# A Study on Optimal Capacities of a New Cruise Line with Quadratic Operating Cost using Stackelberg Game Model

## Supervisor: Professor Seong-Cheol Cho

**By**

**Wei Wei**

A thesis submitted in partial fulfillment of the requirements the degree of Master of Business Administration

**Graduated School of Korea Maritime and Ocean University**
**Department of Shipping Management**

**June 2017**

## Approval Page

This thesis, which is an original work undertaken by Wei Wei in partial fulfillment of the requirements for the degree of Master of Business Administration, is in accordance with the regulations governing the preparation and presentation of dissertations at the Graduate School in the Korea Maritime and Ocean University, Republic of Korea.

**Approved by the Thesis Committee:**

Prof. Han-Won Shin
Chairman

Prof. Si-Hwa Kim
Member

Prof. Seong-Cheol Cho
Member

**Department of Shipping Management**

**Graduate School of Korea Maritime and Ocean University**

June 2017

# Table of Contents

**Chapter1 Introduction** 1

1.1 Background of Study 1

1.2 Research Problem 2

1.3 Purpose of the Study 5

1.4 Thesis Outline 6

**Chapter 2 Literature Survey** 7

2.1 Introduction of the game theory 7

2.1.1 History of Game Theory 7

2.1.2 Concept of Game Theory 7

2.1.3 Classification of game theory 10

2.2 Cournot and Stankelberg model 14

2.2.1 Cournot Model 14

2.2.2 Stackelberg Model 15

2.2.3 Comparing with Cournot and Stackelberg Model 16

2.2.4 Why choose Stackelberg Model 18

2.3 Existing reasearching 19

**Chapter 3 MODEL AND ANALYSIS** 22

3.1 Model and assumptions 22

3.1.1 Introducing the differences of the cost function 24

3.1.2 Calculating the optimal monopoly capacity of Line 1 27

3.1.3 Calculating the optimal capacity of Line 2 27

3.2 Optimal capacities for Line 1 and Line 2 28

3.3 Analysis on variable cost and dajustment parameter 31

3.3.1 Analysis on variable cost of Line 2 31

3.3.2 Analysis on adjustment parameter of Line 2 32

3.4 Numerical Examples 35

3.4.1 Analysis on the numerical examples 40

3.4.2 The managerial implications of increasing market share of Line 2 48

**Chapter 4 CONCULSION** 50

4.1 Summary and Conclusions 50

4.2 Limitations of this thesis 55

4.3 Future research direction 55

**References** 57

**Acknowledgments** 61

# List of Tables

Table 1 Dominat Strategy Equilibruim and Nash Equilibrium 13

Table 2 Cournont and Stackelberg Model 17

Table 3 Managerial implication of Line 2 34

# List of Figures

Fig. 1.1 Cruise management structure (Porter, M, 1980) 3

Fig. 2.1 Example of Extensive (Recitation Note#7,2004) 9

Fig. 2.2 Example of Nomal Form(Recitation Note#7,2004) 10

Fig. 3.1 Economies of scale average cost curve (Typical Average Cost Curve) 26

Fig. 3.2 Diseconomies of scale average cost curve 26

Fig. 3.3 Changes of $Q_2^*$ when $v_2$ increases 41

Fig. 3.4 Changes of $Q_2^*$ when $v_3$ increases 41

Fig. 3.5 Changes of $T$ when $v_2$ increases 42

Fig. 3.6 Changes of $T$ when $v_3$ increases 42

Fig. 3.7 Changes of $P$ when $v_2$ increases 43

Fig. 3.8 Changes of $P$ when $v_3$ increases 43

Fig. 3.9 Comparison with four different values of $Q_2^*$ 44

Fig. 3.10 Comparison with four different values of $T$ 45

Fig. 3.11 Comparison with four different values of $P$ 45

Fig. 3.12: How to increase the market share of Line 2 49

Fig. 4.1: The relationship of the conclusion 53

Fig. 4.2: The step of analyzing in the thesis 54

# A Study on Optimal Capacities of a New Cruise Line with Quadratic Operating Cost using Stackelberg Game Model

Wei Wei

Department of Shipping Management

Graduate School of Korea Maritime and Ocean University

**Abstract**

The cruise industry has grown rapidly since the 1990s and today represents one of the healthiest sectors in the shipping industry, with newer and bigger vessel on order. With the capacity of cruise companies increasing steadily, competition in the market has also become fiercer in several regions. This research study, aims at investigating a market strategy which smaller cruise lines could adopt in order to gain market shares and compete with bigger players.

This thesis develops and applies a Stackelberg Game Model to find out what factors are important for a new cruise line penetrating into a particular market. Using the concept of Nash equilibrium, the optimal capacity of the follower, and then the total capacity and the price of the cruise market are computed.

Numerical examples with artificial market data are used to derive the most significant managerial implications that could help boosting the share of cruise market for the new

entrants (followers). They show how the new entrants (followers) get a suitable way to have a larger market share.

Findings of thesis study could be useful for a beginning small cruise line to develop the marketing strategies to increase its market share after entering the cruise market. In addition, this study also provides a method for controlling the variable cost of the follower.

KEYWORDS: Nash Equilibrium, Stackelberg Game Model, Marketing Strategies, Cruise Line, Optimal Capacity

# CHAPTER 1 INTRODUCTION

In this chapter, the background information and the objectives of this study will be introduced. This chapter includes three main parts: Firstly, the background of the research is described; secondly, the underlying objectives of this study are clarified; thirdly, the thesis structure will be presented.

## 1.1 Background of the Study

In this study, the Stackelberg game model is utilized to calculate the optimal capacities of new cruise line with a quadratic operating cost. At first, the importance of this study will be emphasized providing an introduction to the cruise industry's historical development. The cost components of a cruise line will also be introduced at the end of this chapter.

By the early 1900s, White Star Line, P&O in their own right and the Hamburg America Line were offering regular cruises. Since the late 1890s, Orient Line had been offering the regular Caribbean, Mediterranean and Scandinavian cruises on board three of its vessels. For British passengers, the Norwegian Fjords and the Mediterranean were the major cruising areas, a not too dissimilar situation to today (Cartwright, R. & Baird, C., 1999). After the Second World War, the nations of Europe and North America entered into the cruise industry, sea travel was then booming again. In the years up to, many countries laid down strict criteria for crews of ships registered with them (Ladany, S.& Arbel, A.,1991).

The late 1990s saw a massive expansion in the Asian market. The growth started in Japan, as well as the expansion of domestic cruising market in South-East of Asian. Star Cruises, which catered for the indigenous and the US/European cruise according to Ward (1999) rapid become the Carnival Cruise of Asia (CLIA, 2002). By 1996 the Asian market including Japan formed 9.5 per cent of the market, this being on a par with the UK which provided just over 10 percent (Cartwright, R. & Baird, C., 1999).

A cruise liner/ship is a passenger vessel operating for pleasure purposes only and not employed in the transportation industry (Cartwright, R. & Baird, C., 1999). The first cruise line present to UK. Following the development of Cruise Industry, increasing number of new cruise lines join into the cruise market. Some of the Cruise Lines entered the market at the same time; meanwhile, others were latecomers of the cruise market compared to the former. Therefore, there are many competitors in the present day. At the same time, many types of research and reports about the competitive condition of the cruise market have been conducted. Nevertheless, after a new cruise line had entered the market, there are many factors need to be considered. Consequently, in this thesis, the game model is utilized to find out the key factors of management implications for the new cruise line as a follower entering the cruise market.

## 1.2 Research Problem

The previous section showed some historical development of the cruise line industry.

Comparing with the past, today's cruise operations are managed differently and as efficiently as possible, but there are still several cost factors which can affect the profitability of a cruise line.

The total number of vessels in the world fleet in 2009 stood at 74,991, or an estimated 853,276,000 GRT. In 2003 there were 89,899 ships or 605,218,000 GRT. This presents an interesting development, where ships as individual units have been decreasing in number but increasing in volume or capacities (Gibson, P., 2012). This implies that there is a higher risk when a cruise line decided to enter a new cruise market.

Cruise ships are likely to be heterogeneous- that is, containing a mixture of the crew, with different nationalities, various ages, different backgrounds and prior learning, and varying needs and aspirations (Gibson, P., 2012). Therefore, managing such a multicultural and diverse crew situation requires someone to find the right way to control its cost. On cruise ships, there will always be many organization charts, while the management structure can be shown in Figure 1.1

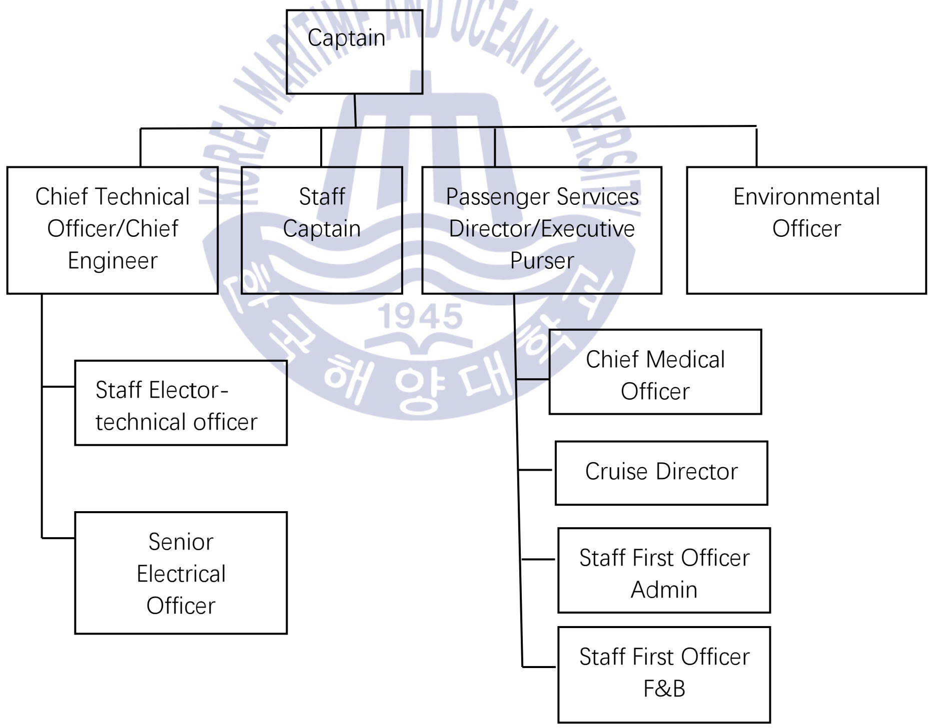



**Fig. 1.1 Cruise management structure (Porter, M., 1980)**

The Chief Technical Officer belongs to the deck department; this department oversees navigation and the care of the vessel (Sill, B., 1991). The Chief Engineer is the person responsible to the Master for the vessel's propulsion, steering, and power for auxiliary systems such as heating, ventilation, air conditioning, lighting and refrigeration; and also have responsible for fuel, maintenance and repairs. The Passenger Services Director belongs to the medical department; some cruise companies locate the medical team under the management of the hotel services department (Sill, B., 2000).

The Cruise Director, who tends to be an experienced professional from the world of entertainment, leads the entertainment department (Klassen, K.& Rohleder, T., 2002). The range of employees can include musicians, dancers, actors and sports instructors, children's staff, etc.

A summary of the management structure can include the deck department, the engine department, the medical department, the entertainment department and the hotel department. From these management departments, it is easy to find out that managing hotel services on the cruise ship tend to be a reflection of the vessel and the labor intensity associated with the quality of products and services. Therefore, a cruise line which wants to find out the right way to control its cost should first consider the most important factors in the cruise management. Moreover, in practice, tourists usually choose cruise line based on the following points:

(1) Food and drink: it includes kitchen brigade and bars; waters and officer's mess chefs, etc (Papathanassis, A. & Vogel, M.P., 2013).
(2) Passenger services: it includes accommodation manager and administration; cabin stewards and butlers; assistant laundry master and laundry assistants, etc (Papathanassis, A. & Vogel, M.P., 2013).
(3) Administration and personnel: it includes administrator managers; assistant

administration manager, etc (Papathanassis, A. & Vogel, M.P., 2013).

(4) Additional areas: it includes shops; administration stores; art auctions; beauty center, etc (Papathanassis, A. & Vogel, M.P., 2013).

These points (1) to (4) show that the fundamental ground of tourists' choice is the quality of services and products. Therefore, the Cruise Line which enters a new cruise market must think critically on how to improve their quality of services and products onboard. With these being put into considerations, the following questions could be summarized:

(1) What are the main factors affecting the cost of a new cruise line?

(2) How can a new cruise line make a larger share of the cruise market?

(3) What factors need to consider in the optimal capacity of the new entrants (followers) (Papathanassis, A. & Vogel, M.P., 2013)?

### 1.3 Purpose of the Study

The elemental aim of this study is about the needs of the new entrants (followers); they have the need to pursue the best strategy for controlling the cost and finding out the optimal capacity, in order to gain a larger share of a cruise market.

The cruise business cost includes the fixed cost, the variable cost and the adjustment adding cost. The fixed cost includes the ship itself, the fixtures and fitting. The variable cost includes the labor elements involved in providing services and products onboard. The adjustment adding cost includes the technical and operational aspects of maintaining the ship, and the cost of adding any extra passenger to reduce or add capacities. Nevertheless, the service is difficult to adjust the capacity of a cruise ship, so the critical factor is to ensure the ship sails on full capacity or as close to full capacity as can be achieved (Papathanassis,

A. & Vogel, M.P., 2013). Therefore, the variable cost and the adjustment adding cost are very important factors in a cruise operation. If the cruise line enters the cruise market, the most important effectors are the variable cost and the adjustment adding cost. In the Stackelberg game model, the management decision could not be influenced by the fixed cost because that cruise company had entered the cruise market, so it is common to choose the variable cost and the adjustment adding cost as variables to find out the influential factors of the cruise Line.

