j}^{+} + \sum_{b=1}^{2}\sum_{r=1}^{R} R_{j,r,b} \times Pr_{j,r} = 2 \quad \forall j \tag{14}$$

$$d_{7,j}^{-} - d_{7,j}^{+} + \frac{1}{d} \times \sum_{b=1}^{d}\sum_{r=1}^{R} R_{j,r,b} \times review_{j,r} = Avgr_j \quad \forall j \tag{15}$$

Second-stage constraints: Customer choice constraints

$$\sum_{j=1}^{K}\sum_{k=1}^{K} y_{i,j,k} \leq 1 \quad \forall i \tag{16}$$

$$y_{i,j,k} \leq O_{i,j} \quad \forall i, \forall j, \forall k \tag{17}$$

$$\sum_{j=1}^{K}\sum_{k=1}^{K} U_{i,j,k} \geq \xi_i - (1 - \sum_{j=1}^{K}\sum_{k=1}^{K} y_{i,j,k}) \times L \quad \forall i \tag{18}$$

$$U_{i,j,k} \leq y_{i,j,k} \times (u_{i,j} - p_j) + \frac{w_i}{d} \times \sum_{r=1}^{R}\sum_{b=1}^{d} review_{j,r} \times R_{j,r,b} \quad \forall i, \forall j, \forall k \tag{19}$$

$$U_{i,j,k} \leq y_{i,j,k} \times L \quad \forall i, \forall j, \forall k \tag{20}$$

$$y_{i,j,k} \leq x_{j,k} \quad \forall i, \forall j, \forall k \tag{21}$$

$$y_{i,j,k} \leq (1 - z_n) \quad \forall i, \forall j, \forall k, \forall n = 1,.., k-1 \tag{22}$$

$$s_i = \sum_{j=1}^{K}\sum_{k=1}^{K} k \times y_{i,j,k} + (1 - \sum_{j=1}^{K}\sum_{k=1}^{K} y_{i,j,k}) \times K \quad \forall i \tag{23}$$

Given a sequence of hotels with a sequence of available online reviews, a customer makes a hotel booking decision according to their preferences. We assume that a customer observes the number of hotels presented on the website and looks at online review board before making a booking decision. A customer with multidimensional preferences selects a satisfactory hotel that all attributes satisfy their expectation at the highest utility gained from hotel above the reservation price. Eq. (1) states the composite score which combines five main objectives of model, namely (1) the minimum search cost by selecting a suitable number of hotels shown on the website, rather than showing the full list of thousand hotels, (2) the maximum utility gained from hotel above the reservation price, (3) the minimum expected ranking position of hotel selected by customer, (4) the minimum unwanted deviation from a desired goal of an ideal online review sequencing and (5) the maximum individual review rating presented at the upper position. Accordingly, the objective function of the proposed model is to minimize the composite score so that multi-objectives are achieved. Eqs. (2) to (15) present the first-stage constraints to make a sequencing decision (i.e., sequence of hotels, number of hotels presented on the website, sequence of online reviews). Eq. (2) determines the number of available hotels selected to show on the website. Eqs. (3) to (4) determine the upper bound and lower bound of the number of available hotels shown on the website. Eqs. (5) to (6) determine the ranking position of each hotel shown in the sequence. Eq. (5) states that each hotel can be assigned to only one position. Eq. (6) states that each position can be assigned by only one hotel.

Eqs. (7) to (15) present the constraints to design the sequence of online reviews. Eqs. (7) to (8) assign the ranking position of individual online reviews available at each hotel. Eq. (7) states that each online review can be assigned to only one position. Eq. (8) states that each position can be assigned by only one individual online review. Eqs. (9) to (11) represent the valence of positive review in the desired goal. That is, Eq. (9) determines the number of positive reviews, 42% of online reviews, presented on the website at each hotel. Eq. (10) determines the number of neutral reviews, 33% of online reviews, presented on the website at each hotel. Eq. (11) determines the number of negative reviews, 25% of online reviews, presented on the website at each hotel. Eq. (12) states that service-targeted review is preferred to present on the website to achieve the desired goal. Eqs. (13) to (14) present the positive framing of online review in the desired goal. That is, Eq. (13) states that the last position of online reviews at each hotel should be the neutral review. Eq. (14) states that the first two positions of online reviews at each hotel should be positive. Eq. (15) states that average review rating of all individual online reviews presented on the website at each hotel should be consistent with overall review rating (given by all customers) of that hotel.

Eqs. (16) to (23) present the second-stage constraints to make a customer choice decision, given a sequence of hotels with available sequence of online reviews. Eq. (16) states that a customer can either book a hotel from a given sequence or leave without booking. The criteria for a customer choice decision are given by Eqs. (17) to (20). Eq. (17) states that a customer can book a hotel if all attributes (e.g., price, star rating, overall review rating, available number of rooms) are satisfied with customer's expectation (e.g., budget, expected star rating, review rating, number of required rooms). Eqs. (18) to (20) state that a customer can book a hotel if the net utility gained from a hotel satisfies the personal reservation price. Specifically, Eq. (19) determines the net utility gained from a selected hotel. That is, the net utility is the term of the expected utility of hotel perceived by a customer, actual price per room, and the effect of online reviews on the perception of customer. Note that a customer can evaluate online review if shown on the website. Eq. (21) states that a customer can select a hotel presented in the sequence at a given position. Eq. (22) states that a customer can select a hotel if shown on the website. Eq. (23) indicates the ranking position of the hotel selected by a customer.

6.5. Case study

We developed a case study of online hotel booking in Kanchanaburi province, Thailand. The case study was simulated through the numerical experiments to derive the managerial insight. The hotel information and customer characteristics are presented as following.

6.5.1. Hotel characteristics

The sample data of hotel characteristics were collected from an OTA, Agoda.com, http://www.agoda.com/. Agoda.com is ranked number 790 in the global ranking whereas 8.5% of visitors come from Thailand (Alexa, 2016).

Hotels located in Kanchanaburi Province, Thailand were selected to develop a case study for numerical experiments in this chapter. Kanchanaburi Province is Thailand's third largest of 76 provinces where covers an area of 19,480 km^2. It is located 130 kilometers west of Bangkok, a capital of Thailand. The province becomes an interesting tourist attraction including beautiful nature and friendly people. The major attractions within Kanchanaburi Province include the several waterfalls, mountains, caves national parks and River Kwai. Specially, within the province, Erawan waterfalls with its seven levels are recognized as the most beautiful falls in Asia. Kanchanaburi Province was selected as it is a popular tourist attraction located near the capital of Thailand, resulting in the number of hotels with available online reviews made by various types of travelers. Also, its size of data set can be manageable manually and used for running a numerical experiment within acceptable computation time.

Hotel information of Kanchanaburi Province, Thailand for the check-in dates of April 19 to 21, 2016, was collected. A total number of 31 available hotels and 25 online reviews per hotel on Agoda.com were collected and used as input data for the numerical experiments. Note that the average number of reviews per hotel is 158 reviews (total number of reviews of 4,894 is available on the website). Hotel information comprising of price per room (in Thai Baht), star rating (scale by 1 to 5), available room, overall review rating (scale by 1 to 10), and individual review rating (scale by 1 to 10) with the target review (text comment on core or service) were collected. Also, the existing sequences of 31 hotels in Kanchanaburi Province sorted by Agoda.com (sorted by price, star rating, review rating, website's favorite) were collected. Also, the sequence of individual online reviews was collected (sorted by the lowest to highest review rating, the highest to lowest review rating, and the most recent review). The descriptive data of the subject hotels is summary in Table 6.3.

Table 6.3
Descriptive data of the subject hotels located in Kanchanaburi Province

Hotel attributes	Mean	Std.dev	Min	Max
Price (Baht)	1,594	864.82	680	4,458
Star rating	3	0.65	1	5
Supply (Room)	5	2.87	1	9
Overall review rating	7	1.99	0	9
Total number of reviews given by individual customer per hotel	158	241.66	0	1,192

Note. Data source: http://www.agoda.com/.
Total number of hotels = 31 hotels, Total number of individual reviews = 4,894 reviews;
Location: Kanchanaburi Province, Thailand; Check-in date: April 19, 2016 to April 21, 2016

6.5.2. Customer characteristics in a selected area

Similar to Chapter 5, we used the survey data to randomly generate the profile of customers (e.g., multidimensional preferences). Also, we used the history of online reviews given by various types of customers from all hotels located in a selected area to assume the historical ratio of customers in Kanchanaburi Province, Thailand. We generated a set of customer based on the ratio of types of customers, whereas the arrival of customers was random. A summary of customer ratio are provided in Table 6.4.

Table 6.4
Estimated ratios of customers in Kanchanaburi Province

Type of customer	Ratio
Solo traveler	4.54
Couple	46.27
Business traveler	1.39
Family	27.75
Friend	20.02

Note. Total number of customers giving the individual online review = 4,894 customers

6.6. Numerical experiment

In this section, the numerical experiments were conducted to design the sequence of hotels and the sequence of online reviews under the multidimensional preferences of customers and the desired goal of ideal online review sequencing. A case study of 31 available hotels, located at Kanchanaburi Province, with available online reviews was applied in the experiments. The customer profile was randomly generated from survey data to represent overall customer in the case study. The problem was solved optimally using the optimization solver ILOG CPLEX 12.6 on a PC with 64 bit Intel(R) Core(TM) i3-234 with 1.60 GHz processor and 4.0 GB RAM.

6.6.1. Example of results derived from the proposed model

Table 6.5 shows the example of numerical results derived from the proposed model (i.e., sequence of hotels, number of hotel shown on the website, and sequence of online reviews). In this experiment, we generated 40 scenario customers to make a decision on the sequences of hotels and online reviews. The results indicate that the proposed model can select a specific hotels placed at a given ranking position shown on the website (as in highlight). In this example, the number of hotels selected to show on the website is 3 hotels whereas the number of online review per hotel shown on the website is 7 individual online reviews. Also, the sequence of online reviews can be designed for each hotel by considering valence, framing, variation and target of reviews.

Table 6.5
Example of numerical results for the sequencing decision of hotels and online reviews

Ranking position	Hotel name		Online review selection										Variation from overall review rating
			1st	2nd	3rd	4th	5th	6th	7th	8th		25th	
1st	A	Review no.	8	16	15	7	23	10	25	24		14	0.23
		Target	+S	+S	+S	+S	+S	+S	+S	+S		+S	0.21
2nd	B	Review no.	3	12	21	22	18	17	20	19		15	0.24
		Target	+S	+S	+S	^{m}S	^{m}S	^{m}S	^{m}S	+S		+C	3.68
3rd	C	Review no.	18	1	4	25	8	6	24	23		10	0.008
		Target	+S	+S	+S	^{m}S	^{m}S	-S	-S	^{m}S		+C	0.45
4th	D	Review no.	22	23	14	4	3	20	7	21		9	0.007
		Target	+S	+S	^{m}S	^{m}S	^{m}S	-S	-C	-C		C	0.008
31st	E	Review no.	10	14	5	12	15	2	11	3		18	0.075
		Target	+S	+S	+S	+S	^{m}S	-S	-C	-S		C	

Note. Target of review (S = Service, C = Core); Valence (+ = positive descriptors; - = negative descriptor; ^{m} = neutral descriptor.

6.6.2. Effectiveness of the proposed model

Table 6.6 compares the effectiveness of the sequences sorted by our proposed model and the sequences sorted by the website function. The sequences sorted by the website function were observed from Agoda.com (e.g., sorting by price, star rating, review rating and website's favorite. A set of 20 scenario customers was randomly generated to make an optimal sequence decision by the proposed model. Then, to test the effectiveness of the sequence, another set of 10 actual customers was generated, and tested with the sequences sorted by different sorting methods.

We divided the numerical experiments into two parts. In the first part, called an optimal case, the proposed model determines the optimal number of hotels shown on the website (n^*) at $n^* = 7$ hotels, and further minimize the search cost to just 0.24 Bath (lower than the number of hotels shown on the first page (normally, n = 20 to 30 hotels). In the second part, the number of hotels shown on the website is fixed at 20 hotels for all sorting methods. The result shows that the proposed model with the optimal number of 7 hotels leads to the highest utility gained from hotel, lowest search cost, lowest ranking position of selected hotels, same number of booking rooms, resulting in the lowest composite score compared with different sorting methods. Also, given the same number of 20 hotels, using the proposed model, a customer can find a satisfactory hotel at the higher utility gained from hotel compared with the sequences sorted by the website function. Using the proposed model, the ranking position of the hotels selected by a customer is on average at 3.9 (in an optimal n^*case) and 7.9 (fixed n = 20) which are lower than that of other sorting methods provided by the website. These results imply that, using the proposed model, the hotels placed on the top position are interesting for most customers.

