ดุลยภาพการแข่งขันเมื่อมีความไม่แน่นอนในคุณภาพสินค้า

นางสาว ปภัศร ชัยวัฒน์

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COMPETITIVE EQUILIBRIUM WITH QUALITY UNCERTIANTY

Miss Papusson Chaiwat

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By	Miss Papusson Chaiwat
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Thesis Advisor	Associate Professor Pongsa Pornchaiwiseskul, Ph.D.

Accepted by the Faculty of Economics, Chulalongkorn University in Partial Fulfillment of the Requirements for the Doctoral Degree

..... Dean of the Faculty of Economics

(Associate Professor Sothitorn Mallikamas, Ph.D.)

THESIS COMMITTEE

..... Chairman

(Associate Professor Sumalee Pitayanon, Ph.D.)

..... Thesis Advisor

(Associate Professor Pongsa Pornchaiwiseskul, Ph.D.)

..... Member

(Associate Professor Isra Sarntisart, Ph.D.)

..... Member

(Assistant Professor Chairat Aemkulwat, Ph.D.)

..... Member

(Associate Professor Chaiyuth Punyasavatsut, Ph.D.)

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ข้อมูลของคุณภาพสินค้าเป็นสิ่งจำเป็นและมีผลกระทบต่อการแข่งขันในปัจจุบัน การศึกษานี้มีจุดประสงค์ที่จะอธิบายพฤติกรรมของทั้งผู้ผลิตและผู้บริโภคเมื่อเกิดความไม่แน่นอนในคุณภาพสินค้าในการแข่งขัน โดยใช้วิธีการจำลองสถานการณ์แบบมอนติคาร์โล ความไม่แน่นอนในคุณภาพสินค้าจะก่อให้เกิดความล้มเหลวของตลาด อีกทั้งลดอรรถประโยชน์ของผู้บริโภคและบิดเบือนกำไรของผู้ผลิต ผู้บริโภคที่มีข่าวสารไม่ครบถ้วนนั้นจะถูกผู้ผลิตหลอกได้ง่ายเนื่องจากไม่สามารถแยกแยะคุณภาพสินค้าได้ เนื่องด้วยผู้บริโภคคาดเดาคุณภาพสินค้าผ่านทางราคา ดังนั้นผู้ผลิตจะพยายามหลอกลวงผู้บริโภคโดยตั้งราคาสินค้าของตนให้สูงแต่ผลิตสินค้าคุณภาพต่ำ (กลยุทธ์ตั้งราคาสินค้ารวม) ผลลัพธ์ของการศึกษานี้แสดงถึง ดุลยภาพแนช 3 รูปแบบ นั่นคือ 1. ถ้าผู้บริโภคทั้งหมดในตลาดมีข่างสารครบถ้วน ผู้ผลิตจะตั้งราคาอย่างมีเหตุผล นั่นคือตั้งราคาตามคุณภาพสินค้าที่แท้จริง (กลยุทธ์ตั้งราคาแยกตามคุณภาพสินค้า) อรรถประโยชน์ของผู้บริโภคในกรณีนี้มีค่าสูงสุด 2. ถ้าผู้บริโภคส่วนมากเป็นผู้มีข่าวสารครบถ้วนหรือผู้ผลิตสามารถหลอกลวงผู้บริโภคได้น้อย ผู้ผลิตที่ผลิตสินค้าคุณภาพต่ำที่สุดในตลาดจะเลือกใช้กลยุทธ์ตั้งราคารวม ในขณะที่ผู้ผลิตรายอื่นเลือกใช้กลยุทธ์ตั้งราคาแยกตามคุณภาพสินค้า อรรถประโยชน์ของผู้บริโภคในกรณีนี้มีค่าลดลง 3.ถ้าผู้บริโภคส่วนมากมีข่าวสารไม่ครบถ้วนหรือผู้ผลิตสามารถหลอกลวงผู้บริโภคได้ง่ายมาก ผู้ที่ผลิตสินค้าที่มีคุณภาพสูงที่สุดและต่ำที่สุดในตลาดจะเลือกใช้กลยุทธ์ตั้งราคาแยกตามคุณภาพสินค้า แต่ผู้ที่ผลิตสินค้าคุณภาพในระดับกลางจะเลือกใช้กลยุทธ์ตั้งราคารวมเพื่อหลอกลวงผู้บริโภคและเพิ่มผลกำไร อรรถประโยชน์ของผู้บริโภคในสองกรณีหลังนี้มีค่าลดลงเนื่องจากผู้บริโภคจะไม่พอใจที่บริโภคสินค้าที่มีราคาสูงแต่คุณภาพสินค้าต่ำ ดังนั้นผู้บริโภคจะปรับเปลี่ยนความพึงพอใจเพื่อกำจัดความไม่แน่นอนในคุณภาพสินค้า โดยพยายามปรับเปลี่ยนจนไม่เลือกซื้อสินค้าที่หลอกลวงและไปบริโภคสินค้าอื่นแทน อรรถประโยชน์ของผู้บริโภค ณ เวลาที่ไม่มีสินค้าหลอกลวงในตลาดนั้นจะมีค่าเพิ่มขึ้น อย่างไรก็ตามอรรถประโยชน์นี้จะไม่มีค่าสูงเท่ากับกรณีแรก เนื่องจากมีการสูญเสียจากการถูกหลอกของผู้บริโภค ดังนั้นผู้กำหนดนโยบายจึงควรให้ข้อมูลแก่ผู้บริโภคอย่างครบถ้วนก่อนที่ผู้บริโภคจะซื้อสินค้า เพื่อป้องกันการสูญเสียอรรถประโยชน์ของผู้บริโภค โดยการให้ข้อมูลนั้นอาจทำได้โดยกำหนดเป็นกฎหมายเพื่อบังคับผู้ผลิตให้ชี้แจงคุณภาพสินค้าคนเปรียบเทียบกับคู่แข่งขัน หรือทำหนังสือแนะนำข้อมูลแก่ผู้บริโภค มาตราการเหล่านี้จะช่วยกำจัดความไม่แน่นอนในคุณภาพสินค้า และเพิ่มสวัสดิการแก่สังคม