## 1.4 Thesis outline

This thesis is divided into four chapters. The first chapter is an introduction to the topic's background, research problem, and purpose of the study. The second chapter introduces the methodology-game theory and existing research on the cruise capacities; the Stackelberg and Duopoly Model are compared. The third chapter utilizes the Stackelberg Model to calculate the optimal capacities of the cruise line, analyzes the variable cost influential factors and by using the results obtained, suggests some managerial implications for a cruise line penetrating a new market. Finally, the last chapter summarizes the results obtained in the previous chapters and indicates the limitation of the study and future research.

# CHAPTER 2 LITERATURE SURVEY

In this chapter is introduce the existing methods related to the thesis and summarize the related studies on the optimal capacity of cruise field. The chapter consists of three parts. In the first part that introduce the evolution of the game theory. In second part, comparing the difference between the Cournot and Stackelberg model. In last part, summarizing the related studies on the optimal capacities in the cruise field.

## 2.1 Introduction to the game theory

### 2.1.1 History of Game Theory

Game theory is a field of study that was developed by John Nash in the latter half of the twentieth century. Today, game theory attracts attention for its wide range of applications ranging from business, auctions, and elections, biology, and gambling. The game theory originated as a branch of mathematics, but research in game theory has included experimental as well as mathematical methods from the first (Roger, A.M. &Phillips, D.,2003).

### 2.1.2 Concept of Game Theory

Game Theory is the study of the choice of strategies by interacting rational agents. A key step in a game theoretic analysis is to discover which strategy is a person’s best response to the strategies chosen by the others. It is always used to analyze the environmental where competitors had existed (Rasmusem, E.P., 1991).

In neoclassical economics, the rational individual faces a specific system of institutions, including property rights, money, and highly competitive market. These are among the circumstances that the person takes into account in maximizing rewards. The implication of property rights, a money economy, and competitive markets is that the individual need to consider his or her interactions with other individuals (Stahl, S., 1998). Each person needs to consider only his or her situation and conditions of the market, but this leads to two problems:

1.It limits the range of the theory. Whenever competition is restricted, or property rights are not fully defined, consensus neoclassical economic theory is inapplicable, and neoclassical economics has never produced a generally accepted extension of the theory to cover these cases (Basar, T., & Olsder, G.J, 1982).

2.Decisions taken outside the money economy were also problematic for neoclassical economics. Game theory was intended to confront just this problem: to provide a theory of economic and strategic behavior when people interact directly, rather than through the market (Basar, T., & Olsder, G.J, 1982).

In neoclassical economic theory, to choose rationally is to maximize one's rewards. From one point of view, this is a problem in mathematics: choose the activity that maximizes rewards in given circumstance. In game theory, the case is complex, since the outcomes depend not only on one's own strategies and the market conditions but also directly on the strategies chosen by others (Porter, M., 1980). Therefore, the solution of the game is maximizing the rewards of a group of interaction decision makers.

There are two different ways of presenting a game: First is the Extensive form, second is the Normal form.

(1) Extensive form: When a game is represented as a tree diagram, we say that the game is represented in extensive form. In other words, it represents each decision as a branch point in a tree diagram (Recitation Notes#7, 2004). The example like figure 2.1

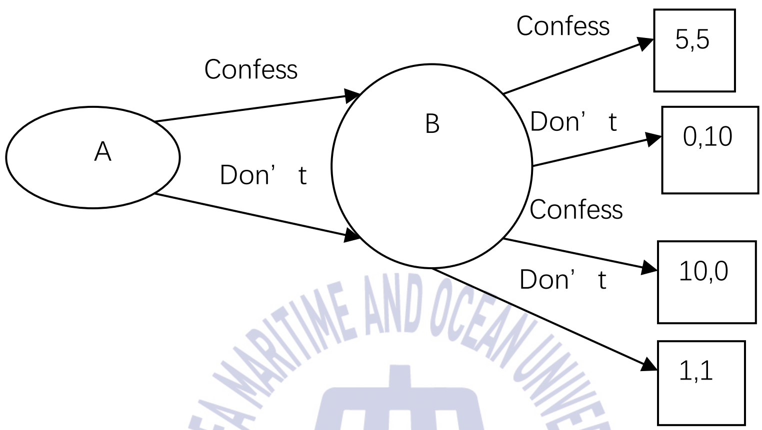



**Fig. 2.1 Example of Extensive** (Recitation Notes#7, 2004))

In figure 2.1, the prisoner’s dilemma is given. In this dilemma, if prisoner 1 makes his decision to confess or not confess the crime at point A, and prisoner 2 makes the decision to confess or not confess the crime at point B. Point A and B are the time of the interrogation. We can get different results in this game. If prisoner 1 chooses to confess the crime at point A, and prisoner 2 chooses to confess the crime at point B, both of them are prisoned for 5 years. Nevertheless, when prisoner 1 chooses to confess the crime at point A, but prisoner 2 chooses not to confess the crime at point B, the result will end up with prisoner 2 will be imprisoned for 10 years, prisoner 1 will not be imprisoned (Recitation Notes#7, 2004). Obviously, in this example, prisoner 1 and 2 wouldn’t know the choice which other side make, they just need to consider the choice that themselves are going to make.

(2) Normal form: The game is shown as a table of number with the different strategies available to the players enumerated at the margins of the table (Recitation Notes#7, 2004). For example, Figure 2.2 shows the Grade point averages for Julia and Lily:

| | | Lily | |
|---|---|---|---|
| | | Math | History |
| Julia | Math | 3.1,3.2 | 4.5,4.5 |
| | History | 3.2,4.5 | 3.1,4.5 |

**Fig. 2.2 Example of Normal form (Recitation Notes#7, 2004)**

In this example, they are siblings who are the two best students in their class. They are both very good at math, but Lily is better at history. Each wants to maximize her grade point average; they can make the strategies by themselves. Assuming that the sisters make their decisions at the same time, Lily makes her decision first while Julia knows Lily's decision when she chooses her strategy(Recitation Notes#7, 2004). Therefore, in this situation, two players are made known to the choice of each other, and thus they can change their strategy based on the choice of their competitor.

### 2.1.3 Classification of game theory

The game solution always has two kinds of classification: Noncooperative game and Cooperative game. In practical, the noncooperative game is used more often than the cooperative game. The noncooperative game includes Dominant Strategies and Social dilemmas, Maximin strategy, Zero-sum Game, Constant-sum and Nonconstant-sum Game, Three-Person Games, Pure Strategy and Mixed strategies, Proportional and N-Person Games, etc.

Dominant Strategy: If one strategy better than all other strategies, it refers to a dominant strategy (Daskalakis, C., 2008).

Social Dilemma: If the game has a dominant strategy solution that is different from the cooperative solution to the game, the game is a social dilemma (Daskalakis, C., 2008).

Maximin strategy: If we determine the last possible payoff for each strategy, and choose the strategy for which this minimum payoff is largest, we have the maximin strategy (Daskalakis, C., 2008).

Zero-sum game: A game in which the payoffs for the players always add up to zero is called a zero-sum game (Daskalakis, C., 2008).

Constant-Sum and Nonconstant-Sum game: If the playoffs add up to the same constant for all players, regardless of which strategies they choose, it is the Constant-Sum game. On the contrary, If the payoffs do not add up to a constant, varies depending on which strategies are chosen, then we have a nonconstant-sum game (Daskalakis, C., 2008).

Three-person game: the complications are presented in games with more than three persons, it is more complication than the two-person game (Daskalakis, C., 2008).

Pure Strategy and Mixed strategy: In a game have a list of strategies with their payoffs, it is called pure strategy. In a game, one player who chooses the list of pure strategies-two or more of which are positive is said to choose a mixed strategy(Daskalakis, C., 2008).

Proportional Games: A game in which the state variable is the proportion of the population choosing one strategy rather than another (Daskalakis, C., 2008).

N-Person Game: A game with N players is an N-person game. N can become any number, 1,2,3 or more, but as the number increased the assumption in this game will be increased, and we need some simplifying assumptions to make the game analysis useful(Daskalakis, C., 2008).

Normally there are two equilibrums related with Game Theory: Dominant strategy equilibrium and Nash equilibrium. The difference between these two equilibriums can be summarized in the following table 1. Therefore, we may clearly conclude that Nash equilibrum is suitable for the condition of this thesis based on this table.

**Table 1 Dominant Strategy Equilibrium and Nash Equilibrium**

| Dominant Strategy Equilibrium | Nash Equilibrium |
|---|---|
| **1. Concept:**<br>(1) Dominant Strategy: whenever one strategy yields a higher payoff than a second strategy, regardless of which strategies the other players choose, the first strategy dominates the second. If one strategy dominates all other strategies, it is to be a dominant strategy (Daskalakis, C., 2008).<br>(2) Dominant Strategy Equilibrium: If in a game, each player has a dominant strategy, and each player plays the dominant strategy, then that combination of strategies and the corresponding payoffs are said to constitute the dominant strategy equilibrium for that game (Daskalakis, C., 2008).<br>**2. Solution:**<br>(1) Cooperative Solution: it is the list of strategies and payoffs that the participants would choose if they could commit themselves to a coordinated choice of strategies (Daskalakis, C., 2008).<br>(2) Noncooperative Solution: if the strategies and payoffs they would choose and there are no enforceable agreements is the noncooperative solution (Daskalakis, C., 2008).<br>3. **Example:**<br>Firm A doesn't know what choice will be made by Firm B. Each firm only chooses the best strategy for themselves. | 1**. Concept:**<br>Nash Equilibrium: For any game in normal form, if there is a list of strategies, with one strategy per player, such that each strategy on the list is the best response to the other strategies on the list, that list of strategies is Nash equilibrium(Daskalakis, C., 2008).<br>**2. Solution:**<br>(1) Cooperative Solution.<br>(2)Noncooperative Solution.<br>**3. Example:**<br>Firm A can find out what is the best choice for Firm B, and depends on Firm B's choice to come out with the best strategy for own. |

From Table 1, it is easy to discover that if player 1 could obtain information about player 2's choice, it could be use Nash Equilibrium to calculate the game. In this thesis, the new entrance (follower) can get the first entrance (leader)'s choice information, in this situation and based on table 1, the thesis needs to use the Nash equilibrium to calculate the optimal capacity for helping the new entrance (follower) to figure out the best strategy.

## 2.2 Cournot and Stackelberg model

One of the objectives of John von Neumann and Oskar Morgenstern in their great book, the Theory of Games and Economic Behavior, was to solve an unsolved problem of economic theory: oligopoly pricing. From their point of view, that would be the cooperative solution to the game, but if they act non-cooperatively or competitively, the price might fall below the monopoly target, and might even fall to the competitive price level. Since duopoly (a market with just two sellers) is the most extreme form of oligopoly, many studies have been conducted, focusing on duopoly pricing. In this chapter, it will introduce the traditional duopoly models, Cournot and Stackelberg model (a market has two sellers); and then, compare the difference between of them.

### 2.2.1 Cournot Model

**1. Definition**

The Cournot model is a one period game, in which two firms produce an undifferentiated product with a known demand curve. The two firms compete by choosing their respective level of output simultaneously. Each firm chooses the output ( Q ) assuming their competitors' output is fixed.

**2. Optimization in the Cournot game**

In a Cournot game, equilibrium is researched when each firm correctly assumes the competitors' output and chooses a level of output $Q$ that maximize its own profits. There is no incentive for either firm to change from Cournot equilibrium.

(1) Therefore, given a market demand for output is $Q(P)$ and production levels by two producers of $Q = Q_1 + Q_2$, then calculate the maximize profits of each company as follow:

(2) Calculate its Marginal Revenue as a function of $Q_1$ and $Q_2$.

(3) Set this Marginal Revenue equal to the Marginal Cost.

(4) Solve for its Quantity. The reaction curve and illustration of the optimal level of the quantity of each firm can make optimal quantities are like this:

$$Q_1^* = f(Q_2) \ \ and \ \ Q_2^* = f(Q_1)$$

Actually, in Cournot model, two firms just need to be considerate about its optimal quantities based on the market total quantities. Moreover, these two firms had existed in the market at the same time for a long while. This appears to be the biggest difference from Stackelberg Model.

### 2.2.2 Stackelberg Model

**1. Definition**

This is a one period game, where two firms offer an undifferentiated product with known demand curve. Firms have to compete by choosing the amount of output $Q_1$ and $Q_2$ to produce, but one of them (Firm 1) goes first into the market. Therefore, the another firm (Firm 2) can observe what the Firm 1 has chosen for $Q_1$, and then only it chooses $Q_2$

accordingly in order to maximize its profits. At the same time, Firm 1 was made known about Firm 2's strategy, and then Firm 1 can change another strategy, relying on Firm 2.

**2. Optimizing in the Stackelberg model**

In Stackelberg model, equilibrium is reached when Firm 1 preemptively expands output and secures large profits as a monopolist. Therefore, the Firm 1 as a leader has the "first mover advantage" and Firm 2 as a follower in this term. In fact, Firm 2 is always forced to curtail output given that the leader (Firm 1) has already produced a large output. Hence Firm 2's optimal output is lower than Firm 1. Nevertheless, Firm 1 being influenced by Firm 2, will face competition from rival and couldn't be a monopolist anymore. As a result, Firm 1's optimal output will also be lower than the time when it was still a monopolist.