Table 6.6
Comparison the effectiveness of hotel sequencing by different sorting methods

Sorting method	Number of shown hotel	Search cost	Avg. utility	Avg. no. of position	Total booking rooms	Composite score (lower is preferred)	Avg. Computation time/customer (sec.)
Proposed model	Optimal n n^*= 7	0.24	1,616.32	3.9	9	-1,332.27	10.81
Proposed model	Fixed n = 20	0.68	1,610.23	7.9	9	-1,326.84	1.95
Price		0.68	1,494.69	15.1	8	-1,204.10	0.05
Star rating		0.68	1,562.49	9.9	9	-1,277.10	0.05
Review rating		0.68	1,602.82	11.9	9	-1,315.43	0.06
Website's favorite		0.68	1,572.51	9.8	9	-1,287.22	0.05

6.6.3. Analysis of numerical results

Table 6.7 compares the results derived from the sequence of online reviews sorted by our proposed model with the existing sequences sorted by OTAs (e.g., from the most recent review, from the highest to lowest review rating and from the lowest to highest review rating). In our proposed model, we developed a set of 40 scenario customers to make a sequence of hotels with the available sequence of online reviews. To evaluate the effect on sequence of online reviews, another set of 40 actual customers were randomly generated and tested with each sorting methods of OTAs. The results show that the sequence of online reviews has no effect on the number of hotels presented on the website (n = 7 for all sorting methods of online reviews) but it slightly influences on the sequence of hotels as same hotels selected by a customer are placed in different ranking position. Although, at the current status, the effect of online reviews sorted by our desired goal is not clear in the customer choice decision (as customers select same hotels in every sorting methods), it is our belief that this study provides a new framework to create a new perspective of online review management. This is the main contribution of this study. However, we will improve the result and discuss in the future work.

Table 6.7
Comparison the results by different sorting methods of online reviews

Online review's sorting method	Shown on the website		Avg. Utility	Avg. no. of position of selected hotels	Total booking rooms	Selection of online reviews	Avg. Computation time/customer (sec.)
	Number of hotels	Number of reviews				Variation from overall rating	
Proposed model	7	12	1,616.32	3.9	9	0.72	10.81
Most recent	7	12	1,616.92	4.2	9	0.47	1.11
Lowest to highest	7	12	1,614.65	4.6	9	1.25	1.32
Highest to lowest	7	12	1,619.19	3.9	9	0.81	1.25

6.7. Conclusion

The usage and design of the hotel sequencing feature and online review mechanisms to make an online hotel booking decision were studied. We proposed a new framework that incorporates the theory of customer's behavior and findings derived from prior literatures. Using a service coding framework, we proposed a mathematical model, namely a two-stage stochastic programming model (2SSP) and goal programming model. Specifically, the proposed model was developed to examine the findings related to the effect of online review by prior literature. The desired goal of an ideal online review mechanism considered four main variables comprising of (i) framing of reviews (positive framing is preferred), (ii) the target of review (service-targeted review is preferred), (iii) overall valence of a set of reviews (positive valence is preferred), (iv) variation from overall review rating (low variation is preferred). To show the practical application of the proposed model, the case study developed by a set of real data was used to conduct the numerical experiments. The result shows that the proposed model could be used to make a decision on sequence of hotels, number of hotels presented on the website and sequence of online reviews under the objectives to enhance the customer experience.

The contribution of this study is to propose a new framework to examine the findings derived from prior researches and to provide a new perspective of online review management.

CHAPTER 7

MULTIDIMENSIONAL SEQUENCING OF HOTEL ROOMS AND ONLINE REVIEW SELECTION

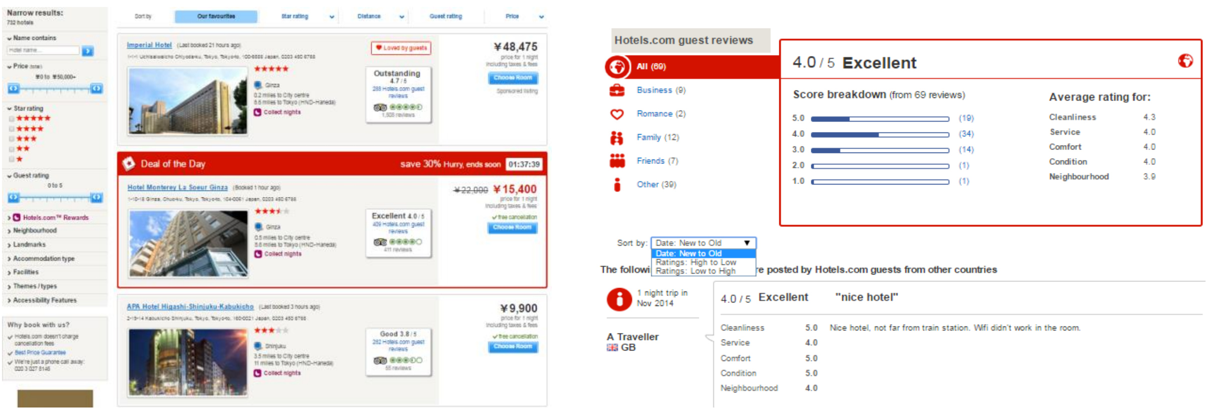
This chapter incorporates a hotel sorting mechanism and online review mechanism to select only a hotel and online review that most satisfy the customer's preferences. These considerations encompass the overall system from a customer to service provider. The main concern is on the minimum number of search steps which reflect the current situation of customer's behavior under a constraint of time. The customer's search behavior, namely sequential search model, is incorporated to represent actual behavior of customer. The case study of online hotel booking is developed to simulate the realistic mechanism with the proposed model. Specifically, the model under this chapter is developed to response the specific website design such as Hotels.com. The OTA presents online reviews given by individual customers in form of individual text content, average review rating and review ratings in various indicators (e.g., cleanliness, service, location etc.). The effectiveness of the proposed model is confirmed in a case study, and tested through the numerical experiments.

7.1. Introduction

The growing number of hotels and the availability of online reviews on OTAs increase the searching space but incur the search effort to an online customer. Today's society is more concerned on the search cost and search time. Thus, the development of effective mechanism is necessary to select useful information from unnecessary information, resulting to reduce information overload for online shopping. It is essential to incorporate the criteria of hotel selection, the effect of online review and the customer's searching behavior when consider a useful sorting mechanism.

Several approaches for a hotel recommendation were developed to predict the customer's preferences while the most classical recommendation systems was designed based on the user-generated content (e.g. social media and online review). However, these approaches have some limitations to include the customer's searching behavior. Moreover, the high volume of unnecessary online review makes confusion for an online customer to evaluate the product. A mechanism for selecting the useful online reviews on the basis of user-preference criteria is necessary (although a few have been developed). While the main characteristics of useful online reviews have been analyzed extensively (for example, by Liu and Park, 2015), only one mechanism for ranking online reviews has been proposed (Ghose and Ipeirotis, 2007). However, this mechanism ignored user-preference criteria in the online-tourism context.

In this chapter, we developed a mathematical model capable to design an optimal sequence of hotels with the selection of online reviews based on the customer-defined indicator criteria in OTAs. The website feature and sorting mechanism under the scope of study are provided in Fig.7.1. To the best of our knowledge, there is no study incorporating (i) the sequential searching behavior under the uncertain condition of customers and (ii) the sorting mechanism of hotel and online review selection based on the multi-attribute criteria in an online hotel booking decision. That is, our model incorporated the optimal searching behavior, multidimensional preferences of customer and effect of online review. The uncertain conditions of customers were captured with a stochastic programming approach. Our study considered the minimum number of expected search steps but maintaining the satisfaction of customer on a selected hotel. Moreover, we applied our proposed method to the realistic case using a case study of Asakura, Japan from a selected OTA, Hotels.com. The analysis of numerical result provided the managerial insight for OTAs to respond the customer's searching behavior. These serve as the guideline to deal with the information overload, and enhance the full utilization of sorting mechanism and online review in an online hotel booking.



(a) Sorting mechanism of hotels (b) Sorting mechanism of online reviews

Fig. 7.1. Website design and sorting mechanism of Hotels.com

The following sections of this chapter are organized as following. The research method is shown in Section 7.2. Section 7.3 describes the problem description and the proposed model is presented in Section 7.4. The development of a case study using survey data and observation on OTAs is described in Section 7.5. The numerical results derived from the proposed model are shown in Section 7.6. We conclude the chapter in Section 7.7.

7.2. Research method

7.2.1. Service coding framework

We establish a framework to represent overall service system of online hotel booking, using a coding method of a mathematical model approach. That is, the problem is formulated as a two-stage stochastic programming approach (2SSP) model.

7.2.2. Mapping a model

We formulate the problem into a mathematical model whereas the standard mapping processes include the identification of parameters related to all actors, parameters, decision variable, assumptions of model, objectives, and constraints.

After a problem is appropriately formulated into a mathematical model, we can simulate the usage of a hotel sorting mechanism and online review mechanism in an online hotel booking. An optimal decision is made optimally using optimization software, namely IBM ILOG CPLEX version 12.6. We develop a case study using actual data from survey data and information taken from OTA, Hotels.com. The numerical experiments are conducted using a case study to show the effectiveness of proposed model.

7.3. Problem Description

We consider a customer who uses the hotel sorting and the online review mechanism to make a hotel booking decision through online travel agencies (OTAs). The overall stages of a hotel booking decision are shown in Fig. 7.2. The OTAs present a list of available hotels with hotel information (e.g. room type, price, star, overall review rating, available room etc.) and the individual online reviews containing various indicators (e.g., location, cleanliness, service etc.). A customer searches for a hotel from the top to bottom of a given sequence and reads online reviews given by individual past customers. A customer determines the minimum requirement concerning the multidimensional preferences (e.g., price, expected star, overall review rating, reservation utility and number of room) and the important criteria concerning the online review indicators. Different customers have the different requirement. Thus, the expected number of search step varies from customers to customers based on their personal expectation.

This study develops a model to design an optimal sequence of hotels with the selection of online reviews concerning the customer-defined indicators. The objective is to help all customers find a satisfactory hotel that all characteristics are satisfied with customer's expectation at the minimum number of search steps.

As for this model, to meet the proposed objective, a fictional hotel $n+1$ with ideal characteristics (where n is the total number of available real hotels) is put at the last positon $n+1$ so that a customer will select exactly one hotel if he or she cannot find any hotels meeting their expectation. That is, if the customer decides to leave without booking, he or she will select the fictional hotel with the expected number of search step at $n+1$ unconditionally.

Key questions that can be answered with an appropriate model are listed as following.

- Which hotel should be presented on the website? And at which ranking position?
- Which hotel a customer will book? How much utility does customer get from the hotel experience?
- Which online review should be presented on the website? And at which ranking position?

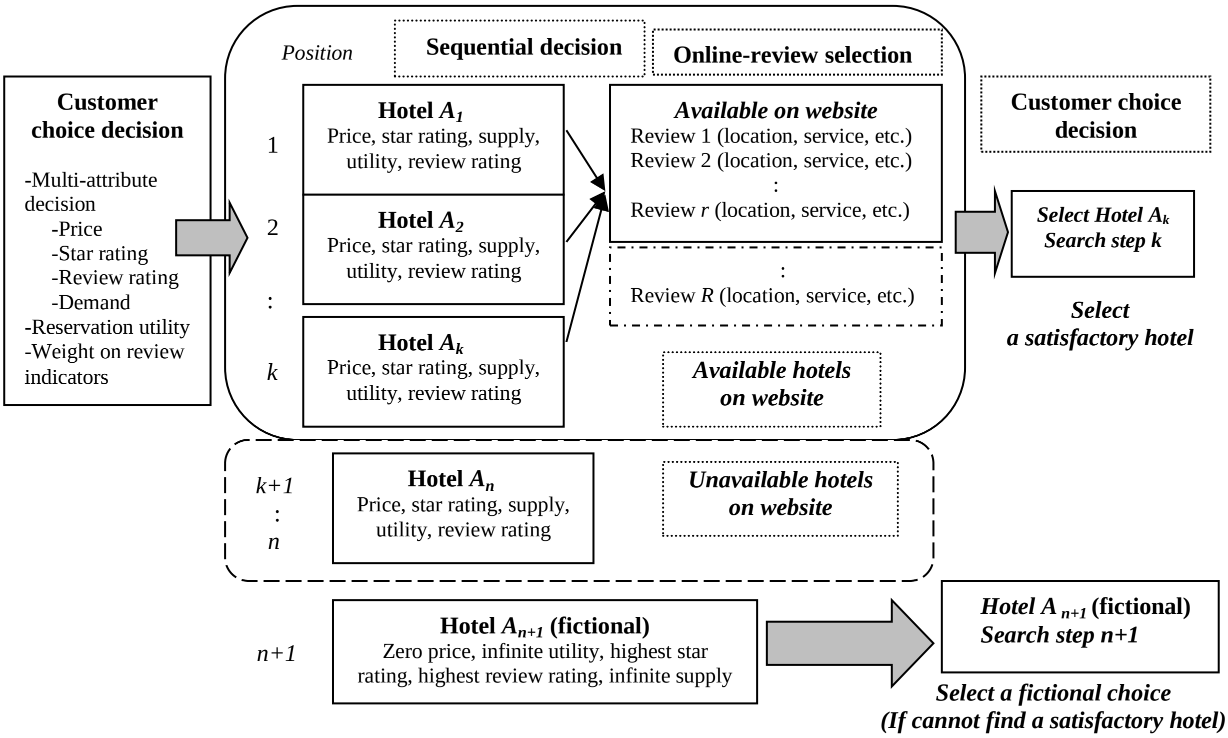


Fig. 7.2. Overall stages of an online hotel booking decision

7.4. Mathematical model approach

The input parameter and decision variable are provided as following.