สาขาวิชา เศรษฐศาสตร์ ลายมือชื่อนิสิต.....

ปีการศึกษา 2550 ลายมือชื่ออาจารย์ที่ปรึกษา.....

4586005029 : MAJOR ECONOMICS

KEY WORD: QUALITY COMPETITION / ASSYMETRIC INFORMATION / MOTE CARLO SIMULATION

PAPUSSON CHAIWAT: COMPETITIVE EQUILIBRIUM WITH QUALITY UNCERTAINTY. THESIS ADVISOR: ASSOC. PROF. PONGSA PORNCHAIWISESKUL, 129 pp.

The product quality plays important role in modeling competition. This paper explains the behaviors of both consumers and firms by using Monte Carlo simulation when they face quality uncertainty during the competition. Quality uncertainty will lead to market failure, which decreases consumer welfare and distorts profits among firms. Uninformed consumers that face difficulty to recognize quality of each product are easily deceived by firms. Because consumers use price as a signal of product quality, deceiving firms set the high price with low quality (pooling price strategy) to deceive uninformed consumers. Model of simulation shows the Nash equilibrium results for three cases. In the first cases when all consumers are informed, all firms will set reasonable price with their quality (separating price strategy). The utility is the highest. In the second cases when the market has a small fraction of uninformed consumers and low deceiving power of firm, at the Nash equilibrium the lowest quality producing firm will use the pooling price strategy. The consumer utility decreases when the uninformed fraction increases. In the last case with more uninformed consumers or high power of deceiving, at the Nash equilibrium firms that produce the highest quality and the lowest quality will use the separating price strategy whereas the firms that produce medium quality products will use the pooling price strategy. The medium quality firms have incentives to create the unclear quality to consumers by using the pooling price strategy to increase profits. The utility of consumers in last two cases are not maximized because some consumers suffer from consuming low-quality products with high-priced. Consumers will adjust their taste to eliminate quality uncertainty. When no ones will be deceived, welfare of buyers is high but there are still some losses from deceiving attempt. This utility level is lower than in the case when there is no quality uncertainty. Policymakers can solve this problem by giving information about quality to buyers before they make a decision. Government should set up the regulation for the producer to reveal quality of their product in comparison with others opponents or make the consumers guide book to explain the feature of products to consumers. These measures will help eliminate the quality uncertainty to uninformed consumers and raises social welfare of market.