### 2.2.3 Comparing with Cournot and Stackelberg Model

In 2.2.1 and 2.2.2 is compare Cournot to Stackelberg model like being shown in table 2.

**Table 2 Cournot Model and Stackelberg Model**

| | **Cournot Model** | **Stackelberg Model** |
|---|---|---|
| **1.Definition is different** | The two firms existed in the market at the same time for a long while, and they compete by choosing their respective level of output simultaneously. | There are two firms: one of them as a leader who first entered the market and has the first mover advantage; another one as a follower who entered the market after the leading company. The follower can choose to maximize profit following the choice of the leader, meanwhile, the leader can change its strategy by relying on the follower's economic rationality. |
| **2. Optimizing calculation is different** | Calculate the optimize equilibrium of each firm as: $Q_1^* = f(Q_2)$ $Q_2^* = f(Q_1)$ | First, calculate the optimize equilibrium for the leader one($Q_1^*$). Second, based on the leader's output calculate the optimize equilibrium for the follower($Q_2^* = f(Q_1^*)$). |

From Table 2, the differences between Cournot and Stackelberg model could be clearly observed. Firstly, in Cournot model, the two firms existed in the market at the same time, but in Stackelberg model one of two firms goes first. Secondly, in Cournot model, the two firms can choose their strategy simultaneously, but in Stackelberg model, the follower can choose the best strategy based on the leader's output while the leader can also change its strategy depends on the follower's economic situation. At last, in Stackelberg model, the leader has the first mover advantages; it can preemptively expand output and control the market price as a monopolist. Meanwhile, the follower can observe what the leader has chosen for his output. In Cournot model, the two companies just need to consider the total outputs of the market.

### 2.2.4 Why choose Stackelberg model?

This thesis is assumed that there are two cruise lines: one of them is a big company as a leader who has the first mover advantages; another one is a small company as a follower, and both of them had entered the cruise market. Based on these preconditions using the Stackelberg model to analyze the optimal capacity is more suitable than the Cournot model, and there are some differences to the traditional Stackelberg model. The reason is followed by:

**1. The different kinds of companies.**

According to the traditional Stackelberg model, one of the two firms moves firstly, and the second follows to it. However, the two firms have different sizes in the thesis, one of them is a big firm and another is a small firm. Big companies are often have more profitable than smaller ones because of economies of scale: in microeconomics, the economies of scale are the cost advantages that enterprises obtain due to size, output, or scale of operation, with cost per unit output generally decreasing with increasing scale as fixed costs are spread out over more units of output, for example, suppliers may offer discounts for larger orders, shippers may decrease per trip cost to compete for a large volume of business, and necessary production management staff may increase internal manufacturing efficiency. It means that, the big firm reveals the mode of economics of scale, so it results in different cost function between big and small firms.

The detailed economic of scale will be introduced in Chapter 3.

**2. The cost function is different.**

In traditional Stackelberg model, these two firms are in the same form (one of them is a big firm, and another one has the same form). Therefore, the cost functions of them have the same modality - the liner equation. Nevertheless, in this thesis the two firms have different forms (one of them is a big firm (Line 1) has the first mover advantage, and another one is a small firm (Line 2 ) as a follower in the cruise market), so the cost function of them are different.

Based on this assumption to summary as follow: there are a big firm as a leader (Line 1) and a small firm as a follower (Line 2), and the average costs of the big firm (Line 1) must be lower than that of the small one (Line 2), the result of that they are cost functions have two different forms. In other word, these two firms have not the same modality- the liner equation, it is because of the big firm (Line 1) has the economies of scale.

## 2.3 Existing Research

Following the development of the cruise industry, there are a lot of studies on the optimal capacities of cruise line industry.

Papathanassis, A. & Vogel, M. P. (2013) on Cruise Sector Growth derive five stylized facts of cruise line economics to analyses the impact of onboard revenue on the optimal price of the cruise, on profit, and on optimal capacity levels. They conclude that high-margin onboard revenue is likely to be the main driver of cruise industry growth because it gives the cruise lines the possibility of subsidizing ticket prices to make cruises more affordable. Lower ticket prices attract more customers who, once onboard, fuel this process with their spending.

Pullman, M. & Rodgers, S. (2010) on Capacity management for hospitality and tourism mentioned that capacity design solutions are affected by a number of noncooperation factors such as social stratification rules. Simulation models are now being developed and applied to these problems, and the industry is facing a significant opportunity to incorporate more sophisticated capacity management tactics across different enterprises. Traditional yield management style models could be adjusted to supplement price with non-price attributes (crowding, wildlife, safety, etc.), so that visitor "utility maximization" occurs subject to the capacity constraints of the environment.

Phillips (2005) on Pricing and Revenue Optimization studied the strategies and tactics used by a number of industries to manage the allocation of their capacity to different fare class over time in order to maximize revenue. He presented two capacity allocation problems: the two kinds of model and the multiclass model. The trade-off between the two-class problems is shown by Phillips in his Decision Tree Approach. Although this strategy is most commonly used in the airline industry, the cruise and hotel industry has also adopted this approach.

Wie, B.-W. (2005) in a dynamic game model of strategic capacity investment in cruise line industry used the non-cooperative Nash equilibrium capacity investment strategies of cruise lines which theoretically analyzed under the open-loop information structure. It is used with the numerical results to provide a number of important managerial guidelines for cruise capacity investment decisions.

The collected studies can help us determine which methodology is used in this study. The first step is to collect information about the capacity of cruise industry which always be connected with high profit and high market price, it is to say that the optimal capacity changing is influenced by the cost of the cruise line. Therefore, the focus on the relationship between the optimal capacity and the cost of the cruise line, as well as the change of market price of the cruise is our study's objective. In addition, the capacity management can be better than the traditional yield management model, so this study can find out the appropriate model for analyzing base on the previous assumption. Finally, the model can be applied for the game method. Phillips (2005) used the Decision Tree Approach to analyze the different classes of capacity. Nevertheless, this study wants to find out the situation for two sellers' competitive analysis by applying the game theory. Next chapter is to calculate the optimal capacity and to find out main influential factors, and then make suggestions about how to manage the cost in reaching the optimal capacity for a new entered cruise line company.

# CHAPTER 3 MODEL AND ANALYSES

This chapter on the one hand mainly focuses on a game of Stackelberg Duopoly Model and to explain it in a very detailed way, on the other hand it is also suggests some managerial and valid economic implications. In this game, Line 1 is a bigger leader cruise line company, therefore it has the first mover advantage. Meantime for the cruise market, Line 2 is smaller and newborn compared with Line 1. It is assumed that the cost efficiency of Line 2 is inferior to Line 1 because of the economics of scale, as what could be usually found in real duopoly markets.

Furthermore, it will be included three major parts in this chapter as discussed phases. Firstly, in Section 3.1 and Section 3.2, calculating the optimal capacities of Line 1 and Line 2. Secondly, in Section 3.3, it fully analyzes the variable cost of Line 2 and the adjustment parameter of it. Lastly, in Section 3.4, taking a thoroughly look at some numerical examples, meanwhile it puts forward some managerial implications for Line 2 in order to have a larger share in the cruise market.

## 3.1 Model and assumptions

Line 1 and Line2 are both wise decision makers. As mentioned in the previous introduction, Line 1 is a bigger cruise line and has first mover advantage. Line 2 is a smaller cruise line as a follower in the sense that it enters into the cruise market after Line 1. Assume the increase demand function of cruise market as (1), where $P$ denotes the price of the cruise of the market.

$$P = a - bQ \tag{1}$$

In (1), $Q$ is the total of capacity $(Q = Q_1 + Q_2)$ of the cruise market, the total capacity in this context refers to the total number of berths in Line 1 and Line 2. Other parameters include $a$ and $b$, they are positive constants, whereby $b$ is the demand elasticity. It is assumed and that $P$>0 for any practical capacities $Q_i$ $(> 0)$, provided by Line $i$ ($i$=1,2). All the parameters and variables are also assumed to be non-negative.

Meanwhile, for the duopoly game in this thesis, Line 1 is the leader and has the first mover advantage. It means that Line 1 has already been preeminent in the cruise market equipped with an efficient linear cost function. Therefore, the cost function of Line 1 is (2)

$$C_1(Q_1) = f + v_1 Q_1, \forall Q_1 > 0 \tag{2}$$

In (2), $f$ is the fixed cost of Line 1. As Line 1 had entered the cruise market, the fixed cost of Line 1 has no relation with the decision making of Line 1. On the other hand, $v_1$ is the variable cost of Line 1, which includes the labor costs and bunker fuel expenses directly coming from cruise operation.

In contrast, Line 2 is a smaller cruise line company that had entered into the cruise market later than Line 1. Hereby, the cost function of Line 2 is assumed to be (3).

$$C_2(Q_2) = f + v_2 Q_2 + v_3 Q_2^2, \forall Q_2 > 0 \tag{3}$$

In (3), $f$ is the fixed cost of Line 2, similar with Line 1, Line 2 has entered the cruise market too, so the fixed cost of Line 2 does not have any influence on its decision making either. Other parameters in this context include $v_2$ $(> 0)$ and $v_3$ $(> 0)$. $v_2$ is the variable cost of Line 2 whereas $v_3$ is the adjustment parameter of Line 2; $v_3$ is includes all of the cost for improve their competitive of Line 2, for example, the cost of new vessels and the total amount of expenditure required when the aging cruise ship equipment needs to be repaired, etc. Therefore, as same as the variable costs of Line 2 ($v_2$), the adjustment parameters of Line 2 ($v_3$) cannot be avoided.

The list below is the notation of key variables and functions that will be employed in the remainder of this paper:

$T$ = the total capacity of Line 1 and Line 2.

$C_1(Q_1)$ = the cost function of Line 1.

$C_2(Q_2)$ = the cost function of Line 2.

$v_2$ = the variable cost of Line 2.

$v_3$ = the adjustment parameter of Line 2.

$Q_1^*$ = the optimal capacity of Line 1.

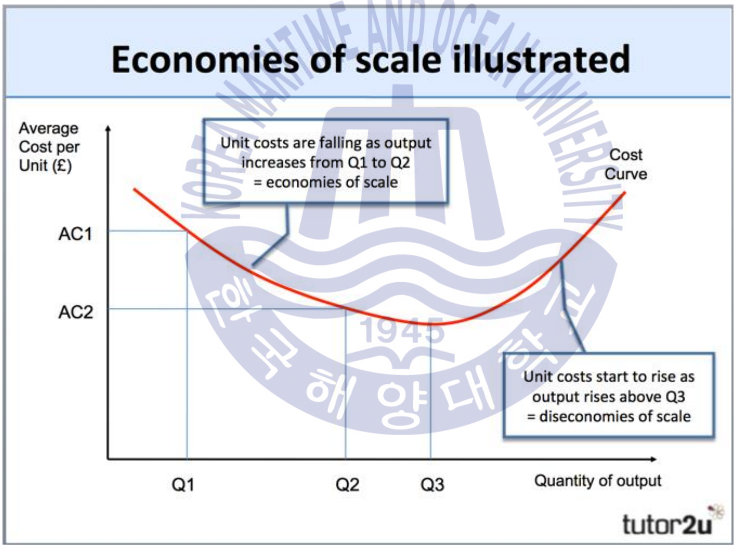
$Q_2^*$ = the optimal capacity of Line 2.

$Q_1^M$ = the optimal monopoly capacity of Line 1.

### 3.1.1 Introducing the differences of the cost function of Line 1 and 2

In Chapter 2 (section 2.2.4), it had justified the underlying reasons for using the Stackelberg model, and the contributors to the difference in cost function between two firms. There are different categories of the cruise line in this thesis. More often than not, in section 2.2.4 had mentioned that the bigger cruise line is more profitable than the smaller one due to economies of scale. Therefore, it could be deduced that their cost functions are different; and more specifically, the cost function of Line 1 will be lower than Line 2 on account of economies of scale.

As the focus with economies of scale is always on the cost per unit, or average cost (*AC*), not the total cost, if you take advantage of economies of scale, your unit cost will be typically decreased as the number of unit increases – so you'll probably earn more (Wikipedia. Economies of Scale). Most firms could be made such conclusion while they practice economies of scale. As their production output increases, they may achieve lower costs per unit. This can be illustrated as follows:




**Wikipedia. Economies of Scale (http://www.en.wikipedia.org/wiki/Economies_of_scale)**

In the economies of scale illustrated, the unit costs fall from *AC1* to *AC2* when output increases from *Q1* to *Q2*. Therefore, as the unit cost with economies of scale is growing, bigger producing can yield much more significant returns. Figure 3.1 (below) shows the average cost curve if a firm has the edge of economies of scale. As output increases, the average unit cost decreases.