Table 7.1
Input parameters and description

Notation	Description	Notation	Description
n	Total number of available real hotels	$w_{i,c}$	Weight of online review indicator *c* to customer *i*
N	Total number of customers	$R_{j,r,c}$	Review rating of review number *r* at hotel *j* in an online review indicator *c*
I	The number of arriving customers	$\overline{r}_j$	Total number of review to appear at hotel *j*
$u_{i,j}$	Expected utility that customer *i* perceived from hotel *j*	L	Assumed large number
B_i	Available budget of customer *i*	P_j	Price per room per night at hotel *j*
Eq_i	Minimum hotel star rating expected by customer *i*	Q_j	Star rating of hotel *j*
Er_i	Minimum overall review rating expected by customer *i*	Ar_j	Overall review rating at hotel *j*
D_i	Number of room required by customer *i*	S_j	Number of room available at hotel *j*
ξ_i	Reservation utility expected by customer *i* as a willingness level to stop searching and select a hotel		

Decision variables and auxiliary decision variables are shown as follow.

First-stage decision variables

$x_{j,k}$ = 1 if hotel *j* is selected to place at ranking position *k;* 0 otherwise

$z_{j,r}$ = 1 if individual review number *r* of hotel *j* is selected to show on the Website; 0 otherwise

Second-stage decision variable

$y_{i,j,k}$ = 1 if customer *i* books hotel *j* placed at ranking position *k*; 0 otherwise

$U_{i,j,k}$ = Net utility of customer *i* gained from booking hotel *j* placed at ranking position *k*

$b_{i,j}$ = 1 if the budget is not enough when customer *i* books hotel *j;* 0 otherwise

$q_{i,j}$ = 1 if the minimum star rating is not satisfied when customer *i* books hotel *j*; 0 otherwise

$s_{i,j}$ = 1 if the required number of room is not satisfied when customer *i* books hotel *j*; 0 otherwise

$a_{i,j}$ = 1 if the minimum overall rating is not satisfied when customer *i* books hotel *j*; 0 otherwise

7.4.1. Formulation of a two-stage stochastic programming model

- First-stage decision: In the first stage, the decisions are made prior the random events are observed. We assume many possible scenarios of customers to decide the sequence of hotel $x_{j,k}$ and the selection of online review $z_{j,r}$ to meet with the actual demand in the future.
- Second-stage decision: After the random events are observed, the second-stage decisions are optimally determined, at the certain cost, depend on the earlier stage. That is, when an actual customer is realized, the customer choice decisions $y_{i,j,k}$ are determined on the basis of a given sequence of hotels and online reviews made by the first-stage decision.

The objective of the proposed model is to minimize the expected number of search steps as the second-stage objective. A diagram of the two-stage decision process is shown in Fig. 7.3.

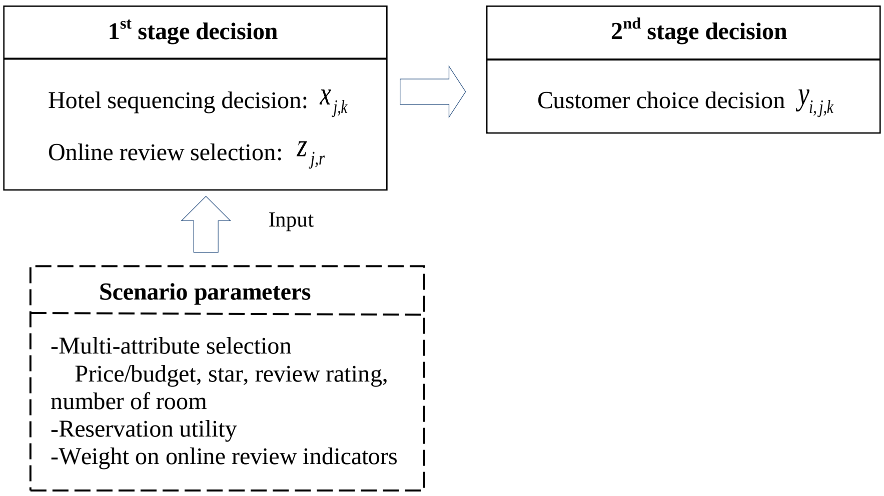


Fig. 7.3. Two-stage decision diagram

7.4.2. Customer choice decision

In a hotel booking decision, a customer considers the multi-attributes of hotel in which the minimum requirement for each attribute varies among individual customers. A customer also reads online reviews and weights the importance of review indicators (e.g. location, service, cleanliness etc.) differently. We assume that a customer will search a hotel from the top to bottom in a given sequence. A customer will assume the net utility gained from a hotel, the function of the expected utility, the price and the additional utility perceived from available individual online reviews. Different customers perceive the expected utility gained differently. A customer is assumed to perform the sequential search behavior (see Zwick et al., 2003; Müller, 2000). In the case of sequential search behavior, it is assumed that the customer is a "risk neutral" customer; namely, one that expects to find a hotel with maximum expected gain (Lippman and McCall, 1976). However, the search time and cost per observation (*c*) will limit the number of search steps (*k*), which varies among customers and depends on the distribution of the expected utility gained; that is, *k* is the random number of stopping search steps when $1 \le k \le n+1$. As shown by the results of a study by Morgan (1983), a searcher will determine the sample size of a search and decide to stop searching in each decision period. In the proposed model, a customer determines a personal reservation utility, ξ_i, as the expected gain from searching according to the optimal stopping rule. By using the conclusion of the optimal stopping rule found by Morgan (1983), we assume that the customer will accept a hotel, and stop searching at number of search steps *k* if the net utility gained from that hotel satisfies their personal reservation utility; otherwise, he or she will continue searching. That is, the customer will select the first hotel of which all attributes are satisfied with his or her minimum requirements (e.g., budget, expected star rating, expected overall review rating, and number of required room) and exceed his or her personal reservation utility. It is equivalent to say that a customer seeks to find a hotel at the minimum number of expected search steps under all constraints (e.g., reservation utility, budget, expected quality, review rating, and number of required room) are all satisfied. The optimal stopping rule to determine the sequential search behavior of the customer is shown in Fig. 7.4.

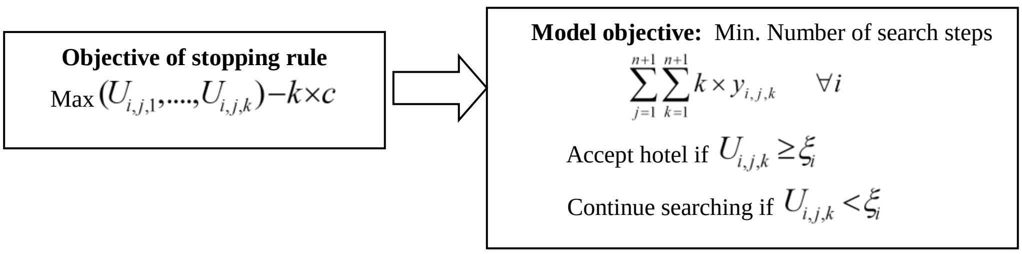


Fig. 7.4. Sequential searching behavior

The assumption of sequential search behavior and optimal stopping strategy described above is standard searching behavior mentioned in many literatures. In particular, the assumption of sequential search assumed in our proposed model is the same as the classical one proposed in job search (Lippman and McCall, 1976) and adopted as a basis by literatures of similar searching in the Internet (Chhabra et al., 2014; Grosfeld-Nir et al., 2009; Zwick et al., 2003), and other search literatures such as residential search (Phipps and Laverty, 1983), choosing a mate (Cheng et al., 2014), and other search problems (Müller, 2000; Mak et al., 2014). Accordingly, the use of this assumption has a justification, commonly discussed by mathematical theorems. Also, the analysis of actual search behavior, derived from the experimental studies on job search and apartment search, supported the consistency of actual search behavior and sequential search's assumption (Braunstein and Schotter, 1982; Phipps and Laverty, 1983). Also, the sequential search can simplify the model, and lead to an optimal decision within the acceptable computation time.

7.4.3. Second-stage decision: Customer choice model

Given a sequence of hotels with available online reviews, an actual customer decides a hotel choice as explained above. However, the probability that a customer i will arrive first and complete searching a hotel with the expected number of search step is $\frac{1}{N}$, where N is the total number of customers. Accordingly, the objective of second-stage decision (1) is to minimize the expected number of search steps for a customer.

Minimize the expected searching step =

$$\frac{1}{N}\times\sum_{i=1}^{N}\sum_{j=1}^{(n+1)}\sum_{k=1}^{(n+1)}k\times y_{i,j,k} \tag{1}$$

7.4.4. First-stage decision: Hotel sequencing and online review selection

Following the optimal searching behavior, if we know that which customer will come first, we can provide the optimal sequence of hotels with the useful individual online reviews so that a customer can find a hotel meeting his expectation at the minimum number of search steps. However, in the first-stage decision, the sequence needs to be posted on the website before an actual customer arrives. That mean, we cannot know which customer will come first and it is equally likely that each customer will come first. Thus, we need to prepare an optimal sequence with the available online reviews so that it can serve all possible cases of uncertain arrival customers with the concerned objective of the second-stage decision suitably. Moreover, the supply of hotel room needs to be updated whenever the booking transaction is made. The sequence decision and the online review selection will be re-optimized at the specific period. The re-optimized period is experimentally determined in Section 7.6.3.

Two stages of decision are incorporated as the sequencing model with one two-stage stochastic programming.

7.4.5. Sequencing model with two-stage stochastic programming

Minimize the expected number of search steps =

$$\frac{1}{N}\times\sum_{i=1}^{N}\sum_{j=1}^{(n+1)}\sum_{k=1}^{(n+1)}k\times y_{i,j,k} \tag{2}$$

Subject to:

Second-stage constraints: Customer choice constraints

$$\sum_{j=1}^{n+1}\sum_{k=1}^{n+1}y_{i,j,k}=1 \qquad \forall i \tag{3}$$

$$u_{i,n+1}=\infty \quad \forall i \tag{4}$$

$$Q_{n+1}=\infty \tag{5}$$

$$Ar_{n+1}=\infty \tag{6}$$

$$P_{n+1}=0 \tag{7}$$

$$\sum_{j=1}^{n+1}\sum_{k=1}^{n+1}U_{i,j,k}\geq\xi_i \qquad \forall i \tag{8}$$

$$U_{i,j,k}\leq u_{i,j}-P_j+\frac{1}{r_j}\sum_{r}\sum_{c}R_{j,r,c}\times w_{i,c}\times z_{j,r} \quad \forall i,j,k \tag{9}$$

$$U_{i,j,k}\leq y_{i,j,k}\times L \qquad \forall i,j,k \tag{10}$$

$$U_{i,j,k}\leq(1-b_{i,j})\times L \quad \forall i,j,k \tag{11}$$

$$P_j\times y_{i,j,k}-B_i\leq b_{i,j}\times L \quad \forall i,j,k \tag{12}$$

$$U_{i,j,k}\leq(1-q_{i,j})\times L \quad \forall i,j,k \tag{13}$$

$$Eq_i-Q_j\times y_{i,j,k}\leq q_{i,j}\times L+L\times(1-y_{i,j,k}) \quad \forall i,j,k \tag{14}$$

$$U_{i,j,k}\leq(1-s_{i,j})\times L \quad \forall i,j,k \tag{15}$$

$$D_i\times y_{i,j,k}-S_j\leq s_{i,j}\times L \quad \forall i,j,k \tag{16}$$

$$U_{i,j,k}\leq(1-a_{i,j})\times L \quad \forall i,j,k \tag{17}$$

$$Er_i-Ar_j\times y_{i,j,k}\leq a_{i,j}\times L+L\times(1-y_{i,j,k}) \quad \forall i,j,k \tag{18}$$

First-stage constraints:

Sequencing constraints

$$y_{i,j,k} \leq x_{j,k} \qquad \forall i, \forall j, \forall k \tag{19}$$

$$\sum_{k=1}^{n+1} x_{j,k} = 1 \qquad \forall j \tag{20}$$

$$\sum_{j=1}^{n+1} x_{j,k} = 1 \qquad \forall k \tag{21}$$

$$x_{n+1,n+1} = 1 \tag{22}$$

Online review selection constraints

$$\sum_{r} z_{j,r} = \overline{r_j} \qquad \forall j \tag{23}$$

Given a sequence of available hotels with the availability of online reviews, a customer performs the optimal searching behavior and selects a hotel as explained in the customer choice model. Objective function (2) is to minimize the expected number of search steps from searching a hotel from a given sequence. Eq. (3) states that a customer must select one room from hotel choices 1 to *n+1*. The hotel at the position *n+1* is assumed to be fictional; that is, a customer will select this choice if he or she cannot find any hotels meeting with their minimum requirements. Eqs. (4) to (7) set the characteristics of the fictional hotel at the position *n+1*. The hotel at position *n+1* has infinite utility, infinite star rating, infinite overall review rating and zero price so that it can be satisfied any customer requirements. Eqs. (8) to (10) state the optimal stopping rule, that is, a customer is willing to stop searching and select a hotel if the net utility gained from a hotel satisfies their personal reservation utility. The customer requirements and the choice decision are given by Eqs. (11) to (18). If the budget constraint is satisfied or not is determined by using Eq. (11). According to Eq. (12), a customer will select a hotel if the price does not exceed their budget. If the star rating constraint is satisfied or not is determined by using Eq. (13). According to Eq. (14), a customer will select a hotel if the hotel star rating meets their minimum required star rating. If the supply constraint is satisfied or not is determined by using Eq. (15). According to Eq. (16), a customer will select a hotel if the supply of rooms satisfies their required number of rooms. If overall review rating constraint is satisfied or not is determined by using Eq. (17). According to Eq. (18), a customer will select a hotel if overall review rating satisfies their minimum expectation.