Field of study Economics Student's signature.....

Academic year 2007 Advisor's signature.....

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TABLE OF CONTENTS

Pages

Pages

LIST OF FIGURES

Pages

Pages

LIST OF TABLES

Pages

Pages

NOMENCLATURE

α	= probability that firm L successfully cheat uninformed consumers
C	= marginal cost of both firms
CS_separating	= consumer surplus when firm L uses separating price strategy
CS_pooling	= consumer surplus when firm L uses pooling price strategy
λ	= fraction of uniformed consumers in the market
p_H	= price of firm H's product
p_L	= price of firm L's product
q_H	= quantity of firm H's product
q_L	= quantity of firm L's product
r	= ratio of high and low quality (v_H / v_L)
t0	= beginning time of competition
t_criteria	= time when no consumers will be cheated by firms
u	= utility of consumers
v_H	= quality of firm H's product
v_L	= quality of firm L's product
v_E	= expected quality of consumers when they faced quality uncertainty
θ	= taste parameter of consumers
$\overline{\theta}$	= upper bound of taste parameter

CHAPTER I
INTRODUCTION

1.1 Statement of the problems

Two decades ago, products made in Japan were considered cheap and low-quality products. The ability of Japanese firms to successfully compete in international markets depended critically on overcoming this image. A seemingly single-minded emphasis on reducing manufacturing defects and enhancing reliability enabled Japanese automobile and electronic companies to completely reverse consumers' perceptions and to ultimately set the world standard to product quality.

Most studies on the characteristics of product competition assume the products' quality to be unchanged or assume that the qualitative differences are insignificant. Consequently, the competitive equilibrium is not realistic. However, a product's quality has become one of significant variables of competition since this factor has gained an important role for high-income consumers. Shaked and Sutton (1990) showed that product quality in some industries will increase market size because the market remains concentrated at the product level. As such, there is a quality competition in the real market. The competitive strategy of firms has also changed toward increasing quality of products. As a result, the quality competition strategy has become increasingly important because the quality competition can raise sales volume, sustain market share and growth. A number of firms attempt to seek out niche markets; in other words, these firms attempt to differentiate themselves from others. This causes them to leave the mass market to the high-end market (or product differentiation market).

Qualitative competition can complicate the competition model, but it will bring the model closer to reality. Under perfect competition, many firms would produce products according to the equilibrium between cost of production and marginal cost whilst the quality is very likely to be overlooked. Differently under oligopoly competition,

both price and quantity at equilibrium are important to give information about the behavior of firms and the effect on the equilibrium of uncertainty in product quality.

According to the sticky assumption, the reaction between two firms seems to be certain if all competitive strategies are known by both agents (consumers and firms). When one of the producers in the market changes its action and buyers in market realize the producers' behavior, the equilibrium is not complicated. On the other hand, in a real world market, it would be difficult to recognize another side's action as well as the reactions of each side. Whenever an uncertain circumstance arises in the market, the unpredictable variable could lead to some calculation difficulties in the market equilibrium and undoubtedly could lead to some serious problem (Akerlof, 1970). Accordingly many economists attempt to explain uncertainty variables in various forms such as uncertainty of information among buyers and sellers, or financial uncertainty. It is concluded in a similar direction that the equilibrium under uncertainty could be found only when some important condition are firstly achieved (Radner, 1968).

The quality strategy is widely used. In some industries, companies react to information on the quality of competitors' product. For example, (Besanko et al., 2003), in 2000 Airbus announced plans to launch the A 380, a super jumbo jet carrying 555 passengers, to compete with Boeing's new product, the 747X. Boeing's managers subsequently decided to abandon the 747X and developed a 175-250 seat aircraft that could fly faster than any existing commercial aircraft. This new aircraft would be named the Sonic Cruiser with delivery envisaged in 2004. Boeing recognized that a small jet could shuttle from one point to another requiring less maintenance, while the jumbo jet operated under the hub-spoke system. These two companies compete in the quality (size of aircraft) of their products. The result of this competition was that Boeing received 61 orders for the plane from high-profile customers such as Singapore Airlines, Quantas, Virgin Atlantic Airways and Federal Express while the first A380s could not fly until 2006.