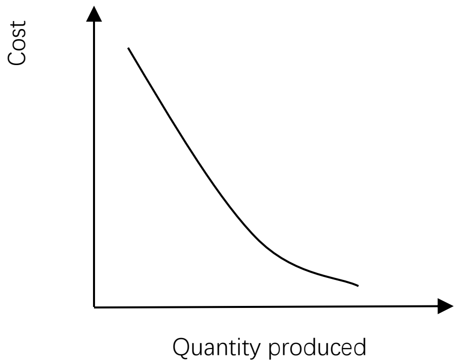



**Fig. 3.1 Economies of scale average cost curve (Typical Average Cost Curve)**

From Fig. 3.1 that if Line 1 benefits from economies of scale, its cost curve will present a monotone decreasing linear function (follow as a function (2)). Nevertheless, for Line 2 who is a latecomer, on the ground that there is already the colossal amount of existing products in the market and it has too little control against competitors, it is often trapped in the plight of ‘diseconomies’ of scale. The average cost curve for diseconomies of scale is as shown in figure 3.2 below:

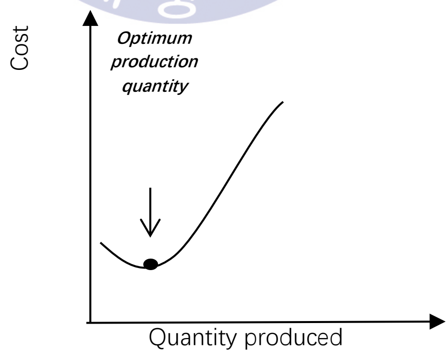



**Fig. 3.2 Diseconomies of scale average cost curve**

In Fig. 3.2, it is easy to find that if Line 2 has diseconomies of scale, its cost curve is close to a quadratic function which is open side up (follow as a function (3)). There is a point at which average costs prevent falling as production increases, which may also be the point at which cost starts to rise as a result of this inefficiency. This point is referred as the company's Minimum Efficient Scale *(MES*). In Fig. 3.2, the turning point at the bottom of the curve is the optimal place to be. If the production volume is higher than the optimal point, the company's output is no longer an advantage for cost reduction. Hereby, it comes to the aim of this thesis which is to find out the optimal capacity for Line 2; and then based on the result obtained, analyze its connection with the cost.

**3.1.2 Calculating the optimal monopoly capacity of Line 1.**

When Line 2 has yet entered the cruise market, Line 1 is the monopolist of the cruise market.

In this context, *MR* of Line 1 is $MR_1(Q_1) = \frac{dTR(Q_1)}{dQ_1} = a - 2bQ_1$ while the *MC* of Line 1 is $MC_1(Q_1) = \frac{dTC(Q_1)}{dQ_1} = v_1$. Hence, based on the principle $MR_1(Q_1) = MC_1(Q_1)$, it can be derived that the optimal monopoly capacity of Line 1 is $\boldsymbol{Q_1^M = \frac{a-v_1}{2b}}$.

**3.1.3 Calculating the optimal capacity of Line 2.**

In this Section, the optimal capacity of reaction function is calculated. The reaction function $Q_2(Q_1^*)$ (Cho & Wei,2017) is the optimal capacity of Line 2. To re-accentuate, Line 1 has existed for a long time in the cruise market as a monopolist while Line 2 is the newcomer of the cruise market. Therefore, Line 1 has already been well acknowledged with its optimal capacity, but Line 2 yet in this situation. With this, the total of capacity could be considered as $Q = Q_1^* + Q_2(Q_1^*)$. *MR* of Line 2 is $MR_2(Q_2) = \frac{\partial TR(Q_1^*, Q_2)}{\partial Q_2} = a - bQ_1^* - 2b\mathrm{Q}_2(\mathrm{Q}_1^*)$ whereas the *MC* of Line 2 is $MC_2(Q_2) = \frac{\partial TC(Q_1^*, Q_2)}{\partial Q_2} = v_2 + 2v_3\mathrm{Q}_2(\mathrm{Q}_1^*)$. From $MR_2(Q_2) = MC_2(Q_2)$, it can be derived that reaction function of Line 2, $\boldsymbol{Q_2(Q_1^*)}$, which computes the optimal capacities to be provided by Line 2 follow as $\boldsymbol{Q_2(Q_1^*) = \frac{a - bQ_1^* - v_2}{2(b + v_3)}}$.

According to Cho & Wei (2017), the entrance of Line 2 into the cruise market will change the optimal capacity of Line 1. In next section, we will use the theorem, proved by Cho & Wei (2017), to find out the new optimal capacities of Line 1 and Line 2 respectively.

## 3.2 Optimal capacities for Line 1 and Line 2

**Theorem 5 (Cho & Wei, 2017)**

Consider the optimal capacity of Line 2 is (4)

$$Q_2^* = Q_2(Q_1^*) = \frac{a - bQ_1^* - v_2}{2(b + v_3)} \tag{4}$$

Cho & Wei (2017) has proved that $(Q_1^*, \frac{a - bQ_1^* - v_2}{2(b + v_3)})$ is Nash equilibrium for Line 1 and Line 2. Let $\boldsymbol{s = \frac{b}{2(b + v_3)}}$, when profit function $\pi_1(Q_1)$ derivative number equals to 0, we can obtain the optimal profit function of Line 1. It means that $\frac{d\pi_1(Q_1^*)}{dQ_1} = 0$ leads to $2b(1 - s)Q_1^* = a(1 - s) - v_1 + sv_2$. Therefore, the optimal profit of Line 1 is (5)

$$Q_1^* = \frac{a(1-s) - v_1 + sv_2}{2b(1-s)} \tag{5}$$

The optimal monopoly capacity of Line 1 is $\boldsymbol{Q_1^M = \frac{a-v_1}{2b}}$. Assuming the variable cost of Line 2 $(v_2)$ is larger than the variable costs of Line 1 $(v_1)$ $(v_2 \geq v_1)$, then $Q_1^*$ will be larger than $Q_1^M$ $(Q_1^* \geq Q_1^M)$. Since $0 < \boldsymbol{s} \leq \frac{\mathbf{1}}{\mathbf{2}}$, $Q_1^*$ as follows (6).

$$Q_1^* = Q_1^M + \frac{s(v_2 - v_1)}{2b(1-s)} \tag{6}$$

Now, Theorem 5 is applied to calculate the optimal capacity and optimal profit of Line 1.

***1. Since*** $\mathbf{0} < s \leq \frac{\mathbf{1}}{\mathbf{2}}$, ***suppose*** $\boldsymbol{v_2 \geq v_1}$ ***the optimal capacity of Line 1 is.***

$$\begin{cases} Q_1^* = Q_1^M + \frac{s(v_2 - v_1)}{2b(1-s)}, \forall\ v_2 > v_1 & \text{(7a)} \\ Q_1^* = Q_1^M + \frac{s(v_1 - v_1)}{2b(1-s)} = Q_1^M, \forall\ v_2 = v_1 & \text{(7b)} \end{cases}$$

**Theorem 6: (Cho & Wei, 2017)**

When Line 2 entered the cruise market, the total available capacity is $(Q_1^* + Q_2(Q_1^*))$, which leads to the function (8).

$$T = Q_1^* + Q_2(Q_1^*) = Q_1^M + \frac{a - v_2}{4(b + v_3)} \tag{8}$$

The market share of Line 2 is not greater than 1/3. Since $Q_1^M = \frac{a-v_1}{2b}$ and $Q_1^M < Q_1^*, Q_1^M - Q_2(Q_1^*) \geq \frac{1}{2}Q_1^*$ and so $0 < Q_2(Q_1^*) \leq \frac{1}{2}Q_1^*$. It is easy to notice from function (8) that the optimal capacity of Line 2 is $Q_2(Q_1^*) = Q_1^M + \frac{a-v_2}{4(b+v_3)} - Q_1^*$.

Now, the result from Theorem 6 to calculate the optimal capacity of Line 2 could be used.

***2. Since $0 < s \leq \frac{1}{2}$, suppose $v_2 \geq v_1$, the optimal capacity of Line 2 is.***

$$\begin{cases} Q_2^* = Q_2(Q_1^*) = Q_1^M + \frac{a-v_2}{4(b+v_3)} - Q_1^* = Q_1^M + \frac{a-v_2}{4(b+v_3)} - \left[Q_1^M + \frac{s(v_2-v_1)}{2b(1-s)}\right] = \frac{a-v_2}{4(b+v_3)} - \frac{s(v_2-v_1)}{2b(1-s)} \quad, \forall\ v_2 > v_1 & \text{(9a)} \\ Q_2^* = Q_2(Q_1^*) = Q_1^M + \frac{a-v_2}{4(b+v_3)} - Q_1^* = Q_1^M + \frac{a-v_2}{4(b+v_3)} - Q_1^M = \frac{a-v_1}{4(b+v_3)}, \quad \forall\ v_2 = v_1 & \text{(9b)} \end{cases}$$

Therefore, since $0 < s \leq \frac{1}{2}$, suppose $v_2 \geq v_1$, the Nash Equilibrium followed as.

$$\begin{cases} \left(Q_1^M + \frac{s(v_2-v_1)}{2b(1-s)}, \frac{a-v_2}{4(b+v_3)} - \frac{s(v_2-v_1)}{2b(1-s)}\right), & \forall\ v_2 > v_1 \\ \left(Q_1^M, \frac{a-v_1}{4(b+v_3)}\right), & \forall\ v_2 = v_1 \end{cases}$$

From the functions (7a)-(7b) and (9a)-(9b), we can observe that there are a lot of changes of the optimal capacities of Line 1 and Line 2, and the variable cost ($v_2$) and the adjustment parameter ($v_3$) will influence the results of the Nash Equilibrium. In Section 3.3, the variable cost ($v_2$) and adjustment parameter ($v_3$) will be analyzed.

### 3.3 Analysis on variable cost and adjustment parameter

The thesis of Cho & Wei (2017) had proved the result when $v_2 = v_1$. Therefore, in this section it would be considered another condition in which $v_2 > v_1$. In another words, it includes two aspects: First of all, using the functions (7a) and (9a) to analyze the economic interpretation for Line 2. Secondly, using the result of the economic interpretation to put forward some managerial implications for Line 2 to gain larger market share.

#### 3.3.1 Analysis on variable cost of Line 2 ($v_2$).

***1) Analysis on the market total capacities (T).***

The market total capacities

$$T = Q_1^* + Q_2^* = Q_1^M + \frac{s(v_2-v_1)}{2b(1-s)} + \frac{a-v_2}{4(b+v_3)} - \frac{s(v_2-v_1)}{2b(1-s)} = Q_1^M + \frac{a-v_2}{4(b+v_3)}.$$

Demanding the market total capacities ($T$) on the variable cost of Line 2 ($v_2$) partial derivative as shown in (10).

$$\frac{\partial T}{\partial v_2} = \frac{\partial\left(Q_1^M + \frac{a-v_2}{4(b+v_3)}\right)}{\partial v_2} = -\frac{1}{4(b+v_3)}, \forall\ v_2 > v_1 \tag{10}$$

In (10), $\frac{\partial T}{\partial v_2} = -\frac{1}{4(b+v_3)} < 0$, from this result, the conclusion generated is when the variable costs $v_2 \uparrow$, the total capacities of Line 1 and 2 $T \downarrow$.

***2) Analysis of the optimal capacity of Line 2 ($Q_2^*$).***

Demanding the optimal capacity of Line 2 ($Q_2^*$) on the variable cost of Line 2 ($v_2$) partial derivative follow as (11).

$$\frac{\partial Q_2^*}{\partial v_2} = \frac{\partial}{\partial v_2}\left[\frac{a - v_2}{4(b + v_3)} - \frac{s(v_2 - v_1)}{2b(1 - s)}\right]$$

$$= -\frac{1}{4(b + v_3)} - \frac{s}{2b(1 - s)} \quad , \forall \ v_2 > v_1 \tag{11}$$

In (11), $\boldsymbol{s = \frac{b}{2(b+v_3)}}$ (Section 3.2), so $-\frac{1}{4(b+v_3)} - \frac{s}{2b(1-s)} < 0$. Hereby, $\frac{\partial Q_2^*}{\partial v_2} < 0$ and it leads to the conclusion : When the variable cost $v_2$ ↑, the optimal capacity of Line 2 $Q_2^*$ ↓.

***3) Analysis on the market price of the cruise (P).***

If $v_2 > v_1$, the market price of cruise can be calculated by assuming $P = a - bQ = a - bT = a - b[Q_1^M + \frac{a-v_2}{4(b+v_3)}]$. Demanding the market price of cruise $(P)$ on the variable cost of Line 2 ($v_2$) partial derivative in the following as (12).

$$\frac{\partial P}{\partial v_2} = \frac{\partial}{\partial v_2}\left\{a - b[Q_1^M + \frac{a - v_2}{4(b + v_3)}]\right\} = \frac{b}{4(b + v_3)} \tag{12}$$

In (12), it is easy to find that $\frac{\partial P}{\partial v_2} > 0$. Based on this result, we can conclude that $v_2$ is in direct proportion to *P*; and hence, when $v_2$ ↑, the market price of cruise *P*↑.

**Conclusion 1:** Suppose $v_1 > v_{2,}$ if the variable cost of Line 2 ($v_2$) increases, the market price of cruise *(P)* increases. Nevertheless, the optimal capacities of Line 2 ($Q_2^*$) and the total capacities of Line 1 and 2 *(T)* are decreased. We can summarize it as: $\boldsymbol{v_2}$ ↑ will lead to $\boldsymbol{Q_2^*}$ ↓, $\boldsymbol{T}$ ↓ **and** $\boldsymbol{P}$ ↑.