Eqs. (19) to (23) present the hotel sequencing and online review constraints for the first-stage decision. Eq. (19) states that a customer will select a hotel available on the sequence at a given position. Eqs. (20) to (21) determine the position of hotel in the sequence. Eq. (20) sets that each hotel is assigned to one position, and Eq. (21) sets that each position is assigned to one hotel. Eq. (22) assigns the fictional hotel *n+1* to be the last position at *n+1*. Eq. (23) determines which online review of a hotel is selected to show on the website.

The outline of the proposed approximate method is described in Table 7.2.

Table 7.2
Methodology of a proposed approximate method

Step 0	Initialize and set the parameter of fictional hotel *n+1* at position *n+1* Let $P_{n+1}=0,\ Q_{n+1}=\infty,\ Ar_{n+1}=\infty,\ S_{n+1}=\infty,\ u_{i,n+1}=\infty$. Setting $x_{n+1,n+1}=1$
Step 1	Determine the sequence of hotels and the selection of online reviews using the pools of customers randomly generated based on types of customers Solving the model with Eqs. (2)-(23) to get the sequence ($x_{j,k}$, $z_{j,r}$ are determined)
Step 2	When an actual customer comes and books a hotel, a customer choice is determined. (In numerical experiment, this step is simulated by generating another independent customer to determine a customer choice from a given sequence and online review) ($y_{i,j,k}$ are determined)
Step 3	Update the available supply of hotel rooms after a booking transaction Remove a fully booked hotel from a list of available choices (Update S_i).
Step 4	Go to step 2 and repeat until all *I* actual or simulated customers come to OTAs, where $1 \le I \le N$. (*I* represents the frequency of sequence updating.) Repeat Step 4 until reaching all customers (*N*)

7.5. Case study

We developed a case study of online hotel booking in Asakura City, Japan. The case study was simulated through the numerical experiments to derive the managerial insight. The hotel information and customer characteristics are presented as following.

7.5.1. Hotel characteristics

The hotel information was collected from an OTA, namely, http://www.hotels.com. Hotels.com is ranked number 999 in the U.S. ranking and gains over 2.0 million U.S. monthly customers (Quantcast, 2015). The website was selected because of its standard website design with sufficient information on hotels and online customer reviews.

Hotels located in Asakura city, Japan were selected for numerical experiments. Asakura is a small city located in south-central Fukuoka Prefecture, in Kyushu, Japan. It is an interesting tourist attraction offering traditional Japanese culture, a picturesque landscape, and a taste of rural life in Kyushu. Within the city, the ruins of Akizuki castle is one of the many attractions allowing tourists to relax while viewing the autumn leaves and spring cherry blossoms (Close, 2013). Since it is an interesting tourist attraction, Asakura gets many hotel bookings from travelers, resulting in a number of available online reviews to help other travelers make a booking. Hotel information concerning Asakura for the target date of December 28 to 29, 2014 was collected. A total of 43 hotels are shown on Hotels.com. The hotel information comprised price of a double room (in Thai baht), available rooms and star rating. Online reviews, comprising an overall review ratings given by all traveler types and individual review rating based on five review indicators given by individual past travelers (e.g., cleanliness, service, comfort, condition, and neighborhood), were also collected. The review rating, scored by 1 to 5, represents the customer evaluation from the lowest to highest satisfaction. However, as mentioned in many literatures (Sparks and Browning, 2011), the online-review indicator is divided into two main indicators (namely, core and service). These two online-review indicators were thus applied to analyze the effect of online review on a booking decision in our numerical experiments. This hotel information was used as input data to conduct the numerical experiments and discuss the findings. Moreover, the sequence of all 43 hotels in Asakura city (sorted by the website according to price, star rating, review rating, and website's favorite) was collected. Descriptive data concerning the hotels are listed in Table 7.3.

Table 7.3
Descriptive data of the subject hotels located in Asakura, Japan

Hotel attributes	Mean	Std.dev	Min	Max
Price (Thai baht)	1,972.67	1,412.34	585	7,942
Star rating	4.13	1.4	1	5
Supply (room)	2.98	0.52	2	4
Overall review rating	3.91	0.39	3	4.5
Review by individual customer				
Review rating on core	4.08	0.96	1	5
Review rating on service	4.12	0.92	1	5

Note. Data source: http://www.hotels.com
n = 43 hotels; location: Asakura, Japan; time period: Dec 28 to 29, 2014

7.5.2. Customer characteristics

A customer profile, including budget, personal reservation utility, minimum requirement of overall review rating, star rating, and the number of rooms, was randomly generated. Also, the customer looks at online review, but the weight of importance on a review indicator (i.e., core and service) varies among customers. The data is hypothetical but estimated to suitably meet realistic hotel characteristics and represent overall customer's behavior. Moreover, it is assumed that different customers gain the expected utility from a hotel. The expected utility is estimated from the multi-attributes of a hotel (i.e., price, star rating, and review rating) and the customer-defined indicators on online review (i.e., core and service).

7.6. Numerical experiment

Numerical experiments were conducted to design the sequence of hotels and the online review selection under the multi-attribute decision and importance of online review indicators. As a case study on hotel characteristics, 43 available hotels in Asakura city were chosen. The customer profile was randomly generated to represent overall customer demand. The problem was solved optimally by using an optimization solver (namely, ILOG CPLEX 12.6) on a PC with a 64-bit Intel(R) Core(TM) i3-234 with a 1.60-GHz processor and 4.0-GB RAM.

7.6.1. Example of results derived from the proposed model

In the first experiment, 40 scenario customers were generated, and used to decide a hotel and an online review presented on the website. The 43 available hotels (each of which has five individual online reviews) were used in the experiment. This is an example of the optimal decisions derived from the proposed model under a case study. According to Table 7.4, five hotels with two online reviews (as shown by highlight) are selected to be presented on the website at a given position in the sequence.

Table 7.4
Numerical results for the hotel sequencing decision and the online review selection

Ranking	Hotel	Online review				
		1st	2nd	3rd	4th	5th
1st	Takakura Hotel Fukuoka	4	2	1	3	5
2nd	Hotel MyStays Fukuoka-Tenjin	2	1	3	4	5
3rd	Dormy Inn Hakata Gion	2	1	3	4	5
4th	Khaosan Fukuoka Annex	4	3	1	2	5
5th	Kurume Washington Hotel Plaza	4	3	2	5	1
6th	Comfort Hotel Hakata	2	1	3	4	5

7.6.2. Analysis of numerical results

In the next experiment, five different sets of 40 scenario customers were randomly generated to represent the overall demand. Five replications were conducted and an average result from all replications was analyzed. This experiment shows the application of our proposed model to recommend a hotel possibly satisfying overall customer's preference. According to Figs. 7.5(a) to (d), a hotel including all characteristics, as a higher possibility to attract more customers, higher star rating and higher overall review rating, lower price, and higher average net utility will have tendency to be placed at the top positon in a sequence. However, as there are many criteria to be sorted at the same time, this optimal sequence cannot be determined without the model. Also, the proposed model suggests the suitable number of hotels (i.e., five from our numerical result) to display on the website as the "best recommendation" list, to reduce the number of search steps. The analysis of this result is an example under the characteristics of hotels in a selected area but serve as the guideline to select a good hotel in a realistic case.

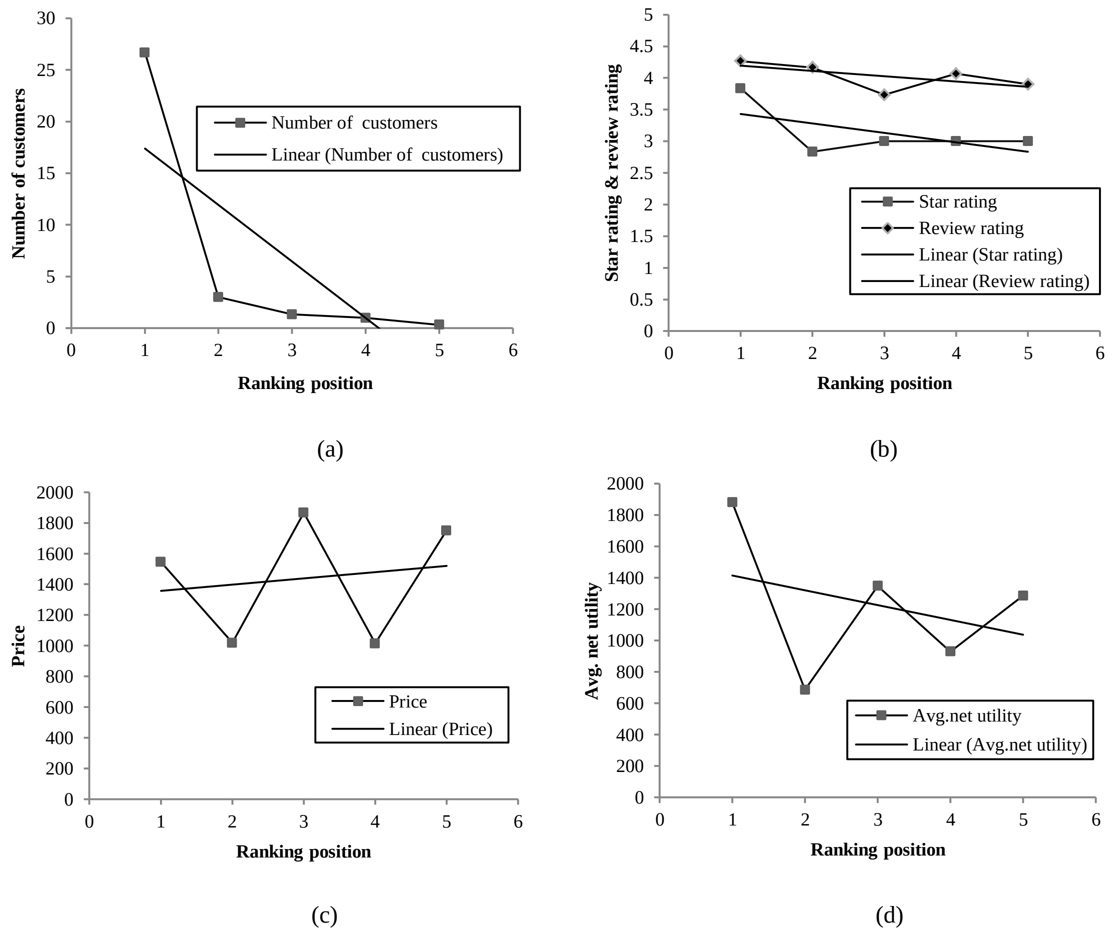


Fig. 7.5. Hotel attributes versus ranking position of top-five hotels

7.6.3. Effectiveness of the proposed model

Table 7.5 compares the effectiveness of the sequence sorted by our proposed model with the current sequences sorted by the single attribute in OTAs. The sequences of hotels sorted by a single attribute (i.e., sorting by price, star rating, review rating and website's favorite) were collected from Hotels.com. In our model, we developed a set of 40 simulated customers to make a sequence decision with the selection of useful online reviews. To evaluate the effectiveness of sequence, another set of 70 simulated customers was randomly generated and tested with each sorting method. Also, each sorting method was tested with two replications using two sets of 70 simulated customers, and thus the average result was compared. In the proposed model, the optimal sequence was optimally re-determined every time a new actual customer comes to OTAs (i.e., every I^{th} actual customer, I = 1). Thus, 70 sequences were optimally prepared for every arriving customer. As shown in Table 7.5 and Fig. 7.6, sorting by our proposed method, a customer could find a satisfactory hotel at the lowest number of search steps. Given the same number of hotel choices of 30 (n = 30), using our method, the customers can book the room at the lowest number of search step (4.15 steps on average) and yield the highest number of room sold (71.5 rooms). If the number of hotel choices to provide to customer is allowed to change, our model selects the optimal number of rooms on average at n^* =5.33 choices and further minimizes the number of search steps to just 2.69 steps (while maintaining roughly same number of rooms sold, 69.5 rooms). The method used by OTAs, website's favorite, can yield the best result in terms of search steps at 9.02 steps but it is still two times higher than our proposed method. The numerical result validates the superiority of our proposed method relative to default sorting method (e.g., Website's favorite) and any other sorting methods of OTAs. OTAs can adopt our proposed model but they can also consider other traditional methods they use which are close to our optimal sorting solution.