Currently, differentiating product quality are a well-recognized strategy that firms use as a tool in order to create a competitive advantage in the market or to sustain market share and growth potential. Competitors attempt to keep development on quality or product innovations secret. Producers will use various levels of quality to capture a wide range market demand. Hence, changes in quality is increasing and growing rapidly. Firms that do not adopt other technologies will lose market share or cease to exist in the market. Finding the competitive equilibrium with quality uncertainty is therefore not only interesting, but also very important.

1.2 Objectives and Research Questions

Recently it is claimed that the product quality strategy could be one of the key strategies that allow the competitors to avoid the price-war strategy. This dissertation is intended to study the equilibrium of the quality uncertainty in the market. The central question is “What are the results among firms and consumers when they face the uncertainty in quality?” The objectives of this study are to set up the model of vertical product differentiation and to explain the behavior of both agents (firms and consumers) with the Nash equilibrium.

1.3 Hypothesis

In accordance with the dissertation objectives, a major hypothesis is created. It is that quality uncertainty can cause market failure. The market without the quality uncertainty will induce higher consumers’ utility. In today competition, firms use a quality strategy as a dominated strategy to react to others’ strategies. Then quality of product creates vertical product differentiated in the market. For consumer perspective, it is costly that consumers can learn the true quality of product. When the quality of product is no certainly known by consumers, it is highly probable to cause some serious problems in market mechanism. This is because consumers use prices as a signal of qualities. It is difficult for them to choose the product that has a proper quality with its

price. Meanwhile, firms use the quality uncertainty to raise its profit (by deceive some uniformed consumers) and ignore the decreasing in consumers' utility.

1.4 Methodology of the study

This study aims to create the quality competition model that can explain the behavior of both agents (consumers and firms) in the market. It is composed of three parts in this study. To find the important components of quality in duopoly firms with price and quantity competition, the first section establish the quality setting model with endogenous quality choices. This game is a competitive game that firms are certain to set their quality. As a result, the market does not have quality uncertainty. However, this part examines only firm side and then finds equilibrium results (both consumer surplus and firms' profit margin). Methodology that uses to solve these results is sub-game perfect Nash equilibrium in static games of complete information by use backward induction method.

Adding behavior of firms which tries to trick some consumers, the second part of this study assumes the uncertainty in quality in quality-setting model. Like the first part, this part has duopoly firms. However, both firms have two strategies to choose in competition: separating price strategy or pooling price strategy. Moreover, consumers in the market have two types: informed and uninformed consumers. Probability that firms successfully cheat uninformed consumers will be considered in this part.

Lastly, to examine the behavior of both consumers and firms, this study uses Monte Carlo simulation to simulate the competition model when the market has 4 firms with four different levels of qualities and 1000 consumers. Then, the study finds the Nash equilibrium of different cases that have different fraction of uninformed and different probability that firms successfully cheated uninformed consumers in the market.

1.5 Expected Benefits of the study

The quality uncertainty will play important role in the future competitions in which have high technology innovation in product development. It is possible that the product suppliers could gain a greater competitive advantage or could monopolize the market if the majority of customers have insufficient information regarding relationships between products' quality and prices. Subsequently, the social welfares are much likely to be depleted. The research therefore aims to specify the factors and agent's behaviors that could arise if product quality seems to be increasingly differentiated.

The research outcomes could provide the great benefits to those relevant parties, like, entrepreneur, business firms or organization's chief executives. Policy makers will use these outcomes to set a policy to increase social welfare and construct the fair-play competition to market's agents.

CHAPTER II

LITERATUE REVIEWS AND THEORY OF THE STUDY

2.1 Literature Reviews

This study focuses on the competition in product quality since this famous strategy has been recently used commonly in the market. The quality competition strategy does not only raise sale volumes, but it also helps sustain market share as well as increase profit growth of firms. Taking into account the significance of product quality, this study therefore sets the quality of product to be endogenous variable in the competition model. Mussa-Rosen (1978) and Motta (1993) examine the quality of product in the competition model, but both studies consider firms' behavior only. Using some useful concepts from both studies, this study, on the other hand, considers both consumers' and firms' sides in order to find competitive equilibrium.