### 3.3.2 Analysis on adjustment parameter of Line 2 ($v_3$).

***4) Analysis on the market total capacities (T).***

Demanding the market total capacities *(T)* on the adjustment parameter of Line 2 ($v_3$) partial derivative as follow (13).

$$\frac{\partial T}{\partial v_3} = \frac{\partial [Q_1^M + \dfrac{a - v_2}{4(b + v_3)}]}{\partial v_3} = -\frac{a - v_2}{4(b + v_3)^2} \tag{13}$$

In (13), $a$ is the price coefficient. It can be calculated that the variable cost of Line 2 ($v_2$) must be always lower than the market price; otherwise, Line 2 will not entered the market. That is to say, the price coefficient $a$ is always be larger than the variable cost of Line 2 ($v_2$), videlicet, $a$-$v_2 > 0$. Hereby, when $\frac{\partial T}{\partial v_3} < 0$, the variable cost of Line 2 $v_3$ ↑, the market total capacities $T$ ↓. Consequently, $v_3$ is inversely proportional to $T$.

***5) Analysis of the optimal capacity of Line 2 ($Q_2^*$).***

In Section 3.2, $\boldsymbol{s} = \frac{\boldsymbol{b}}{\boldsymbol{2(b+v_3)}}$, demanding the optimal capacity of Line 2 ($Q_2^*$) on the adjustment parameter of Line 2 ($v_3$) partial derivative, which is $\frac{\partial Q_2^*}{\partial v_3} = \frac{\partial}{\partial v_2}\left[\frac{a-v_2}{4(b+v_3)} - \frac{s(v_2-v_1)}{2b(1-s)}\right] = \frac{\partial}{\partial v_2}\left[s.\frac{a-v_2}{2b} - \frac{s(v_2-v_1)}{2b(1-s)}\right]$; and s includes $v_3$. Therefore, $\frac{\partial Q_2^*}{\partial v_3} = \frac{\partial Q_2^*}{\partial s}.\frac{\partial s}{\partial v_3}$, the partial derivative function is as shown in (14).

$$\frac{\partial Q_2^*}{\partial v_3} = \frac{\partial Q_2^*}{\partial s}.\frac{\partial s}{\partial v_3} = \left[\frac{a - v_2}{2b} + \frac{v_2 - v_1}{2b(1 - s)^2}\right].\left[-\frac{b}{2(b + v_3)^2}\right]$$

$$= -\frac{(a - v_2)(1 - s)^2 + v_2 + v_1}{4(b + v_3)^2(1 - s)^2} \tag{14}$$

In (14), it is easy to find that $\frac{\partial Q_2^*}{\partial v_3} < 0$, while $v_3$ is in direct proportion to $Q_2^*$. When $v_3$ ↑ the optimal capacity of Line 2 $Q_2^*$ ↓.

***6) Analysis on the market price of the cruise (P).***

In 3), it had calculated the market price of cruise by $P = a - b[Q_1^M + \frac{a-v_2}{4(b+v_3)}]$. Demanding the market price of cruise $(P)$ on the adjustment parameter of Line 2 $(v_3)$ partial derivative, we could obtain an equation as follow, (15).

$$\frac{\partial P}{\partial v_3} = \frac{\partial}{\partial v_3}\left\{a - b[Q_1^M + \frac{a-v_2}{4(b+v_3)}]\right\} = \frac{b(a-v_2)}{4(b+v_3)^2} \tag{15}$$

In (15), $\frac{\partial P}{\partial v_3} > 0$, it means that when the adjustment parameter of Line 2 $v_3 \uparrow$, the market price of cruise $P \uparrow$.

**Conclusion 2:** Suppose $v_1 > v_2$, if the adjustment parameter of Line 2 $(v_3)$ increases, the market price of cruise (*P*) increases. Nevertheless, the total capacities of Line 1 and 2 (*T*) decreases, and also, the optimal capacity of Line 2 $(Q_2^*)$ decreases too. We can summarize it as: $\boldsymbol{v_3} \uparrow$ will cause $\boldsymbol{T \downarrow, Q_2^* \downarrow and\ P \uparrow}$.

Using these conclusions (Conclusion 1-Conclusion 2) to propose managerial implication as shown in the Table 3.

**Table 3 Managerial implication of Line 2**

| *Management Key Words* | *Change of $v_2$ and $v_3$* |
|---|---|
| 1.Increase the optimal capacity of Line 2$(Q_2^*)$ | $v_2 \downarrow and\ \ v_3 \downarrow$ |
| 2.Increase the total capacities of Line 1 and 2$(T)$ | $v_2 \downarrow and\ \ v_3 \downarrow$ |
| 3.Decrease the market price of cruise$(P)$ | $v_2 \downarrow and\ \ v_3 \downarrow$ |

Based on Table 3, it is show that if Line 2 wants to increase its optimal capacity ($Q_2^*$) or the total capacities of Line 1 and 2 (*T*), Line 2 needs to decrease its variable cost ($v_2$) and adjustment parameter ($v_3$). On the other hand, if Line 2 wants to decrease the market price of cruise (*P*), Line 2 will need to decrease its variable cost ($v_2$) and adjustment parameter ($v_3$) as well.

### 3.4. Numerical Examples

In this Section, we will use the Nash Equilibrium (Section 3.2) $(Q_1^M + \frac{s(v_2-v_1)}{2b(1-s)}, \frac{a-v_2}{4(b+v_3)} - \frac{s(v_2-v_1)}{2b(1-s)})$, $\forall\ v_2 > v_1$ to calculate some numerical examples, and then adopt these results to analyze the change of $Q_2^*$, $T$ and $P$ when $v_2$ and $v_3$ are altered. Consequently, the best improvement of cruise market share could then be found.

① Suppose *a*=101, b=2 , $\boldsymbol{v_2 = 2, v_1 = 1}$, $\boldsymbol{v_3 = 0.5}$. In Section 3.1, we had mentioned that the fixed cost of Line 1 has no relation with the decision making of Line 1 and 2, so we can assume $f = 0$. The price function of the market and the cost function of Line 1 are defined as

$$P = 101 - 2(Q_1 + Q_2), C_1(Q_1) = v_1 Q_1.$$

Similar to the fixed cost of Line 1, the fixed cost of Line 2 $f$ also equals to 0, the cost function of Line 2 turns out to be

$$C_2(Q_2) = 2v_2 Q_2 + 0.5 v_3 Q_2^2.$$

The optimal monopoly capacity $Q_1^M$ of Line 1 and other assumed functions are computed as follows.

$$Q_1^M = \frac{101-1}{4} = 25, S = \frac{2}{2(2+0.5)} = \frac{2}{5} = 0.4.$$

The optimal capacity of Line 1 is

$$Q_1^* = 25 + \frac{0.4(2-1)}{2 \times 2(1-0.4)} = 25 + 0.167 = 25.167$$

The optimal capacity of Line 2 is

$$Q_2^* = \frac{101-2}{4(2+0.5)} - \frac{0.4 \times (2-1)}{2 \times 2(1-0.4)} = \frac{99}{10} - 0.167 = 9.9 - 0.167$$

$$= 9.733$$

The total capacities of Line 1 and 2 is

$$T = 25.167 + 9.733 = 34.9$$

The market price of cruise is

$$P = 101 - 2 \times 34.9 = 31.2$$

② Suppose *a=101*, *b=2* , $\boldsymbol{v_2 = 3, v_1 = 1}$, $\boldsymbol{v_3 = 0.5}$, $\boldsymbol{f = 0}$. The boosted function of the market and the cost function of Line 1 are defined as

$$P = 101 - 2(Q_1 + Q_2), C_1(Q_1) = v_1 Q_1$$

Similar to the fixed cost of Line 1, the fixed cost of Line 2 $f$ also equals to 0, the cost function of Line 2 turns out to be

$$C_2(Q_2) = 3v_2 Q_2 + 0.5 v_3 Q_2^2.$$

The optimal monopoly capacity $Q_1^M$ of Line 1 and other assumed functions are computed as follows.

$$Q_1^M = \frac{101-1}{4} = 25, S = \frac{2}{2(2+0.5)} = \frac{2}{5} = 0.4.$$

The optimal capacity of Line 1 is

$$Q_1^* = 25 + \frac{0.4(3-1)}{2\times 2(1-0.4)} = 25 + 0.33 = 25.33$$

The optimal capacity of Line 2 is

$$Q_2^* = \frac{101-3}{4(2+0.5)} - \frac{0.4\times(3-1)}{2\times 2(1-0.4)} = \frac{98}{10} - 0.33 = 9.8 - 0.33 = 9.47$$

The total capacities of Line 1 and 2 is

$$T = 25.33 + 9.47 = 34.8$$

The market price of cruise is

$$P = 101 - 2\times 34.8 = 31.4$$

③ Suppose *a=101*, *b=2* , $\boldsymbol{v_2 = 3}, \boldsymbol{v_1 = 1}$, $\boldsymbol{v_3 = 1}$, $\boldsymbol{f = 0}$. The increase function of the market and the cost function of Line 1 are defined as

$$P = 101 - 2(Q_1 + Q_2), C_1(Q_1) = v_1 Q_1.$$

Similar to the fixed cost of Line 1, the fixed cost of Line 2 $f$ also equals to 0, the cost function of Line 2 turns out to be

$$C_2(Q_2) = 3v_2 Q_2 + v_3 Q_2^2.$$

The optimal monopoly capacity $Q_1^M$ of Line 1 and other assumed functions are computed as follows.

$$Q_1^M = \frac{101-1}{4} = 25, S = \frac{2}{2(2+1)} = \frac{2}{6} = 0.33.$$

The optimal capacity of Line 1 is

$$Q_1^* = 25 + \frac{0.33(3-1)}{2 \times 2(1-0.33)} = 25 + 0.246 = 25.246$$

The optimal capacity of Line 2 is

$$Q_2^* = \frac{101-3}{4(2+1)} - \frac{0.33(3-1)}{2 \times 2(1-0.33)} = \frac{98}{12} - 0.246 = 7.92$$

The total capacities of Line 1 and 2 is

$$T = 25.246 + 7.92 = 33.167$$

The market price of cruise is

$$P = 101 - 2 \times 33.167 = 34.67$$

④ Suppose *a=101*, *b=2* , $\boldsymbol{v_2 = 1.5}, \boldsymbol{v_1 = 1}$, $\boldsymbol{v_3 = 1}$, $\boldsymbol{f = 0}$. The increase function of the market and the cost function of Line 1 are defined as

$$P = 101 - 2(Q_1 + Q_2), C_1(Q_1) = v_1 Q_1$$

Similar to the fixed cost of Line 1, the fixed cost of Line 2 $f$ also equals to 0, the cost function of Line 2 turns out to be

$$C_2(Q_2) = 1.5 v_2 Q_2 + v_3 Q_2^2.$$

The optimal monopoly capacity $Q_1^M$ of Line 1 and other assumed functions are computed as follows.

$$Q_1^M = \frac{101-1}{4} = 25, S = \frac{2}{2(2+1)} = \frac{2}{6} = 0.33.$$

The optimal capacity of Line 1 is

$$Q_1^* = 25 + \frac{0.33(1.5-1)}{2\times 2(1-0.33)} = 25 + 0.062 = 25.062$$

The optimal capacity of Line 2 is

$$Q_2^* = \frac{101-1.5}{4(2+1)} - \frac{0.33(1.5-1)}{2\times 2(1-0.33)} = \frac{99.5}{12} - 0.062 = 8.23$$

The total capacities of Line 1 and 2 is

$$T = 25.062 + 8.23 = 33.292$$

The market price of cruise is

$$P = 101 - 2\times 33.292 = 34.416$$

***1) Analysis of Numerical Examples:***

(1) In example①, *a=101*, *b=2* , $v_2 = 2, v_1 = 1,\ v_3 = 0.5$, the values obtained are as follows.

$$\boldsymbol{Q_1^* = 25.167, Q_2^* = 9.733, T = 34.9,\ P = 31.2}$$

In example②, *a=101*, *b=2*, $v_2$=3, $v_1$=1, $v_3 = 0.5$. With a mere slight increase of $v_2$ and other factors remain, the numerical result turns out as follows.

$$\boldsymbol{Q_1^* = 25.33,\ Q_2^* = 9.47,\ T = 34.8,\ P = 31.4}$$

In accordance with this result, we could see that the optimal capacity of Line 2 ($\boldsymbol{Q_2^*}$) and the total capacities of Line1 and 2 ($\boldsymbol{T}$) are lower than example①, while the market price of cruise (*P*) is comparatively higher than example①. This result is absolutely in consistent with the discussion being mentioned in Conclusion 1 (Section 3.3.1): If $\boldsymbol{v_2 > v_1}$, $\boldsymbol{v_2} \uparrow$ result in $\mathbf{Q_2^*} \downarrow, \boldsymbol{T} \downarrow$ **and** $\boldsymbol{P} \uparrow$.

(2) In example③, *a=101*, *b=2* , $v_2 = 3, v_1 = 1$ and $v_3 = 1$. In this numerical example, $v_2$ is higher than example①and②, while $v_3$ is higher than previous two examples. The numerical result is as follows.

$$\boldsymbol{Q_1^* = 25.246,\ Q_2^* = 7.92, T = 33.167,\ P = 34.67}$$

In example④, *a=101*, *b=2* , $v_2 = 1.5, v_1 = 1$ and $v_3 = 1$ . In this numerical example, $v_2$ is lower than example①and②, while $v_3$ is higher than previous two examples. The numerical result is as follows.

$$\boldsymbol{Q_1^* = 25.062,\ Q_2^* = 8.23, T = 33.292,\ P = 34.416}$$

As shown in the results of example③and④, $Q_2^*$ and T are both lower than example①and②. Meanwhile, *P* is higher than previous two examples .The results obtained from example③and④ are also unequivocally consistent with the previous result discussed in Conclusion 2 (Section 3.3.1): If $\boldsymbol{v_2 > v_1}$, $\boldsymbol{v_3} \uparrow$ result in $\boldsymbol{Q_2^*} \downarrow, \boldsymbol{T} \downarrow$ **and** $\boldsymbol{P} \uparrow$.