Table 7.5
Comparison the effectiveness of sequencing by different sorting methods

Number of hotels shown on the website	Sorting method	Number of search steps				Total booking room
		Avg.	Std.dev	Min	Max	
n^* = 5.33	Proposed model	2.69	3.94	1	5.50	69.50
Fixed n = 30	Proposed model	4.15	6.64	1	10.50	71.50
	Price	12.66	9.57	1	29.00	70.00
	Star rating	10.46	9.66	1	20.50	65.00
	Review rating	9.80	7.23	1	22.50	70.00
	Website's favorite	9.02	7.87	1	22.50	69.50

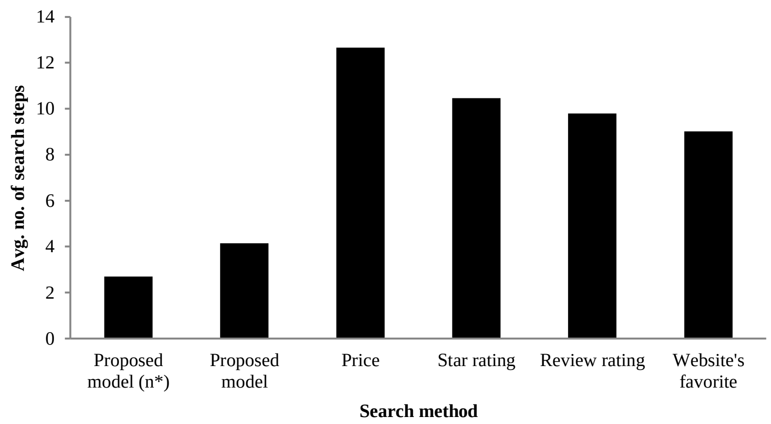


Fig. 7.6. Comparison effectiveness of sorting methods

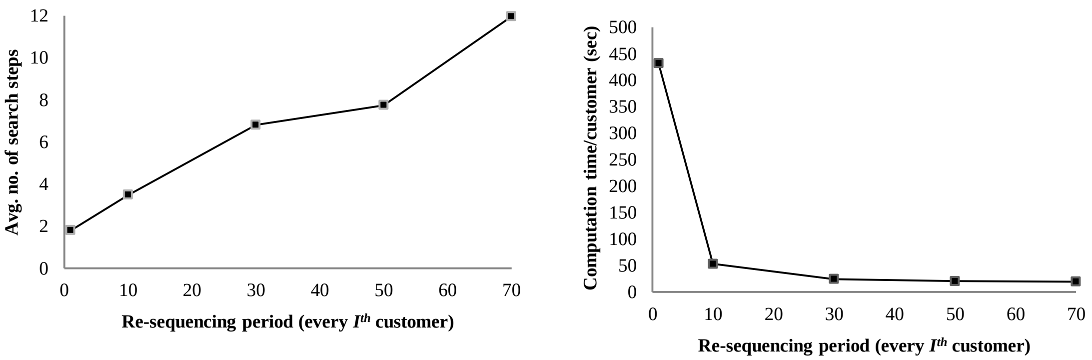
Table 7.6 shows the effect of the re-sequencing period on the average number of search steps and computation time. To determine the sequence of hotels, 40 scenario customers were generated. Then, a set of another 70 actual customers with equal arrival was randomly generated to test the sequence. In an optimal case, the sequence was optimally re-sequenced before a new customer arrives, every I^{th} customer as $I \in \{1\}$. Thus, 70 sequences were generated for every arriving customer. The numerical result shows that all customers complete searching for a hotel in an average number of search steps of 1.8 hotels. Almost all customers book a satisfactory hotel after searching for one to three hotels. The computation time to provide a sequence is 431.87 seconds per customer, and it increases with number of actual customers.

However, in this study, an easy heuristic method for reducing the computation time per customer was proposed in the following. The period of re-sequencing varies as every actual customer I^{th} arrives, namely, $I \in \{1, 10, 30, 50, 70\}$. Another set of 70 actual customers were randomly generated and tested with each of them. It is assumed that the first arriving customer can book a hotel first, the supply of rooms was updated, and the next customer can book a hotel if a room is available. According to Fig. 7.7(a), average number of search steps increases with number of I^{th} actual customers. That is, the more often the sequence is re-optimized, the lower the average number of search steps a customer takes in searching for a satisfactory hotel. However, the re-sequencing period should be planned strategically because it affects the computation time. In Fig. 7.7(b), the computation time increases with frequency of re-sequencing because of a larger number of sequences. In this example, a suitable re-sequencing period is suggested at every I^{th} customer where I = 30, 50 or 70 because a customer can find a satisfactory hotel with an acceptable average number of search steps and computation time.

The effect of the re-sequencing period is significant and the proposed heuristic method is useful in a realistic case (namely, a thousand hotels and customers around the world are collected). This study provides a guideline for OTAs to manage a large number of hotels to satisfy the multi-attribute decisions of customers at the minimum number of search steps. Current OTAs sort hotels by price or review rating. This current sequence will be the same for all periods, but it may not perform best for a realistic case under uncertain arrival of customers with different minimum requirements. Thus, the sequence should be planned to serve all possibilities of customer arrival so that the number of search steps will be reduced. However, the effectiveness of the optimization model can be improved by using more powerful computer system and an efficient heuristic.

Table 7.6
Effect of the re-sequencing period on the average searching step and computation time

Re-sequencing period (Every *I* customer)	Searching step (hotel)				Booking room	Number of sequence	Computation time/customer(sec.)
	Avg.	Std.dev	Min	Max			
1	1.8	5.14	1	3	69	70	431.87
10	3.49	7.35	1	20	69	7	53.10
30	6.81	13.21	1	29	68	3	24.58
50	7.74	11.23	1	21	68	2	20.56
70	11.96	7.53	1	21	68	1	19.67



(a) (b)

Fig. 7.7. Effect of re-sequencing period on average number of search steps and computation time

7.7. Findings and Implications

From the numerical results under a case study, the main findings are provided for business implication as discussed following.

1. Multidimensional sequencing of hotels

We found that multidimensional attributes of hotel needs to be incorporated when making a hotel sequence decision. The findings suggest that a hotel with a higher possibility of attracting more customers, lower price, higher overall review rating, higher star rating, and higher net utility should be placed at the top position of the sequence. Moreover, a few hotels (but good hotels) in the sequence are suggested to response the sequential searching behavior.

2. Online review management based on customer-defined indicators

We suggest that online reviews should be selected to present on OTAs based on the importance of customer-defined indicators.

Accordingly, the OTA managers could use our findings for decision making regarding the strategy to sort the hotels and manage the online reviews. A customer may gain benefit from an effective sorting with online review selection to get a good hotel at the minimum number of search steps.

The contribution of this study is to propose a new approach that OTAs could practically adopt to generate optimal sequence of hotels with the selection of reviews to shorten search time of customers and yield high number of booking. It is confirmed with a case study that the sorting method could improve the accuracy to match a hotel room with the customer's expectation. These show the superior of the proposed model comparable with current mechanism of OTAs. After implemented by OTAs, this model is most valuable to a customer as the search time and numbers of search steps are minimize responding to the current situation of time constraint and searching behavior.

CHAPTER 8
CONCLUSION AND IMPLICATIONS

8.1. Conclusion

In recent years, a customer tends to use online travel agencies (OTAs) for searching the hotel information and making a hotel booking transaction. Although the Internet increases searching space, booking a travel product requires a useful mechanism to support a better decision due to the intangibility of travel product prior purchasing stage. For OTAs, a quality of hotel information along with website design and functionality of OTAs are the critical aspects which can add the value to online booking experience. It seems that the hotel sorting mechanism and online review mechanism served by OTAs are the useful functionalities widely applied by a customer during a hotel booking decision process. However, the current mechanism of hotel sorting mechanism has limitation to serve the multidimensional preferences and time constraint of customers. Moreover, there are a large number of online reviews, some of them contain unnecessary information (e.g., complaints, bias review), resulting to confusion and higher search effort for a customer. Developing a hotel sorting mechanism and online review management has become a pressing issue to enhance the service of OTAs.

In this dissertation, we studied the customer's behavior to use a hotel sorting mechanism and online review mechanism to search for hotel information and make a booking decision. We developed a new approach, using a two-stage stochastic programming model, to design an optimal sequence of hotels and the sequence of online reviews. We incorporated the multidimensional preferences of customers (e.g. price, expected star, review rating), and searching behavior of customers (e.g., reservation price, sequential search behavior), and effect of online reviews (customer-defined indicators, valence, framing and target). Instead of showing a full list of hotels, the optimal number of hotels along with sorting position presented on the website is strategically decided to reduce search cost. That is, the proposed model selects only the hotels likely to be selected by the customers whereas selects only useful online reviews meeting with the main concern of customers. These are the main features of the model that are superior to the current mechanism used by OTAs and other approaches proposed by prior literatures. After implemented our proposed model, we expect that a customer can find a satisfactory hotel at the minimum search cost and maximum utility gained from a selected hotel.

To achieve the objectives of research, in this dissertation, the survey was conducted to observe the customer's behavior (As presented in Chapter 4). Then, three models were proposed along with three case studies. The interesting findings are summary as following.

- Chapter 5: This chapter mainly focuses on the usage and design of hotel sequencing. It provides the interesting findings that serve as a potential sorting strategy to manage a number of hotels on the website. It is suggested that the multidimensional attributes of hotel should be incorporated when making a hotel sequence decision to serve multidimensional preferences of customer. The hotels with a higher net utility, higher overall review rating, higher star rating, and higher price should be placed in the upper positions of the sequence. Also, instead of providing a full list of hotels, the appropriate numbers of hotels need to be considered strategically by selecting only the hotels likely to be selected by the customers to show on the website.
- Chapter 6: This chapter shows the extension of chapter 5 by incorporating the effect of online reviews to design an online review sorting approach. By examining the findings from prior literatures, this study provides a new perspective along with the proposed approach to manage online reviews. In briefly, an ideal online review mechanism needs to consider four main variables comprising of (i) framing of reviews (positive framing is preferred), (ii) the target of review (service-targeted review is preferred), (iii) overall valence of a set of reviews (positive valence is preferred), (iv) variation from average rating (low variation is preferred).
- Chapter 7: This chapter incorporates the hotel sorting mechanism and online review selection. Different from the online review management presented in Chapter 6, this chapter presents a new perspective of online review management concerning the customer-defined indicators (e.g., location, cleanliness etc.). The proposed model can be used by OTAs that have similar website feature as our study.

The first model, proposed in Chapter 5, incorporates three goals in objective function (comprising of minimum search cost, maximum expected utility and minimum ranking position of a selected hotel). The first model is extended in Chapter 6 with maintains three main goals in objective function. However, the second model, proposed in Chapter 7, incorporates only one goal in objective function (focus on the minimum number of search steps). These two models generally aim to simulate mechanism of online hotel booking and decide the optimal sequence of hotels. However, the assumption and objective are slightly different resulting to the different formulation of models. In summary, the first model focuses on the balance the search cost and expected utility gained from a selected hotel which could reflect the search theory of customers. On the other hand, the second model focuses on the minimum search cost or time which response the time constraint of customer in today's society. However, the solution of two models is not significantly different as it incorporates the minimum and standard parameters of customer's choice decision. We need to formulate the second model in different ways to provide different perspectives and simplify the problem of online review selection.

In summary, three chapters (Chapter 5, 6 and 7) propose a new perspective along with the proposed approach to manage the sequence of hotels and online reviews. Three proposed models are differentiated on the basis of assumption and purpose of study. Finally, this dissertation focuses on the service value creation for customer in a case of online hotel booking.