Mussa-Rosen analyzes the model of vertical product differentiation by using a simple extension of the utility function: $U = vu - p$ and conclude that the quality of product is a significant variable in the competition model. In their study, the utility function is denoted by U and a taste parameter that lies between 0 and 1 is denoted by v, u refers to the quality of product in the market and p refers to the price of product. In supporting Mussa-Rosen's idea, Motta uses the same utility function and includes product quality into the two-stage competition model, that is, firms firstly select product quality and then compete in the market by using either price-competition or quantity-competition strategy. Moreover, Motta expands the model to cover product differentiation in an uncovered market and compares the quality equilibrium under the Cournot and the Bertrand frameworks. He analyzes how price competition and quantity competition affect the equilibrium solutions and proves that product differentiation is achieved at the equilibrium. In the last stage, the result contradicts previous findings of symmetric quality choice under the Cournot framework. The conclusion is that, by relaxing some assumptions of the competition market, firms can be more differentiated in the Bertrand model. This is what is expected in a more intense competition at the last

stage of the game, which pushes firms to choose more differentiated products than under the Cournot competition. For the social solution, his study finds that social welfare is higher when firms compete in prices rather than in quantities.

The utility concepts of both previous papers are used in this study, although the characteristics of cost function will be taken into account when the competition model is created. Some studies point out the importance of the quality of product and hence add such factor in their cost functions.

Unlike Mussa-Rosen, Motta includes a cost function into his model. However, the quadratic cost function: $F_i = (u_i^2)/2$ is not capable of solving for the equilibrium solution when more than two firms are in the market. Lederer-Rhee (1995) and Bonanno-Haworth (1996) support the idea of bringing the quality of product into the cost functions. All papers have the same conclusions that an innovation (or quality of products) is an factor of the cost function and had an effect on the outcomes of quality competition. However, they have different assumptions about characteristic of these costs. Lederer-Rhee (1995) explains that the quality of product is an important component of the cost function because if firms do not invest in new technology, it will be forced from market. Whereas firms that adopt new technology faster will be able to earn positive returns. More specifically, firms that invest more in quality-related technology can produce higher quality products with higher prices and earn higher profits.

Bonanno-Haworth (1996) focuses on product innovation and process innovation. Product innovation (or the R&D expenditure) affects product quality directly; on the contrary, process innovation (or technology) affects the cost function directly. Bonanno-Haworth (1996) employ a vertical differentiation model and try to prove that product and process innovations have some effects that are pursued under the Cournot and the Bertrand competitions. The cost function is described in terms of variable cost rather than fixed cost in such a way that it has more effects on the competition. The results suggest that cost-reducing innovations are pursued under the Cournot competition but not under the Bertrand competition. In a situation where firms produce high-quality

products, they prefer product innovation. But if firms produce low-quality products, they prefer process innovation. When product and process innovations exist, they have direct effects on both the cost and the quality of product.

All papers point to the importance of quality in the cost concepts. They agree that the quality of product is the main factor in the cost function. To consider the competition model on quality concepts, the quality is a main part of both the utility function and the cost function.

To create a model of vertical product differentiation, this study refers to quality uncertainty that will affect the equilibrium solutions. There are many papers working on the issues of uncertainty, for examples, Akerlof (1970), Rothschild-Stigltz (1976), Rader (1968), Metrick-Zeckhauser (1999), Jansses-Rasmusen (2002), Carlton-Dana (2005) and Cavaliere (2005). To analyze the effects of uncertainty on the market equilibrium, this study applies Akerlof's research article in which the used car market is as an example of the market having a presence of the uncertainty in the market mechanism. He defines that the problem of individuals in this market is buying new automobile without knowing whether the car they buy is good or bad. Individuals can only anticipate a probability of buying good used cars, q. Because of the asymmetric information on the quality of cars, good cars and bad cars are sold at the same price. Welfare, as a result, is decreasing and the loss in economic mechanism is occurred.

Rothschild-Stigltz analyzes a competitive market in the context of insurance market which has uncertain situation about insurance-buyers income that depends on whether an accident occurs or not. Furthermore, the paper studies the utility function of insurance buyers with income varying with probability of an accident occurrence. This research shows that the imperfect information could have a significant effect on the competitive market. Rader (1968) examines the general equilibrium under uncertainty in information of environment. His results show that economic decision makers with different information bring to differ in all future market in conditional contracts can achieve an optimum allocation of resources.