### 3.4.1 Analysis on the numerical examples

Accordingly, the Numerical examples above could result in figures shown below.

The change of the optimal capacity of Line 2 ($Q_2^*$) can be drawn as Fig. 3.1 and 3.2.

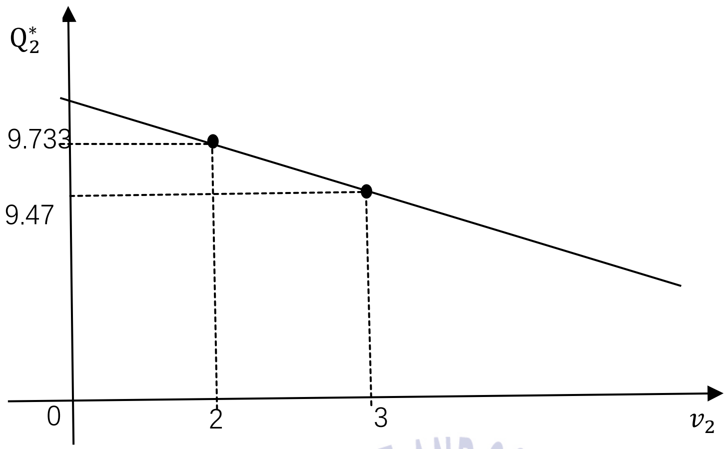



**Fig. 3.3: Changes of $Q_2^*$ when $v_2$ increases**

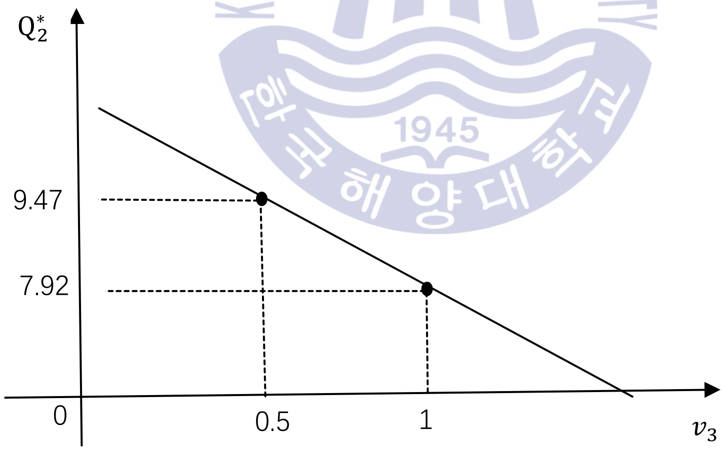



**Fig. 3.4: Changes of $Q_2^*$ when $v_3$ increases**

**Analysis1**: Comparing Fig. 3.3 and 3.4, the slope of Fig. 3.4 is steeper than 3.3. It means that, if $v_3$ does not changes, $v_2$ is increased will bring $Q_2^*$ has a slowly decreases, but if $v_2$ stay the same, $v_3$ is increased will take $Q_2^*$ has a sharply decreases. In other word, when $v_2$ had increased from 2 to 3, in this situation, an increase of $v_3$ will trigger further decline in $Q_2^*$. As a result, if the cruise line company wants to increase the optimal capacities, they must be premised the variable cost $(v_2)$ which has made minimize value of number, then makes the adjustment parameter $(v_3)$ lower than before and it will bring the best result for them.

The change of the total capacities of Line 1 and 2 can be drawn as Fig. 3.5 and 3.6.

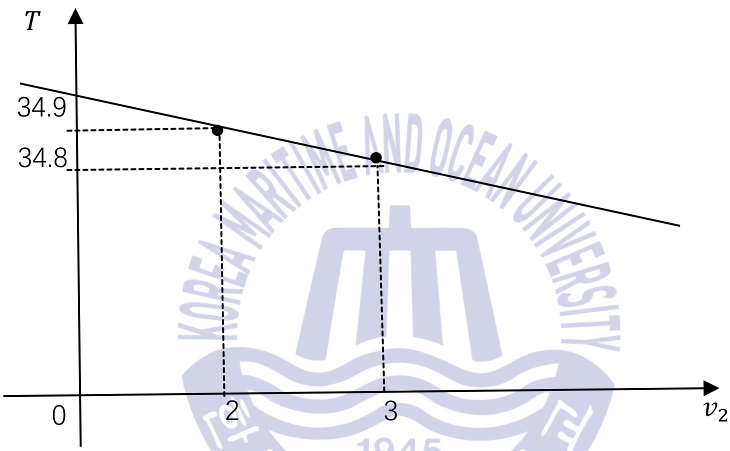



**Fig. 3.5:, Changes of $T$ when $v_2$ increases**

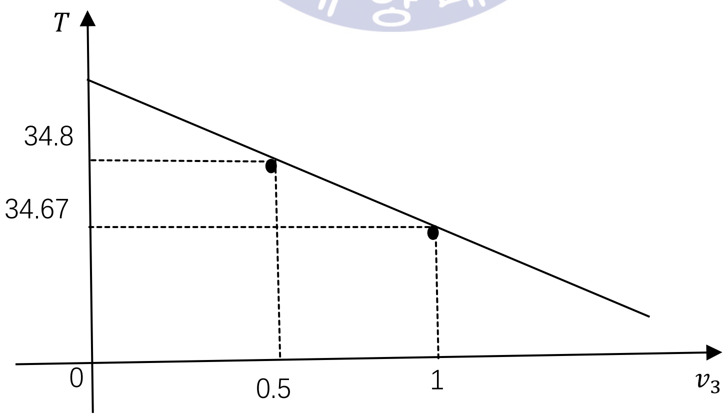



**Fig. 3.6:, Changes of $T$ when $v_3$ increases**

**Analysis 2:** Comparing with Fig. 3.5 and 3.6, the slope of Fig. 3.6 is steeper than Fig. 3.5. Similar with Analysis 1, if $v_3$ does not changes, $v_2$ is increased will bring $T$ has a slowly decreases, but if $v_2$ is a steady state value, $v_3$ is increased will make $T$ has a sharply decreases. It is means that when $v_2$ has increased from 2 to 3, then increasing $v_3$ will bring more decreases on $T$. Incorporate with the cruise line company's countermeasure, it could achieve the same conclusion like Analysis 1.

The change of the cruise price of the market can be drawn as Figure 3.7 and 3.8.

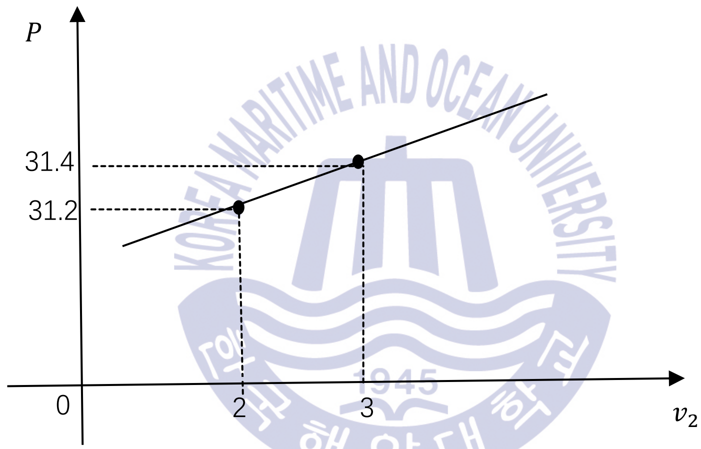



**Fig. 3.7:Changes of $P$ when $v_2$ increases**

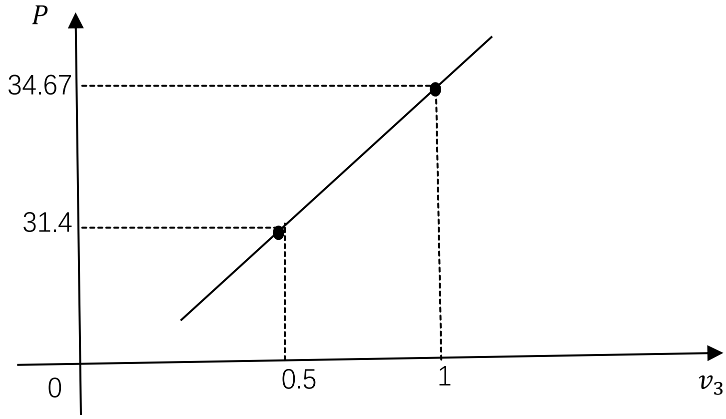



**Fig. 3.8:, Changes of $P$ when $v_3$ increases**

**Analysis 3:** Comparing Fig. 3.7 and 3.8, the slope of Fig. 3.8 is steeper than Fig. 3.7. There are some differences in Fig. 3.3-3.6. In Fig. 3.3-3.6, when $v_2$ and $v_3$ are increased, the optimal capacity of Line 2 and the total capacities (*T*) are all decreased. Nevertheless, in Fig. 3.7-3.8, the price of the cruise market (*P*) is increases follow with $v_2$ and $v_3$ are increased. It is also can see that if $v_3$ does no change, $v_2$ increases will bring *P* has a slowly increased, but if $v_2$ remain stable, $v_3$ increases has a strongly increased. In other word, when $v_2$ increases from 2 to 3, an increase of $v_3$ will engender *P* to increase more. Refer to the conclusion of Analysis 1, the cruise line company needs more concert about decreasing the variable cost $(v_2)$, and makes a suitable decision for the adjustment parameter $(v_3)$ based on this result.

Using Fig. 3.5-3.8, we can draw other figures which serve to compare across the four examples, as shown in Fig.3.9-3.11.