8.2. Significance of research outputs

8.2.1. Contribution to knowledge science

8.2.1.1. Service value creation for the customers

In the first viewpoint, our research stands on the *service science* in a way that concerns *"the service value creation for the customers"*. To drive such a research goal, we investigate on the customer's behavior and try to maximize the benefit in the view of customers. Most of typical customers are not rational person and they tend to make a booking decision under their own assumptions. Also, today customers have no enough time to take a look at all choices on the website. As the way of service thinking, our research provides a new framework for OTAs to understand the profitable design of OTAs website in the view of customers. Thus, we believe that our trial drives a new direction for tourism and e-commence research.

Accordingly, this research relates to knowledge science, which deals with human knowledge and covers knowledge creation and knowledge management, which motivates the maximization of the service value for customers. In the viewpoint of knowledge science, service can be defined as knowledge creation process of creating service value. Changing the mindset from traditional good dominant logic (GDL), we proposed the research direction to service dominant logic (SDL) which concerns more on the role of customer and service value determined by a customer. In SDL, a customer acts as the co-producer, rather than only a recipient of products, and thus, the interaction between service providers and customers (e.g., online review) may improve the product or service quality to meet with the customer's requirements. The benefits of service providers (e.g., profit) will be created when the service achieves the customer satisfaction.

Throughout the dissertation, we consider the service system of online hotel booking, especially a booking through OTAs. The optimization of service system is achieved using three main approaches including survey method, analysis of customer review and optimization approach for website design. In the service system, the main actors are customers, service providers including hotels and OTAs, and collaboration among them to create service activity satisfying the customer requirements. We concern the value perceived by customer from online hotel booking. That is, service values of information service provided by OTAs and accommodation service provided by hotel are all incorporated. According to our proposed model, the service value for customers, both monetary value (e.g., price of hotel and value for money) and non-monetary value (e.g. search effort from friendly website interface design and utility gained from hotel experience), are concerned. Rather than optimizing the profit of OTAs or hotel, we aim to optimize the online hotel booking experience in the viewpoint of customer.

Specifically, we provide the expected benefit of the proposed model to the customers as following.

- Although the existing sorting mechanism of OTAs is efficient in timely aspect, the sorting might be biased because of the advertising fee to promote some hotels. Our proposed model is developed just to serve customers better without considering the advertising fee. OTAs can use our study to help balance between the better customer services and advertising fee.
- The current sorting mechanism of OTAs has some limitations to satisfy the multidimensional preferences (e.g., price and star rating) of customers, as most of them sort a number of hotels by considering single attribute (e.g., sorting by price). Moreover, a customer may fail to notice a satisfactory hotel if it is placed in the bottom of a long sequence. Thus, our study provides the sorting guideline to address these problems.
- The sorting mechanism adopted by OTAs tends to provide the full list of hotels to customers. Our proposed method can help lower the number of hotel choices and select only the hotels likely to be selected by the customers. It is one of the main features of the model that is superior to the method used by OTAs.

Thus, if OTAs consider our study and could adapt to enhance their current sorting mechanism, our study indirectly provides benefits to a customer.

8.2.1.2. Knowledge creation process

In the second viewpoint, our research provides the contribution to knowledge science in such a way that it promotes *"the knowledge creation process"*. Specifically, OTAs could create knowledge by learning from our study, findings and theoretical model. They could adopt the proposed model to formulate real simulation of online booking mechanism and use it as a starting point to explore new idea to create total optimization in the view of customers as the service thinking concept. Each OTA creates different knowledge, and our study will be interpreted by different meanings. Accordingly, OTAs could adapt what they learn to manage their current situation. With the knowledge creation process, OTAs could adapt our findings and proposed model to explore meaning and strategy to improve sorting method and website interface design in the practical ways. In this point of view, our theoretical model motivates the knowledge creation process of OTAs, and simultaneously acts as a decision support tool.

8.2.2. Practical implications for e-commerce and tourism industry

1) This dissertation provides a new framework to enhance the understanding of a profitable design of OTAs and customer's behavior (e.g., search behavior, effect of online review, customer-defined indicators, and hotel selection criteria). The framework can promote a new perspective of the website design (hotel sequencing and online review management) that improves the service of OTAs to increase the customer satisfaction and number of booking transactions.

2) OTAs could adopt the proposed approach to learn the sequence of hotels with the selection of online reviews. It helps to deal with information overload and the problem gap of current mechanism.

3) This dissertation proposed an approach that could use as a marketing tool to evaluate the current market situation (e.g., possible competitors, and characteristics of potential customers). Then, it can provide a hotel the useful guidelines of improvement to increase its reservation rate and create a competitive advantage over other hotels.

Since our approach is easy to implement with low investment whereas provide a lot of potential strategy to create a competitive advantage, it could response the current issues in tourism industry and other business process in e-commerce.

8.3. Limitations and future research

This research has some limitations that provide the direction of future research. Firstly, the proposed model requires a large computation time to solve large-size problems optimally. In future research, we will propose an efficient heuristic to speed up the performance of the proposed model. Secondly, the customer is limited to search the hotels from one specific OTA. In future research, we will consider the situation that customers have many accounts of OTAs and shop multiple website for a hotel room before make a booking decision. This extension of study will incorporate the cooperation and competition among OTAs. Moreover, for customer review, the current study is limited to incorporate only review rating in the booking decision. However, there are many aspects of online review (e.g., textual, numeric review rating and qualitative nature of review content) need to be incorporated in the customer choice decision. In future research, we will incorporate all review rating and qualitative nature of review content to improve the application of proposed model more realistic.

List of publication

Student name: Napaporn Rianthong

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- ***Papers published in journals***

[1] Napaporn Rianthong, Aussadavut Dumrongsiri, Youji Kohda, 2016. Improving the multidimensional sequencing of hotel rooms on an online travel agency web site. Electronic Commerce Research and Applications, 17, 74–86.

[2] Napaporn Rianthong, Aussadavut Dumrongsiri, Youji Kohda. Optimizing customer searching experience of online hotel booking by sequencing hotel choices and selecting online reviews: A mathematical model approach. Tourism Management Perspectives, 20, 55–65.

- ***Oral presentations at conferences***

[3] Napaporn Rianthong, Aussadavut Dumrongsiri, Youji Kohda, Maximization service value: A case study of online hotel reservation, Proceedings of IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2014), pp. 803–807, December 9-12, 2014, Selangor Darul Ehsan, Malaysia.
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[4] Napaporn Rianthong, Aussadavut Dumrongsiri, Youji Kohda, Maximizing customer experience by effectively using hotel sequencing mechanism and online reviews for online hotel booking site, International Conference on Tourism (ICOT2016), June 29-July 2, 2016, Naples, Italy. [Oral presentation, Presenter]

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APPENDIX A
QUESTIONAIRE
“FACTORS AFFECTING ON ONLINE HOTEL BOOKING DECISION”

Questionaire
“Factor affecting on online hotel booking decision”

Instruction: The purpose of this questionaire is to study the customer’s behavior and observe factors that affect on hotel booking through online travel agencies. The analysis of result will be adopted to improve the website design of OTAs. This study has been mainly conducted by undergraduate students from the school of management technology, Sirindhorn International Institute of Technology, Thammasat University, Thailand, as the partial fullfillment of requirment of senior project. We would like to thank all of respondents who kindly participate in this study.

PART 1: PERSONAL BACKGROUND

Direction: Please provide your general background by marking ✓ on the appropriate choices for each question.

1) Gender: ☐ Male ☐ Female

2) Age: ☐ 20-30 years ☐ 31-40 years ☐ 41-50 years ☐ more than 50 years

3) Average monthly income (Thai Baht)

☐ Lower than 20,000 Baht ☐ 20,000 - 39,999 Baht ☐ 40,000-49,999 Baht

☐ 50,000-69,999Baht ☐ More than 70,000 Baht

4) How much time you spend on the Internet per day?

☐ Lower than 3 hours ☐ 3-5 hours ☐ 6-8 hours ☐ More than 8 hours

PART 2: QUESTIONS ON HOTEL BOOKING DECISION

Direction: Please give the information about your hotel booking decision by marking ✓ on *the appropriate choices for each question.*

1) What is your type of traveler?

☐ Family ☐ Couple ☐ Friends ☐ Solo traveler ☐ Business traveler

2) Please indicate budget you prepare for a hotel per room per night:___________Baht

3) What is the minimum acceptable level for hotel star rating?

☐ 1 star rating ☐ 2 star rating ☐ 3 star rating ☐ 4 star rating ☐ 5 star rating

4) What is the minimum acceptable level for review rating?

☐ 1 review rating ☐ 2 review rating ☐ 3 review rating ☐ 4 review rating

☐ 5 review rating

5) What is your concern about location of hotel?

☐ Near tourist attraction ☐ Near downtown ☐ Near public transportation

☐ Near airport ☐ Near restaurant and shopping center

6) Please rate the important level of hotel attributes on hotel selection criteria?

Hotel attribute	Not important		Neutral	Very important	
Security	1	2	3	4	5
Cleanliness	1	2	3	4	5
Location	1	2	3	4	5
Service	1	2	3	4	5
Environment	1	2	3	4	5
Facilities	1	2	3	4	5
Booking condition	1	2	3	4	5
Food	1	2	3	4	5
Price	1	2	3	4	5
Review	1	2	3	4	5
Hotel reputation	1	2	3	4	5
Room type	1	2	3	4	5

PART 3: QUESTIONS ON HOTEL BOOKING EXPERIENCE THROUGH ONLINE TRAVEL AGENCIES

Direction: Please give the information about hotel booking experience using online travel agencies by marking ✓ on *the appropriate choices for each question and fill the information on the blank. Use the scale provided for each question to guide your response.*

1) Do you have experience on hotel booking through online travel agencies (e.g., agoda.com, booking.com)?

☐ Yes ☐ No (finish interviewing)

2) How many times per year do you book a hotel through online travel agencies?

☐ 1-2 times ☐ 3-4 times ☐ 5-6 times ☐ More than 9 times

3) What are the purposes of using online travel agencies?

☐ Search information ☐ Online booking transaction ☐ Read reviews

☐ Review on hotel experience ☐ Others ………………………

4) Please rate the important level of website's elements on hotel booking decision?

Element of website	Not important		Neutral	Very important	
Hotel information	1	2	3	4	5
Hotel photo					
Variety of hotel choices	1	2	3	4	5
Hotel's sorting list	1	2	3	4	5
Review and comment	1	2	3	4	5
Convenient booking transaction	1	2	3	4	5
Required information for booking transaction	1	2	3	4	5

5) Please indicate the number of hotels you observe before making a booking decision

…………………Hotels

6) What is your preferable sorting method to present a hotel on online travel agencies?

☐ Sorting by price ☐ Sorting by promotion and special deal ☐ Sorting by distance from destination

☐ Sorting by review rating ☐ Sorting by popularity ☐ Sorting by hotel star rating

☐ Sorting by website suggestion or favorite ☐ Sorting by name of hotel

PART 4: QUESTIONS ON RECENT HOTEL BOOKING EXPERIENCE

Direction: Please give the information about your recent experience of hotel booking on the following questions. Use the scale provided for each question to guide your response.

1) When was your recent trip?

☐ Last week ☐ Last two weeks ☐ Last month ☐ Last two to three months

☐ Last six months ☐ One year ☐ More than one year

2) How you book a hotel?

☐ Walk in to a hotel ☐ Via telephone ☐ Hotel's website

☐ Online travel agencies ☐ Others ………………………

3) Please provide the hotel information on your recent trip

Hotel name:__________________________ Location:__________________________ _ Star rating:

Review rating:_______________________ ____ Number of rooms:_________Rooms

Room type:

☐ Standard room ☐ Superior room ☐ Deluxe room ☐ Suit room ☐ Others

4) Please give the score to evaluate hotels in the following point of view

Hotel attribute	Very poor		Neutral		Very Excellent
Value for money	1	2	3	4	5
Location	1	2	3	4	5
Facility	1	2	3	4	5
Staff and service	1	2	3	4	5
Cleanliness	1	2	3	4	5
Food	1	2	3	4	5
Total	1	2	3	4	5

5) After booking but not yet stay at a hotel, how would you rate the value for money compared with the actual price?

Very unworthy, the price should be reduced 50%	Unworthy	Unworthy	Worth for money	Worthy	Worthy	Very worthy, the price should be increase 50%
1	2	3	4	5	6	7

6) After stay at a hotel, how would you rate the value for money compared with the actual price?

Very unworthy, the price should be reduced 50%	Unworthy	Unworthy	Worth for money	Worthy	Worthy	Very worthy, the price should be increase 50%
1	2	3	4	5	6	7

PART 5: QUESTIONS ON ATTITUDE TOWARD ONLINE REVIEW

Direction: Please give the information that best represents your attitude toward online review during online booking transaction. Use the scale provided for each question to guide your response.

1) What is your preferable sorting method to present online review on online travel agencies?