To consider the uncertainty in quality of mutual fund and automobile industry, Metrick-Zeckhauser studies the market-clearing mechanisms about these products quality. High quality producers in the market where quality varies can reap superior profits by charging higher prices, selling greater quantities or both. The study of Jansses-Rasmusen examines the uncertainty in the number of active firms in the market. They assume that the competitor in this market does not know the probability of an active firm under the Bertrand competition. The result of their study show that the extreme market transition in the standard Bertrand model from the monopoly to the competitive ones disappears in this case also the expected profit of firm is positive, but declines with the number of firms in industry. The uncertainty in some factors creates the effect on the result in the market competition.

For an uncertainty in the market demand, the paper of Carlton-Dana suggests that the demand uncertainty leads to a vertical product differentiation even when consumers are homogenous. When a firm anticipates that its inventory or capacity may not fully utilized, product variety can reduce its expected costs of excess capacity. When the firm offers a continuum of product varieties, the highest quality product has the highest profit margins with the lowest percentage margin while the lowest quality product has the highest percentage margin with the lowest absolute margin.

Cavaliere considers the information disparities among consumers and firms that affect price competition and consumer externalities. The conclusion of this paper is information about quality differences undermines brands. If uninformed consumers are skeptical, adverse selection issue arises and market demands may be perfectly inelastic to prices. When information disparity happens, the adverse selection problem raises. Therefore, with skeptical consumers, firms may want either to signal quality or subsidize information provision to their consumers to decrease the problem.

2.2 Theory of the study

2.2.1 Quality strategy theory

In the present market, price is obviously not the only factor that drives consumer decisions and firm strategies. While product attributes such as performance and durability as well as matter, and firms may compete on this dimensions just as fiercely on these dimensions as they do on price (Besanko et al., 2003). More consumers concern about the quality of product before selection so many firms develop the quality of product to create the different levels among same product and present these to their consumers.

In a competitive market, either all goods are identical, or they exhibit pure vertical differentiation. When products are vertically differentiated, in a set of prices, all consumers will agree on which products they most prefer. Firms may, therefore, offer different levels of quality at different prices. However, the market will force all firms to charge the same price per unit of quality. This means that market competition mechanism will adjust until the products that have the same quality will have the same price. If there are some products set their price higher than their proper quality, consumers do not choose them. Furthermore this adjustment mechanism will occur when consumers and sellers have full information about the product. If the consumers don't have full information, the seller will be able to charge higher price which exceeds the real quality to consumers.

In the case that some consumers have information about product quality and some others do not, it will be costly to be an informed consumer. This is because they must invest time and effort to identify seller who sell high-quality product. The uninformed consumers may be able to infer the type of sellers merely by observing the behavior of informed consumers. In the market with enough well-informed buyers, most buyers will be satisfied with the quality of what they buy. If uninformed consumers cannot gauge quality through observing informed consumers, then a lemon market can

emerge (Akerlof, 1970). If consumers cannot determine the quality of what they buy, then some sellers might skip on quality and sell only low-quality products but still charge the going price. Consumers may realize that their ignorance of quality makes them susceptible to buying lemons. They may insist on paying less for a product. Figuring its quality is likely to be low. This poses a problem to sellers of high-quality products, who cannot get their money's worth from suspicious consumers. High quality sellers may refuse to sell their product as the price cannot get a price to cover their opportunity cost. If they want to get a price commensurate with quality, they must rely on money-back guarantees to ensure that their products are not lemons.

When firm increases its quality, these strategies have directly effect on the demand curve of market. The demand curve of high-quality product is steeper than that of low-quality product. From figure 1, firm increases its product quality, the demand curves shifts from D_L to D_H. Not only does the firm sell more of product at any given price when its raise quality, but its demand also becomes more inelastic to price.

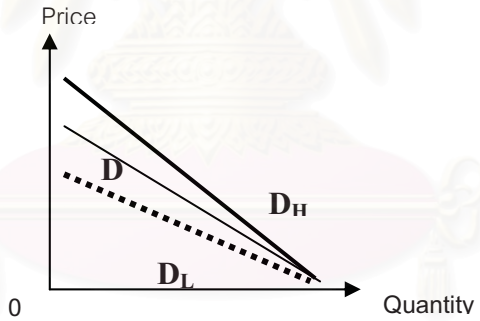

Figure 1 Market demand curve with different quality levels (D_H and D_L).