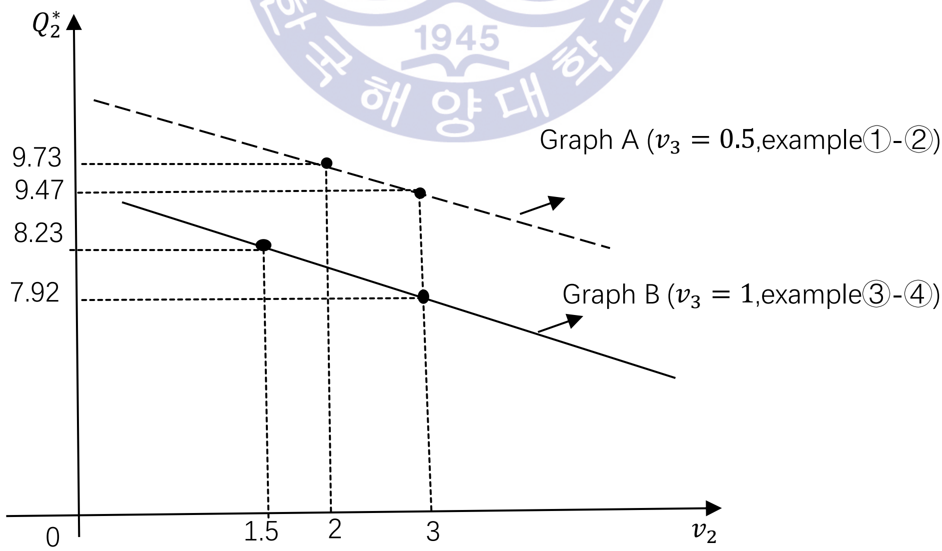



**Fig. 3.9: Comparison with four different values of $Q_2^*$**

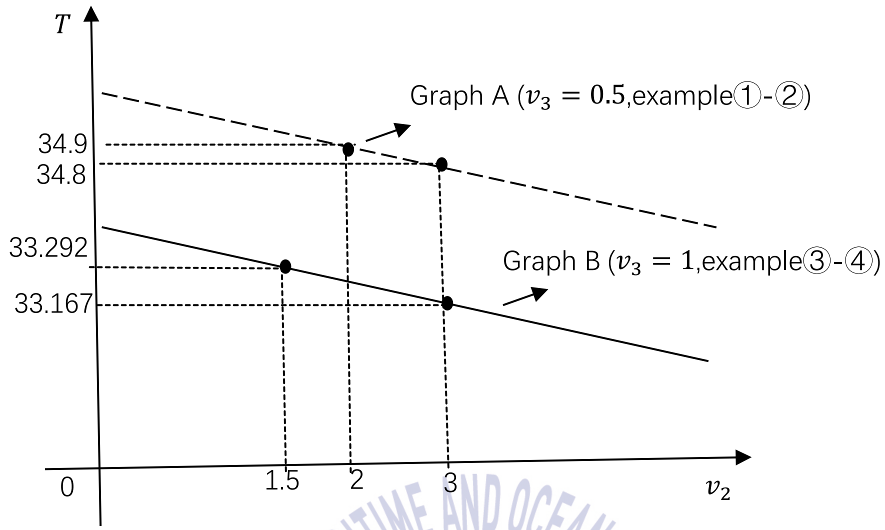



**Fig.3.10: Comparison with four different values of *T***

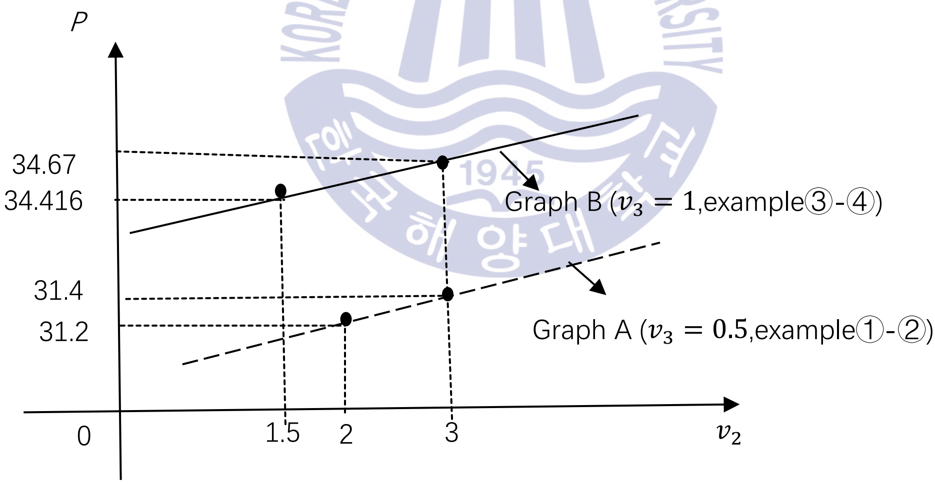



**Fig. 3.11: Comparison with four different values of *P***

**Analysis 4:** In these figures (Fig. 3.9-3.11), Graph A is described by examples ①-② ($v_3 = 0.5, v_2 \uparrow$); while Graph B is described by examples ③-④ ($v_3 = 1, v_2 \uparrow$). First of all, in Fig. 3.9-3.10, the intercept of Graph A is higher than Graph B. If $v_2$ stay the same, $v_3$ increases will generate the intercept have a large decreases (the number is from 9.73 to 7.92 (Fig. 3.9), 34.8 to 33.167 (Fig. 3.10)), but if $v_3$ does not change, $v_2$ increasing is bring about the intercept have a small decreases (the number is from 9.73 to 9.47 (Fig. 3.9), 34.9 to 34.8 (Fig. 3.10)). Therefore, $v_2$ has more effective in the optimal capacity of Line 2 and the total capacity of Line 1 and Line 2. It is means that when $v_2$ is to be increased, an increase of $v_3$ will stimulate further diminishing of the optimal capacity value of Line 2 $(Q_2^*)$. Synonymy, it means that if $v_2$ is to be increased, an increase of $v_3$ will impact more on $Q_2^*$. It is result of that if Line 2 intends to have large increases of its optimal capacity $(Q_2^*)$, Line 2 should considerate two points: firstly, keep a close eye on decreasing the variable cost $v_2$; then, controlling the adjustment parameter $v_3$. This consequence also is proved in Analysis 1.

On the other hand, in Fig.3.11, it is also see that, the intercept of Graph A is lower than B. It is also can see that if $v_3$ remain stable, increasing $v_2$ is make the intercept have a small increase (the number is from 34.416 to 34.67). Nevertheless, if $v_2$ hold steady, increasing $v_3$ is bring the intercept a big increase (the number if from 31.4 to 34.67). It has the conclusion that there is more influences on $v_2$ than $v_3$ to control the market price of cruise ($P$), and if the market price of cruise ($P$) wants to lower than before, Line 2 also needs to decrease the variable cost $(v_2)$ at first, and then controlling the adjustment parameter $(v_3)$. Therefore, regulating the variable cost $(v_2)$ is more important than controlling the adjustment parameter $(v_3)$, if Line 2 would be more effective to control the adjustment parameter, the pre-priority thing is to decrease the variable cost.

One of the most important results is, if Line 2 wants to have the biggest market share in cruise market, its optimal capacity $(Q_2^*)$ and the total capacities ($T$) must be increased.

Undoubtedly, keeping the lowest price ($P$) is very important too. As a sum, on the one hand, Line 2 needs to maximize the optimal capacity of it ($Q_2^*$) and the total capacities ($T$); on the other hand, Line 2 also needs to minimize the cruise price of the market ($P$) ensure it gets the biggest market share.

**Conclusion 3:** In Analysis 1 to 4, Line 2 obviously wants to obtain the bigger market share, firstly, it needs to pay more attention to make a lower value on the variable cost ($v_2$); secondly, it needs to consider a right way to control the adjustment parameter ($v_3$).

**Analysis 5:** Comparing Fig. 3.3-3.11 (Analysis 1-4), it is show that the change of variable cost ($v_2$) has more effect on the optimal capacity ($Q_2^*$) and the total capacities ($T$), also include the price of market ($P$) than the change of adjustment parameter ($v_3$). This is actually equivalent to, if Line 2 can keep the variable cost as low enough, the adjustment parameter ($v_3$) can be increased suitably, if this way can bring more profit for Line 2. To analyze the reason, Line 2 is as a follower, its improved adjustment cost can be more competitive than it used to be. Therefore, it requires to keep the variable cost ($v_2$) low enough and then reasonable increase the adjustment cost ($v_3$), as a result, it may create more profits. Summary as one sentence: Line 2 can not only keep its variable cost to a lower condition, but also it boosts the adjustment parameter which could create more profit and competitive than before.

**Conclusion 4:** Based on the analysis of the resulted data of the samples (Analysis 1-5), a conclusion can be drawn: if Line 2 wants to have a large cruise market share, **it needs a premise, that is related with the variable costs ($v_2$) which is close to that of Line1 ($v_1$), meanwhile its adjustment parameter ($v_3$) is kept in decreasing mode.**

**Nevertheless, if Line 2 wants to increase the adjustment parameter ($v_3$) for getting more profit, its variable costs ($v_2$) must be kept low enough.**

### 3.4.2 The managerial implications of increasing market share of Line 2

The managerial implications of increasing the market share of Line 2 include three aspects as follows:

**A. How to increase the optimal capacity of Line 2 ($Q_2^*$).** Increasing the optimal capacity of Line 2 ($Q_2^*$) can increase the market share of it. The variable cost of Line 2 ($v_2$) is the lowest in example①, and it brings about the highest optimal capacity of Line 2 ($Q_2^*$). In other words, when $v_2$ is minimized, the optimal capacity of Line 2 ($Q_2^*$) is maximized. According to the result of Fig. 3.9 (Analysis 4), $v_2$ has more effect in the optimal capacity of Line 2 than $v_3$, and if Line 2 wants to have large increases of its optimal capacity ($Q_2^*$), the best way is to make $v_2$ is decreased, and then to control of $v_3$.

**B. How to increase the total capacities (*T*).** Increasing the total capacities of Line 1 and 2 could help to improve the market share of Line 2. In Fig. 3.10 (Analysis 4), when $v_2$ and $v_3$ are both increases, the total of capacities (*T*) is decreases. In Analysis 4 also can see that $v_2$ has more influences on the total capacities of Line 1 and Line 2. It means that, decreasing $v_2$ at first, and then, controlling $v_3$ is decreases or increases to find out an optimal total capacities of Line 1 and Line 2.

**C. How to decrease the cruise price of the market (*P*).** Lowering market price can attract more tourists to choose the cruise Line. Therefore, the lowest price of the cruise market could bring the largest market share of Line 2. In Fig. 3.11 (Analysis 4), the variable cost of Line 2 ($v_2$) and the adjustment variable cost ($v_3$) of Line 2 is decreased to minimize the cruise price of market ($P$). It has mentioned in Analysis 4, more impact on $v_2$ than $v_3$ for the cruise price of the market. Therefore, Line 2 needs to consider that to make a lower cruise price of the market ($P$) by two methods: one of them is decreasing $v_2$ and $v_3$; another way is decreasing $v_2$ at first, make sure it is low enough, and then to choose a right way controlling $v_3$.

Summering the managerial implications that how to increase the market share of Line 2 like figure 3.12.

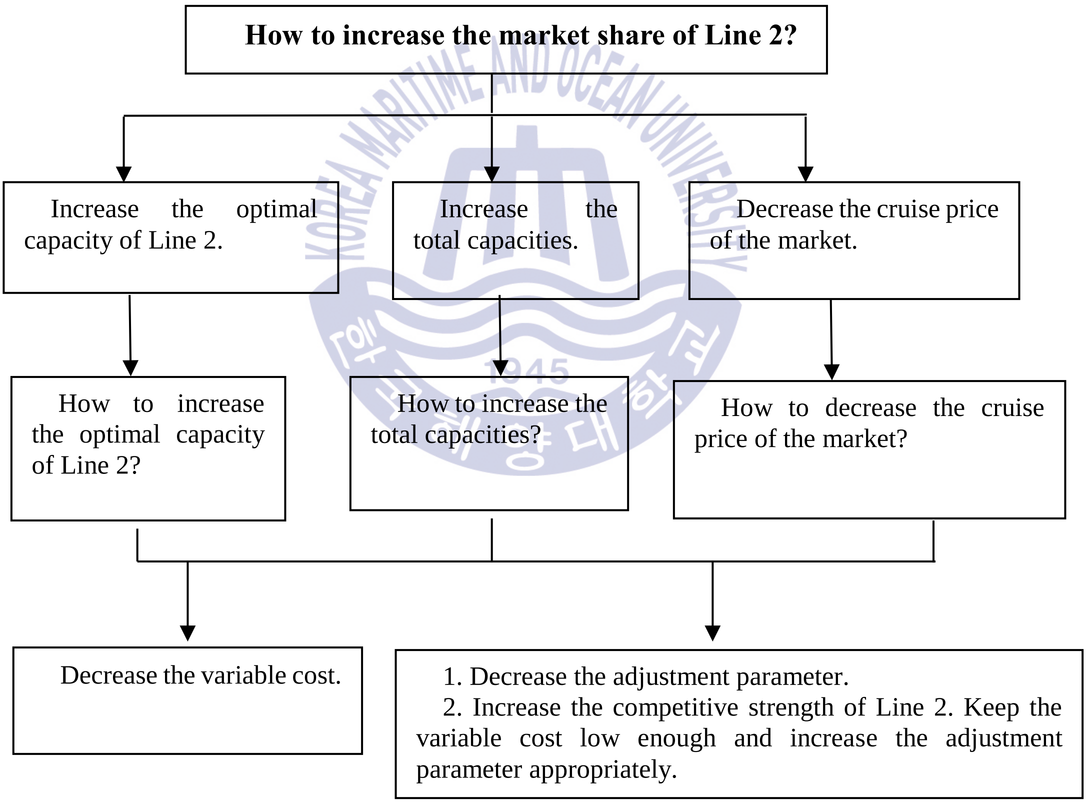



**Fig. 3.12 How to increase the market share of Line 2?**

# CHAPTER 4 CONCLUSION

This chapter summarizes the thesis with the corresponding managerial implications. Some limitations of the study and the relevant future research's directions are also added.

## 4.1 Summary and Conclusions

There are two cruise lines in the cruise market, they are studies in this thesis whereby one of them has the first mover advantage (Line 1); while another is the follower (Line 2). This thesis has shown the way of using Stackelberg Duopoly Model to analyze both, the optimal capacity as well as the measures that the follower's company could pursue to get the most share in cruise market with the existence of two cruise lines. Using Theorem 5-6 which is Cho&Wei (2017) had proved that the optimal capacity of the leaders (Line 1) and the followers (Line 2) to calculate the Nash Equilibrium of Stackelberg Duopoly Model. Hypothetically, the economic interpretation for the follower (Line 2) is analyzed by its variable cost and adjustment parameter. Using analysis of the numerical results to provide a number of important managerial guidelines for cruise Lines investment decisions.

At first, the assumption of this thesis is talking about two cruise Lines, one of them is a leader Line (Line 1) who has the first mover advantage. Another is a follower (Line 2) also had decided to follow and go into the cruise market. In this situation, choosing Stackelberg Duopoly Model, because this Model is about two firms in which one of them functions as a leader and has the first mover advantages; while another is a follower. Nevertheless, the Duopoly Model is only about two monopoly firms which had entered into the market, so it is not fit for the assumption of this thesis.

Secondly, calculating the Stackelberg Duopoly Mode needs to use the Nash Equilibrium, because that before assumption, one firm can be based on the choice from another firm to find out the best strategy for themselves. In our thesis, the Nash Equilibrium is based on this assumption, since $0 < s \leq \frac{1}{2}$, suppose $v_2 \geq v_1$, use Theorem 5 (Cho&Wei,2017) to calculate the optimal capacity of Line 1 $(Q_1^*)$. And then, using Theorem 6 (Cho&Wei, 2017) to calculate the optimal capacity of Line 2$(Q_2^*)$. At last, the total of capacities of Line1 and 2 could be calculated as $T$=$Q_1^* + Q_2^* = Q_1^* + Q_2(Q_1^*)$; after that, the price of cruise market (*P*) can be derived from the total of capacities of Line 1 and 2 (*T*).

Thirdly, the economic interpretation for the follower (Line 2) needs to be analyzed the relationship among its optimal capacity $(Q_2^*)$, the total capacities *(T)* and the market price of cruise *(P)* by using its variable cost $(v_2)$ and adjustment parameter $(v_3)$. Hereby, this thesis using the theorem of partial derivative to analyze the change of $Q_2^*$, $T$ and *P*. On top of that, seeking for the rules of changes of $v_2$ and $v_3$. Based on this date analysis find out some conclusions (Conclusion 1-2). At the end of it, using the numerical examples to draw some figures; and analyze these figures to find out the managerial implications about how to increase the market share of Line 2 (Conclusion 3).