☐ Type of traveler ☐ Sorting from most recent review ☐ Sorting from highest review rating

☐ Sorting from lowest review rating

2) How many online review you read per hotel:_________Reviews

3) Please indicate the minimum acceptable level for review rating in the following attributes

Hotel attribute	Very poor		Neutral		Very Excellent
Value for money	1	2	3	4	5
Location	1	2	3	4	5
Facility	1	2	3	4	5
Staff and service	1	2	3	4	5
Cleanliness	1	2	3	4	5
Food	1	2	3	4	5
Total	1	2	3	4	5

4) Please indicate the important level of each review indicator you will read.

Hotel attribute	Very unimportant		Neutral		Very important
Value for money	1	2	3	4	5
Location	1	2	3	4	5
Facility	1	2	3	4	5
Staff and service	1	2	3	4	5
Cleanliness	1	2	3	4	5
Food	1	2	3	4	5

APPENDIX B

PROGRAM SOURCE-CODE

APPENDIX B-1

PROGRAM SOURCE-CODE

Source-code of the program used in this dissertation (Chapter 5) is presented below.

- Source-code of CPLEX

The first-stage decision: Sequencing decision

```
/// PART I: DEFINE TYPES OF PARAMETERS AND VARIABLES \\\

int N=...;
int K=...;
range i = 1..N;
range j = 1..K;
range k = 1..K;
range n= 1..K;

float p[j]=...;
float u[i][j]=...;
float E[i]=...;
float w1=...;
float w2=...;
float w3=...;
float t=...;
float o[i][j]=...;
float Ub=...;
float Lb=...;

/// PART II: DECISION VARIABLES \\\

dvar boolean x[k][j];
dvar boolean y[i][j][k];
dvar boolean z[n];
dvar float s[i];
dvar float obj;

/// PART III: OBJECTIVE FUNCTION \\\

minimize obj;
subject to
{
obj==(w1*N*t*(sum(n in n)n*z[n]))-(w2*(1/N)*(sum(i in i,j in j, k in k)(u[i][j]-P[j])*y[i][j][k]))+(w3/N*sum(i in i)s[i]);

/// PART IV: CONSTRAINTS \\\

//Second-stage constraints: Customer choice constraints
forall(i in i)
sum(j in j, k in k)y[i][j][k]<=1;
forall(i in i,j in j,k in k)
y[i][j][k]<=o[i][j];
forall(i in i,j in j,k in k)
(u[i][j]-p[j]-E[i])*y[i][j][k]>=0;
forall(i in i,j in j,k in k)
y[i][j][k]<=x[k][j];
forall(i in i,j in j,k in k,n in 1..k-1)
y[i][j][k]<=(1-z[n]);
forall (i in i)
s[i]==sum(j in j, k in k)k*y[i][j][k]+(1-sum(j in j, k in k)y[i][j][k])*K;

//First-stage constraints: Sequencing constraints
sum(n in n)z[n] == 1;
sum(n in n)n*z[n]<=Ub;
sum(n in n)n*z[n]>=Lb;
forall (j in j)
sum(k in k)x[k][j]==1;
forall (k in k)
```

```
sum(j in j)x[k][j]==1;
}


/// PART VI: LINK TO EXCEL SPREADSHEET \\\

N = 80;
K=42;
SheetConnection sheet("Nplan80.xlsx");
p from SheetRead(sheet, "Sheet1!E5:E46");
u from SheetRead(sheet, "Sheet1!BN5:DC84");
E from SheetRead(sheet, "Sheet1!P5:P84");
o from SheetRead(sheet, "Sheet1!T5:BI84");
w1 from SheetRead(sheet, "Sheet1!E58");
w2 from SheetRead(sheet, "Sheet1!E59");
w3 from SheetRead(sheet, "Sheet1!E60");
t from SheetRead(sheet, "Sheet1!E61");
Ub from SheetRead(sheet, "Sheet1!E62");
Lb from SheetRead(sheet, "Sheet1!E63");
```

The second-stage decision: Customer choice decision (actual customer)

```
/// PART I: DEFINE TYPES OF PARAMETERS AND VARIABLES \\\

int N=...;
int K=...;
range i = 1..N;
range j = 1..K;
range k = 1..K;
range n= 1..K;
{int} index_a=...;

float p[j]=...;
float u[i][j]=...;
float E[i]=...;
float w1=...;
float w2=...;
float w3=...;
float t=...;
float o[i][j]=...;
float Ub=...;
float Lb=...;
float x[k][j][index_a];

/// PART II: DECISION VARIABLES \\\

dvar boolean y[i][j][k];
dvar boolean z[n];
dvar float s[i];
dvar float obj;

tuple result {
 int index_k;
  int index_j;
 int index_a;
 float x;
 }

{result} Get_Actual_x =...;

execute {
 for (var g in Get_Actual_x){
           x[g.index_k][g.index_j][g.index_a]=g.x
}
}


/// PART III: OBJECTIVE FUNCTION \\\

minimize obj;
subject to
{
obj==(w1*N*t*(sum(n in n)n*z[n]))-(w2*(1/N)*(sum(i in i,j in j, k in k)(u[i][j]-P[j])*y[i][j][k]))+(w3/N*sum(i in i)s[i]);
```

```
/// PART IV: CONSTRAINTS \\\

//Second-stage constraints: Customer choice constraints
forall(i in i)
sum(j in j, k in k)y[i][j][k]<=1;
forall(i in i,j in j,k in k)
y[i][j][k]<=o[i][j];
forall(i in i,j in j,k in k)
(u[i][j]-p[j]-E[i])*y[i][j][k]>=0;
forall (i in i)
s[i]==sum(j in j, k in k)k*y[i][j][k]+(1-sum(j in j, k in k)y[i][j][k])*K;
forall(i in i,j in j,k in k,a in index_a)
y[i][j][k]<=x[k][j][a];

//First-stage constraints: Sequencing constraints
sum(n in n)z[n] == 1;
sum(n in n)n*z[n] == sum(j in j,a in index_a,k in k)x[j][k][a];
sum(n in n)n*z[n]<=Ub;
sum(n in n)n*z[n]>=Lb;
}


/// PART VI: LINK TO EXCEL SPREADSHEET \\\

N = 80;
K=42;
index_a = {1};

SheetConnection sheet("seqN.xlsx");
pfrom SheetRead(sheet, "Sheet1!E5:E46");
u from SheetRead(sheet, "Sheet1!BN5:DC84");
E from SheetRead(sheet, "Sheet1!P5:P84");
o from SheetRead(sheet, "Sheet1!T5:BI84");
w1 from SheetRead(sheet, "Sheet1!E58");
w2 from SheetRead(sheet, "Sheet1!E59");
w3 from SheetRead(sheet, "Sheet1!E60");
t from SheetRead(sheet, "Sheet1!E61");
Ub from SheetRead(sheet, "Sheet1!E62");
Lb from SheetRead(sheet, "Sheet1!E63");

Get_Actual_x from SheetRead(sheet, "Sheet1!B70:E111");
```

APPENDIX B-2

PROGRAM SOURCE-CODE

Source-code of the program used in this dissertation (Chapter 6) is presented below.

- Source-code of CPLEX

```
/// PART I: DEFINE TYPES OF PARAMETERS AND VARIABLES \\\

int N=...;
int K=...;
int T=...;
range i = 1..N;
range j = 1..K;
range k = 1..K;
range n= 1..K;
range r= 1..T;
range b= 1..T;
range e= 1..2;
range d=1..12;
float P[j]=...;
float utility[i][j]=...;
float E[i]=...;
float w1=...;
float w2=...;
float w3=...;
float w4=...;
float w5=...;
float t=...;
float o[i][j]=...;
float Ub=...;
float Lb=...;
float Pr[j][r]=...;
float Nr[j][r]=...;
float Mr[j][r]=...;
float Sr[j][r]=...;
float review[j][r]=...;
float avgr[j]=...;
float wi2[i]=...;
float NR[j]=...;
float wi1[i]=...;
float nr[j]=...;

/// PART II: DECISION VARIABLES \\\

dvar boolean x[k][j];
dvar boolean y[i][j][k];
dvar boolean z[n];
dvar float s[i];
dvar float obj;
dvar float netutility[i];
dvar boolean R[j][b][r];
dvar float+ d1[j];
dvar float+ d2[j];
dvar float+ d3[j];
dvar float+ d4[j];
dvar float+ d5[j];
dvar float+ d6[j];
dvar float+ d7[j];
dvar float+ d11[j];
dvar float+ d22[j];
dvar float+ d33[j];
dvar float+ d44[j];
dvar float+ d55[j];
dvar float+ d66[j];
dvar float+ d77[j];
dvar float u[i][j][k];
```

```
/// PART III: OBJECTIVE FUNCTION \\\

minimize obj;
subject to
{
obj==(w1*N*t*(sum(n in n)n*z[n]))-(w2*(1/N)*sum(i in i,j in j, k in k)(u[i][j][k]))+(w3/N*sum(i in i)s[i])+w4sum(j in j)(d1[j]+d2[j]+d3[j]+d4[j]+d5[j]+d6[j]+d11[j]+d22[j]+d33[j]+d44[j]+d55[j]+d66[j]+d7[j]+d77[j])+w4*sum(j in j,r in r, b in b)b*R[j][b][r]*review[j][r];

/// PART IV: CONSTRAINTS \\\

//Second-stage constraints: Customer choice constraints

forall(i in i)
sum(j in j, k in k)y[i][j][k]<=1;
forall(i in i,j in j,k in k)
y[i][j][k]<=o[i][j];
forall (i in i)
s[i]==sum(j in j, k in k)k*y[i][j][k]+(1-sum(j in j, k in k)y[i][j][k])*K;
forall(i in i)
sum(j in j, k in k)u[i][j][k]>=E[i]-(1-sum(j in j,k in k)y[i][j][k])*10000;
  forall(i in i,j in j,k in k)
  u[i][j][k]<=y[i][j][k]*(utility[i][j]-P[j])+(1/nr[j])*wi1[i]*sum(r in r, b in d)review[j][r]*R[j][b][r]+wi2[i]*NR[j];
 forall(i in i,j in j,k in k)
  u[i][j][k]<=y[i][j][k]*10000;
forall(i in i,j in j,k in k)
y[i][j][k]<=x[k][j];
forall(i in i,j in j,k in k,n in 1..k-1)
y[i][j][k]<=(1-z[n]);

//First-stage constraints: Sequencing constraints

sum(n in n)z[n] == 1;
sum(n in n)n*z[n]<=Ub;
sum(n in n)n*z[n]>=Lb;
forall (j in j)
sum(k in k)x[k][j]==1;
forall (k in k)
sum(j in j)x[k][j]==1;
forall (j in j,r in r)
sum(b in b)R[j][b][r]==1;
forall (j in j,b in b)
sum(r in r)R[j][b][r]==1;
forall (j in j)
d55[j]-d5[j]+sum(r in r)R[j][12][r]*Mr[j][r]==1;
forall (j in j )
d66[j]-d6[j]+sum(r in r,b in e) R[j][b][r]*Pr[j][r]==2;
forall (j in j)
d11[j]-d1[j]+sum(r in r, b in d)R[j][b][r]*Pr[j][r]==5;
forall (j in j)
d22[j]-d2[j]+sum(r in r, b in d)R[j][b][r]*Mr[j][r]==4 ;
forall (j in j)
d33[j]-d3[j]+sum(r in r, b in d)R[j][b][r]*Nr[j][r]==3;
forall (j in j)
d44[j]-d4[j]+sum(r in r, b in d)R[j][b][r]*Sr[j][r]==12;
forall (j in j)
d77[j]-d7[j]+(1/12)*(sum(r in r, b in d)R[j][b][r]*review[j][r])==avgr[j];
}

/// PART VI: LINK TO EXCEL SPREADSHEET \\\

N = 15;
K=31;
T=25;

SheetConnection sheet("kanchanaburi.xlsx");
P from SheetRead(sheet, "Sheet1!C4:C34");
utility from SheetRead(sheet, "Sheet1!BB4:CF18");
E from SheetRead(sheet, "Sheet1!O4:O18");
o from SheetRead(sheet, "Sheet1!T4:AX18");
w1 from SheetRead(sheet, "Sheet1!C38");
w2 from SheetRead(sheet, "Sheet1!C39");
w3 from SheetRead(sheet, "Sheet1!C40");
w4 from SheetRead(sheet, "Sheet1!F38");
```

```
w5 from SheetRead(sheet, "Sheet1!F39");
t from SheetRead(sheet, "Sheet1!C41");
Ub from SheetRead(sheet, "Sheet1!C42");
Lb from SheetRead(sheet, "Sheet1!C43");
nr from SheetRead(sheet, "Sheet1!I4:I34");
Pr from SheetRead(sheet, "Sheet1!G193:AE223");
Mr from SheetRead(sheet, "Sheet1!G159:AE189");
Nr from SheetRead(sheet, "Sheet1!G125:AE155");
Sr from SheetRead(sheet, "Sheet1!G87:AE117");
review from SheetRead(sheet, "Sheet1!G52:AE82");
avgr from SheetRead(sheet, "Sheet1!G4:G34");
wi1 from SheetRead(sheet, "Sheet1!Q4:Q18");
wi2 from SheetRead(sheet, "Sheet1!R4:R18");
NR from SheetRead(sheet, "Sheet1!H4:H34");
```

APPENDIX B-3

PROGRAM SOURCE-CODE

Source-code of the program used in this dissertation (Chapter 7) is presented below.

- Source-code of CPLEX

```
/// PART I: DEFINE TYPES OF PARAMETERS AND VARIABLES \\\

int N=...;
int n=...;
range i = 1..N;
range j = 1..n+1;
range k = 1..n+1;
{int} index_c=...;
{int} index_r=...;
{int} index_a=...;
{int} index_t=...;

float S[j][index_t]=...;
float P[j][index_t]=...;
float Budget[i]=...;
float Qj[j]=...;
float Qi[i]=...;
float Lj[j]=...;
float nreview[j]=...;
float Li[i]=...;
float ratingj[j]=...;
float ratingi[i]=...;
float u[i][j]=...;
float M = 100000;
float D[i][index_t]=...;
float E[i]=...;
float R[j][index_r][index_c];
float w[i][index_c]=...;

/// PART II: DECISION VARIABLES \\\

dvar boolean x[k][j][index_a];
dvar boolean y[i][j][k];
dvar boolean b[i][j];
dvar boolean q[i][j];
dvar boolean s[i][j];
dvar boolean ra[i][j];
dvar boolean l[i][j];
dvar boolean z[j][index_r];
dvar float TUtility[i][j][k];
dvar float obj;
dvar float utility;

tuple result {
 int index_j;
  int index_r;
 int index_c;
 float R;

}

{result} Get_Actual_R =...;

execute {
 for (var g in Get_Actual_R){
          R[g.index_j][g.index_r][g.index_c]=g.R

}

          }
```

```
/// PART III: OBJECTIVE FUNCTION \\\

minimize obj;
subject to
{
obj==(1/N)*sum(i in i,j in j,k in 1..(n+1))k*y[i][j][k];

/// PART IV: CONSTRAINTS \\\

//Second-stage constraints: Customer choice constraints

forall(i in i)
sum(j in j, k in 1..(n+1))y[i][j][k]==1;
forall(i in i)
sum(j in j, k in 1..(n+1))
TUtility[i][j][k]>=E[i];
forall(i in i,j in j,k in 1..(n+1),t in index_t)
TUtility[i][j][k]<=u[i][j]-P[j][t]*D[i][t]+((1/nreview[j])*sum(r in index_r,c in index_c)R[j][r][c]*w[i][c]*z[j][r]);
forall(i in i,j in j,k in 1..(n+1))
TUtility[i][j][k]<=y[i][j][k]*M;
forall(i in i,j in j,k in 1..(n+1))
TUtility[i][j][k]<=(1-b[i][j])*M;
forall(i in i,j in j,k in 1..(n+1))
TUtility[i][j][k]<=(1-q[i][j])*M;
forall(i in i,j in j,k in 1..(n+1))
TUtility[i][j][k]<=(1-ra[i][j])*M;
forall(i in i,j in j,k in 1..(n+1))
TUtility[i][j][k]<=(1-l[i][j])*M;
forall(i in i,j in j,k in 1..(n+1))
TUtility[i][j][k]<=(1-s[i][j])*M;
forall(i in i, j in j, k in 1..(n+1),t in index_t)
P[j][t]*y[i][j][k]*D[i][t]-Budget[i]<=b[i][j]*M;
forall(i in i, j in j, k in 1..(n+1))
Qi[i]-Qj[j]*y[i][j][k]<=q[i][j]*M + M*(1-y[i][j][k]);
forall(i in i,j in j,k in 1..(n+1),t in index_t)
D[i][t]*y[i][j][k]-S[j][t]<=s[i][j]*M;
forall(i in i, j in j, k in 1..(n+1))
ratingi[i]-ratingj[j]*y[i][j][k]<=ra[i][j]*M + M*(1-y[i][j][k]);

//First-stage constraints: Sequencing constraints

forall(i in i,j in j,k in k,a in index_a)
y[i][j][k]<=x[k][j][a];
forall(j in j,a in index_a)
sum(k in k) x[k][j][a] == 1;
forall(k in k,a in index_a)
sum(j in j) x[k][j][a] == 1;
forall (a in index_a)
x[n+1][n+1][a]==1;
forall(j in j)
sum(r in index_r) z[j][r] == nreview[j];

}

/// PART VI: LINK TO EXCEL SPREADSHEET \\\

N = 24;
n=43;
index_c = {1,2};
index_a = {1};
index_r = {1,2,3,4};
index_t = {1};

SheetConnection sheet("Asakura8improve.xlsx");
S from SheetRead(sheet, "Sheet1!F5:F48");
P from SheetRead(sheet, "Sheet1!E5:E48");
Qj from SheetRead(sheet, "Sheet1!H5:H48");
Lj from SheetRead(sheet, "Sheet1!I5:I48");
ratingj from SheetRead(sheet, "Sheet1!J5:J48");
nreview from SheetRead(sheet, "Sheet1!K5:K48");
Budget from SheetRead(sheet, "Sheet1!S51:S74");
Qi from SheetRead(sheet, "Sheet1!T51:T74");
u from SheetRead(sheet, "Sheet1!AH51:BY74");
D from SheetRead(sheet, "Sheet1!X51:X74");
```

```
E from SheetRead(sheet, "Sheet1!W51:W74");
ratingi from SheetRead(sheet, "Sheet1!V51:V74");
Li from SheetRead(sheet, "Sheet1!U51:U74");
w from SheetRead(sheet, "Sheet1!AA51:AB74");

Get_Actual_R from SheetRead(sheet, "Sheet1!M5:P348");
```

APPENDIX B-4
IBM ILOG CPLEX OPTIMIZATION SOFTWARE

In this dissertation, we develop the mathematical model which is optimally solved using optimization software, namely IBM ILOG CPLEX version 12.6. The description and solution processing by ILOG CPLEX are described as following.

IBM ILOG CPLEX Optimization Studio is an analytical decision support toolkit for rapid development and deployment of optimization models using mathematical and constraint programming. It combines an integrated development environment (IDE) with the powerful Optimization Programming Language (OPL) and high-performance ILOG CPLEX optimizer solvers.

A linear programming and constraint programming models are expressed in a declarative fashion, using decision variables, constraints and objectives that must be minimized or maximized, just as in mathematical programming; Lexicographical multi-criteria objectives are possible in ILOG CPLEX Optimizer. IBM's OPL modeling language and integrated development environment (IDE) and ILOG Concert Technology interfaces, also part of IBM ILOG CPLEX Optimization Studio, can be used to formulate constraint programming models as well as mathematical programming models.

The concept behind a mathematical programming problem is simple. It consists for four basic components. All of them are coded on the Optimization Programming Language (OPL) as shown in Fig. B-1.

1) Decision variables represent quantities to be determined

2) Objective function represents how the decision variables affect the cost or value to be optimized (minimized or maximized)

3) Constraints represent how the decision variables use resources, which are available in limited quantities

4) Data quantifies the relationships represented in the objective function and the constraints

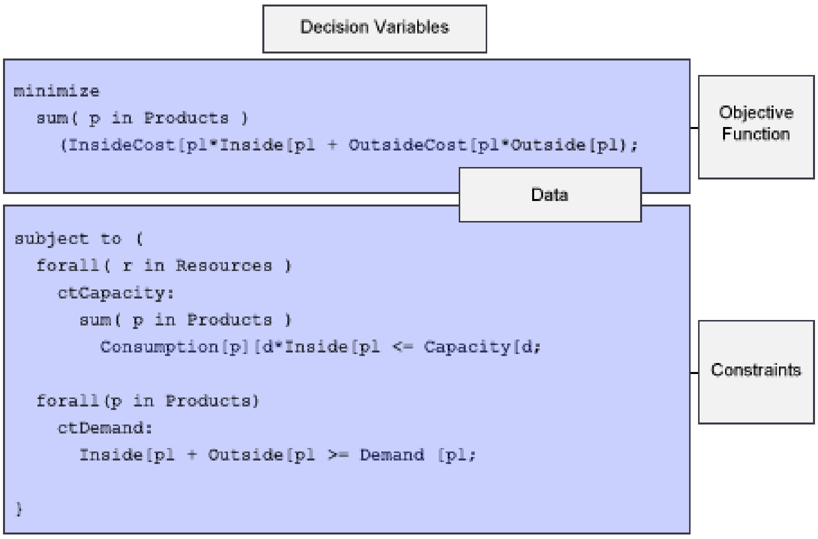

Fig. B-1. Basic components of a mathematical model on OPL

Using ILOG CPLEX and solution processing

A mathematical programming and constraint programming look first to reduce the set of possible values of the decision variables (feasible solution) which will satisfy all the constraints using logical, graph-theoretic, arithmetic and other arguments. Once the deduction that some values from the decision variable's domain are not possible, this information is propagated through the constraints perhaps enabling further deductions. Various search strategies are also used until a value is assigned to every decision variable, that is, until a solution is found. Once a first solution is found, the search proceeds to find further solutions with better objective values.

As shown in Fig. B-2, most of the times CPLEX can detect a feasible solution (square point) and the best integer (above line) can also be defined. The search proceeds to find further solutions with better objective values (at the further computation time). For example, in our study, the objective is to find the solution with the minimum objective values. Accordingly, the problem detects a feasible solution and proceeds searching for better objective values (lower value is preferred).

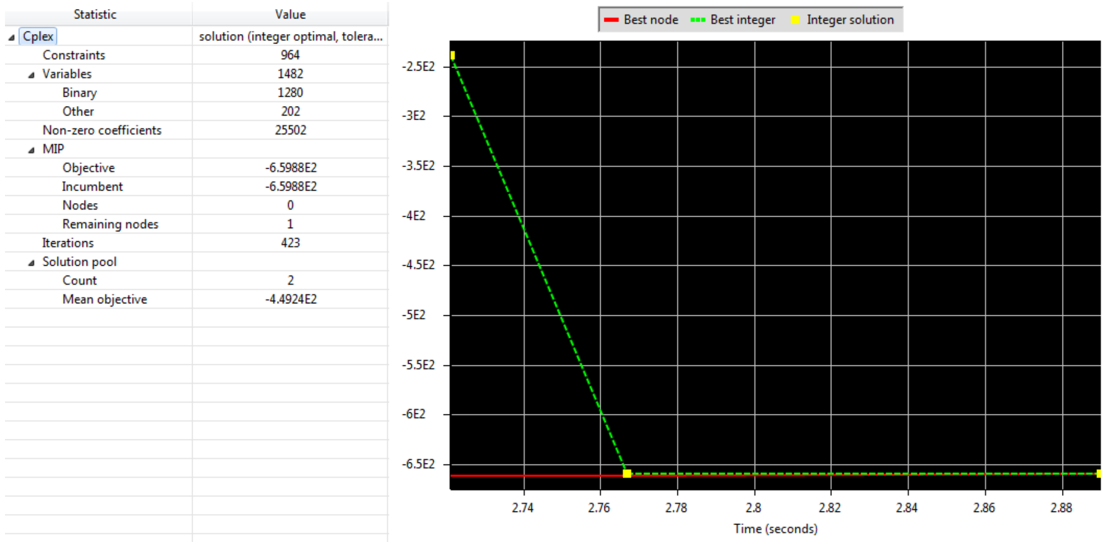

Fig. B-2. CPLEX Statistics

Also, according to Fig. B-2 and B-3, we observe that when the computation time increases, the best integer tends to be a feasible solution, and the percentage of gap decreases to an acceptable point. Therefore, in the further study, we will reasonably apply the best integer as a good solution which can be detected in a controlled time.

```
        Nodes                                         Cuts/
   Node  Left     Objective  IInf  Best Integer    Best Bound    ItCnt     Gap

*     0+    0                        -238.5941    -2655.0171      410      ---
      0     0     -661.1972    19    -238.5941     -661.1972      410  177.12%
*     0+    0                        -659.8781     -661.1972      410    0.20%
      0     0     -660.0475    22    -659.8781    MIRcuts: 1      423    0.03%

Mixed integer rounding cuts applied:  1

Root node processing (before b&c):
  Real time             =    0.28 sec. (94.19 ticks)
Parallel b&c, 4 threads:
  Real time             =    0.00 sec. (0.00 ticks)
  Sync time (average)   =    0.00 sec.
  Wait time (average)   =    0.00 sec.
                          ------------
Total (root+branch&cut) =    0.28 sec. (94.19 ticks)
```

Fig. B-3. CPLEX Engine Log

Note: source. http://www-03.ibm.com/software/products/en/ibmilogcpleoptistud