Fourthly, the optimal capacity of Line 2 $(Q_2^*)$ is influenced by the variable cost $(v_2)$. The follower needs to think about decreasing its variable cost $(v_2)$ at first. That is because decreasing the variable cost can bring a large increases in the optimal capacity of Line 2 $(Q_2^*)$ and the total of capacities (*T*), but a large decreases in the price market of cruise *(P)* (the summary of the relationship can be found in Table 3). And then, according to Fig. 3.9, if Line 2 wants to have great increase in its optimal capacity $(Q_2^*)$, there are two ways can make it: firstly, reducing both its variable cost $v_2$ and adjustment parameter $v_3$;

secondly, Line 2 should pay more attention to the variable cost $(v_2)$ than the adjustment parameter $(v_3)$, it needs to decrease the variable cost at first, and then to resize the adjustment parameter.

Lastly, the Lower market price can attract more tourists to choose the cruise Line. Hence, the lowest price of the cruise market will bring the largest market share for Line 2. In Fig. 3.11, the variable cost $(v_2)$ and the adjustment variable cost $(v_3)$ of Line 2 are minimized to reduce the cruise price of market (*P*). Therefore, Line 2 can decrease the cruise price of the market *(P)* by decreasing $v_2$ and $v_3$. In addition, if Line 2 wants to the lower price of cruise market, it should be focus on the adjustment parameter $(v_3)$ more than the variable cost $(v_2)$.

The competitiveness is influenced by the adjustment parameter$(v_3)$. The adjustment parameter $(v_3)$ is all about the lately operations of the cruise ship, includes cost for building the new vessels and the cost for repairing older ships or other measures which can improve the quantity of services in the cruise. Therefore, the cost of adjustment parameter can't be avoided. In previously Analysis 1 to 5, finding that even though the adjustment parameter brings some loses to the optimal capacity, it can actually enhance the competitive strength in a better way. Therefore, if Line 2 can keep a low variable cost, its adjustment parameter can be increased for improving its competitive edge in the cruise market, and then bring more profits than before (Conclusion 4).

The relationship of these conclusions can be summarized like figure 4.1

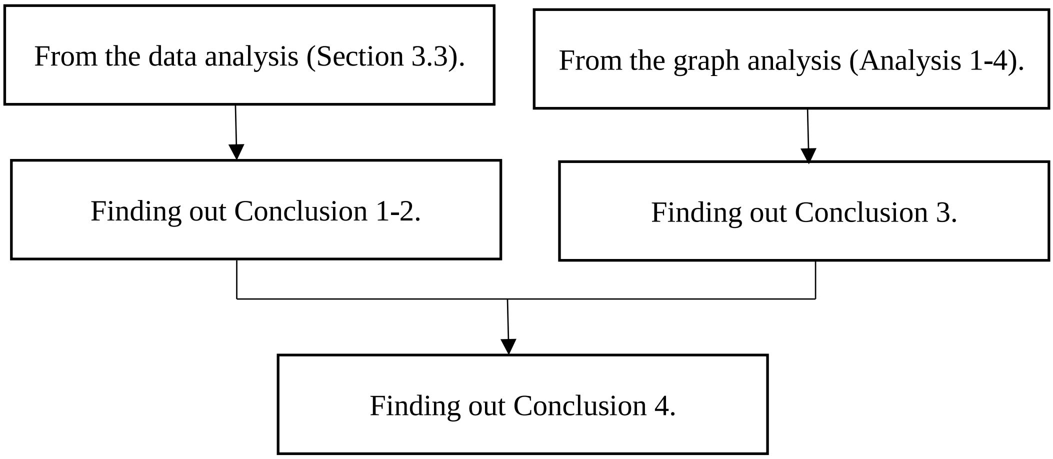



**Fig. 4.1 The relationship of the conclusion**

Summarizing the steps of analysis for this thesis, it can be obtained as figure 4.2.

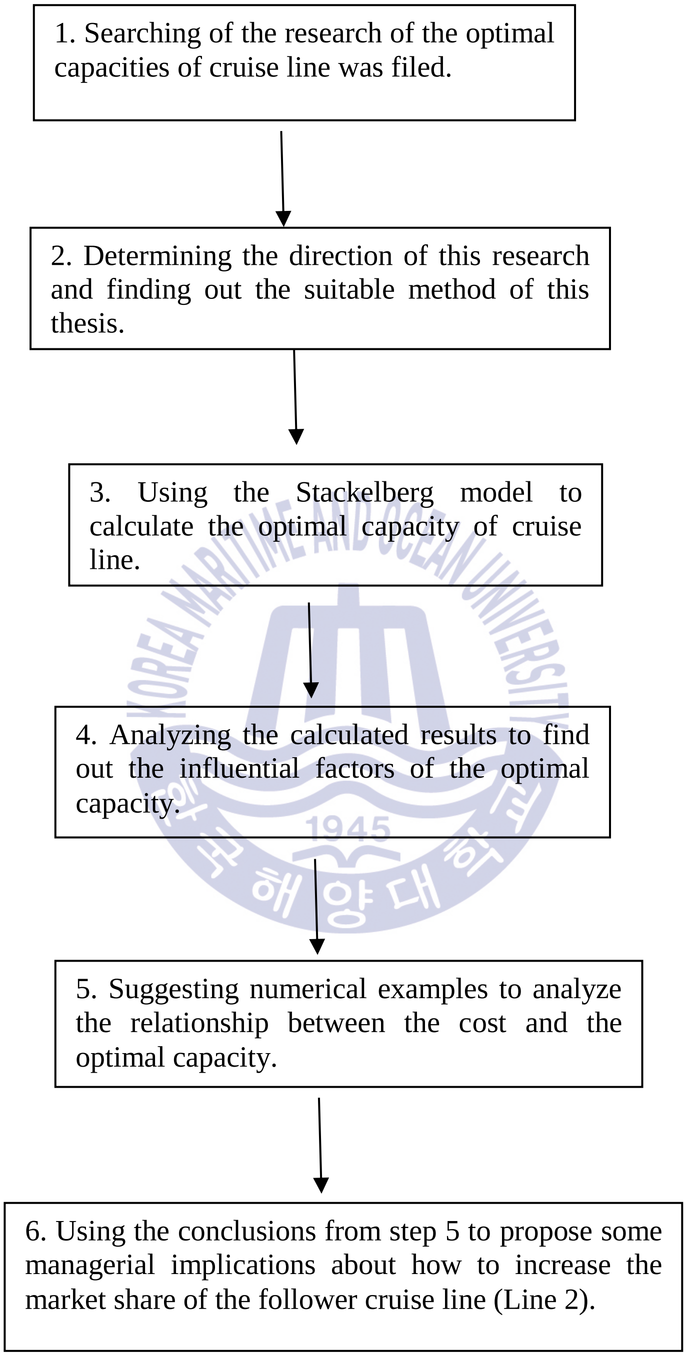



**Fig. 4.2 The step of analyzing in the thesis**

## 4.2 Limitations of this thesis

The thesis study has proved that the follower (Line 2) can have a larger share of the market by changing its variable cost and adjustment parameter. This situation had limited one condition as $0 < s \leq \frac{1}{2}, v_2 > v_1$. In practical, Line 2 might have another situation whereby $v_2 < v_1$. Therefore, if the previous assumptions were to be changed to this situation($v_2 < v_1$), some changes to the conclusions of this thesis could be triggered too. Worst still, the Nash equilibrium will need to be altered to another form as well. On the other hand, this thesis hasn't considerate another situation that when the price of the market ($P$) is lower than before, the share of the market belongs to the leader (Line 1) will be lower too. To illustrate, if the optimal capacity of the leader (Line 1) could be decreased, the follower (Line 2) could have more chances to penetrate into the cruise market which had assumed Line1 as the leader. Therefore, in the future, there should also be some researches on how to decrease the market share of the leader (Line 1).

## 4.3 Future research directions

The present model has demonstrated the way of using the variable cost and the adjustment parameter to analyze a series of measures for the follower to gain larger market share. The thesis found that the price of the cruise market and the total capacities are influenced by the variable cost and the adjustment parameter of the follower. Apart from that, This study also learned that the optimal capacity of the leader (Line1) could also be changed if $v_2$ and $v_3$ are changed. These changes will bring about other influences on the share of market for the follower (Line 2) which are beyond the discussions in this paper. Therefore, future studies may consider developing some economic interpretations about relationship between the optimal capacity of the leader (Line1) and the variable cost of the follower ($v_2$) as well as the adjustment parameter of it ($v_3$). Moreover, the study also can use the cruise price of market to find out the optimal profits of the follower (Line 2), and then to compare both the optimal profit functions of the leader (Line 1) and the follower (Line 2). In the future, the study also could consider a different situation where $v_2 < v_1$ with some new managerial implications expected.

## References


Basar, T.& Olasder, G. J., 1982. Dynamic Noncooperative Game Theory. *New York: Academic Press*

Bengtsson, R., 2014. Pricing Methods and strategies in the cruise line industry: A case study on Carnivel Corporation's premium and luxury brands. *Uppsala University Campus Gotland,* pp.20-21.

Cartwright, R. & Baird, C., 1999. Development and Growth of the Cruise Industry. A Butterworth Heinemann Title.

Cho, S.-C. & Wei, W., 2017. A Modified Stackelberg Game for a Duopoly Cruise Market with a Potential New Entrant. *Journal of International Trade & Commerce 13(1),* pp.37-47.

CLIA, 2002. Cruise Industry Lines International Association. *Cruise Industry Overview.* From *http://www.cruising.org/press/overvies/lind_overview.cfm.*

Daskalakis, C., 2008. The Complexity of Nash Equilibria. *A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Computer Science in the Graduate Division of the University of California. Berkeley.*

Gibson, P., 2012. Cruise Operations Management: Hospitality Perspectives *(2Ed). London: Taylor and Francis.*

Heakal, R., 2015. What are Economies of Scale? From *http://www. Investopedia.com/article/03/012703.asp#ixz4QKYTb15U.*

Investopedia on Facebook. What is 'Economies of Scale'. From *http://www.Investopedia.com/terms/e/economiesofscale.asp#ixzz4QKW26gjR.*

Kims, S., 1989. Yield management: a tool for capacity-constrained service firms. *Journal of operations Management 8(3),* pp.120-127.

Klassen, K. & Rohleder. T., 2002. Demand and capacity management decisions in services: how they impact on one another. *International Journal of Operations & Production Management 5(6),* pp.527-548.

Ladany, S. & Arbel, A., 1991. Optimal cruise-liner passenger cabin pricing policy. *European Journal of Operational Research, Elsevier Science Publishers*.55, pp.136-147.

Lieberman, W., 2012. Pricing in the Cruise Line Industry. *Ozer & Phillips, The Oxford Handbook of Pricing Management,* pp.199-215.

McCain, R. A., 2003. Game Theory: A Non-Technical Introduction to the Analysis of Strategy. *Thomoson. South-Western.*

Mind Tools Editorial Team. Achieving Economies of Scale, Understanding Why Bigger Can Be Better. From *http://www.mindtools.com/pages/article/new STR_63.htm.*

Papathanassis, A. & Vogel, M. P., 2013. Cruise Sector Growth, Managing Emerging Markets, Human Resources, Processes and Systems. *Brmerhaven University.*

Phillips, R., 2005. Pricing and Revenue Optimization. *Stanford University*. Stanford, California.

Porter, M., 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors.* The Free Press, New York.

Pullman, M. & Rodgers, S., 2010. Capacity management for hospitality and tourism: A review of current approaches. International Journal of Hospitality Management. From *http:// www.elsevier.com/locat/ijhosman.*

Rasmusem, E., 1991. Game and information: An introduction to Game Theory. *Oxford, OX, UK; New York, N.Y.:B. Blackewell.* C1981.

Recitation Notes # 7, 2004. The Basic of Game Theory. Friday- November 5, 2004. *MIT. Sloan school of management, Massachusetts Institute of Technology.*

Graham, R.J., 2012. Managerial Economics For Dummies.From *http:// www.dummies.com/search.htm? query=Robert+J.+Graham.*

Sill, B., 1991. Capacity management: making your service delivery more productive. *Cornell Hotel and Restaurant Administration Quarterly 31(4)*, pp.76-88.

Sill, B., 2000. Capacity management: engineering the balance between customer satisfaction, employee satisfaction and company profit. *The Consultant, 2nd quarter*, pp.2-11.

Stahl, S., 1998. A Gentel Intorduction to Game Theory. *American: American Mathematical Society*, 1999.

Wie, B. W., 2005. A dynamic game model of strategic capacity investment in the cruise line industry. *Tourism Management 26(2)*, pp.203-217.

Wikipedia, the free encyclopedia. Economies of scale. From *http://en.wikipedia.org/wiki/Economies_of_scale.*

# Acknowledgments

I would like to express my greatest gratitude to my supervisor, Professor Seong-Cheol Cho for his precious comments and recommendations that have added quality to this thesis. Without his guidance and patience, this research would have not been possible. His help and his guidance, not only in my academic career, but also with everyday life has been the key for my successful graduation. He involved me in many activities and supported me in every way he could and I will be forever grateful; I am very proud I have been one of his students. I give my special thanks to Professor Han-Won Shin and Professor Si-Hwa Kim. They also gave me a lot of help and many useful advices for this thesis.

My special thanks also go to my friends in this university, and my family in China. Without their encouragement and emotional support, my research could not have been carried on successfully.

Last but not least, I would like to thank all the professors in Korea Maritime and Ocean University that passed on knowledge to me. I also want to thank you all the staff of Shipping Management, they were very kind to me and gave me a lot of help from the beginning until the end of my studies.