Sellers with some market power view quality as critical to the demand for their product. When quality is high, demand is higher than when it is low. The vertical difference between high quality and low quality demand curves represents the additional value of quality. As shown in figure 1, the demand curve becomes steeper as quality increases. This will occur if consumers who are willing to pay the highest price of product will also pay for the highest quality improvement. Regarding firm behavior, some sellers with market power have to select a single level of quality for all of their products. The sellers will select the reliability across their products line. Although some

other firms will select strategies to produce more quality product in product line to cover all demands in market. When sellers select the quality they want to produce, they must compare the marginal cost of increasing in quality with the marginal revenue from more consumers that will consume their product when quality increases (Besanko et al., 2003). As a result, rational firm should choose the quality level that will equalize the marginal cost of increasing quality and the marginal revenue obtained when products' range cover higher-quality products.

Concerning consumer, the product will be consumed based on their utility function. In a competitive market, firm that creates more value creation will receive more benefits (profit, market share or reputation) than others. The value creation concept is to find the maximum willingness to pay and also consumer surplus. Defining that w is the expect value of consumer in the term of one unit of product. It is equal to the maximum level that consumer prefers to pay for consuming product. Let p be money price that producer sets for each unit of product. The consumer surplus is therefore w-p; the consumers will buy the product only if the consumer surplus is positive. The competitors in market will publicize the more value of their product, so there are various quality in the product and consumer will select the product that get most value creation to them.

Consumers can select the product that gives the maximum consumer surplus to them. If the selecting products give less consumer surplus, the producers will loss their market share to the competitor. So, the producers give more consumer surplus by reducing the price or increasing the value of product. These show that there are same relation between price and quality in each product. Thereby, the consumer surplus parity will occur. In the case that the quality of products is indifferent and consumer surplus parity holds, the price of product will be the same. On the other hand, if consumer surplus parity does not hold, the competition among producers will occur.

Economic value added comes from the producer bring labor, capital and raw material to produce the product and then sell them to receive the advantage w that more than cost of product: c. The value creation of product can be partitioned into the

producer part and consumer part. The consumers receive the value of benefit that exceeds the price or so-called consumer surplus (w-p) and producer can receive the value of price that exceeds the cost of product or so-called profit (p-c).

The product with negative value creation can not exist in the market. The negative w-c show that the producers are not set theirs products' price that consumer prefers to pay and that can cover the cost. The positive created value is the main reason that allows product to stay in the market. In an aggressive competition among firms, the new competitors enter the market and sell the more value-created product until they can not receive economic profit while the consumers get all value creation. Nevertheless, the producer must increase the value to their product by increasing the quality to differ their product to the others', especially for the group of consumer that has interested in quality specify. Firm try to increase the value in a special consumer group and create the differ level of quality among product to prevent the loss of market share. This market is called the market with vertical difference.

From the real world market, two goods are never perfect substitutes. That is, all consumers are indifferent between the goods when they have the same price. Products are always differentiated by some characteristics. In contrast, a group of products always interacts to some extents of other goods in the market. The price of other goods outside the industry affects the demand for goods in the industry not only through income effects but also though substitution effects. Products can be described by several characteristics name as quality. The consumers can get information about the quality and then rank over the mix characteristic to find the relationship between price and quality.

2.2.2 Game theory

The non-cooperate game theory has played an important role in analyzing the strategic interaction between players (firms). The game in the competition has many applications that relates to with the field of industrial organization. In this study the basic theory of normal-form games and Nash equilibrium are considered.

2.2.2.1 Normal-form representation of games

In this game, a player simultaneously chooses a strategy, and the combination of strategies chosen by the player determines a payoff for each player. The normal-form representation of game specifies: (1) the players in the game, (2) the strategies available to each player, and (3) the payoff received by each player for each combination of strategies that could be chosen by the player. This study discusses an n-player game in which the players are numbered from 1 to n and an arbitrary player is called player i. Let S_i denote the set of strategies available to player i (called i's strategy space), and let s_i denote an arbitrary member of this set. The strategy s_i is a member of the set of strategies S_i. Let $(s_1, \ldots, s_n)$ denote a combination of strategies, one for each player, and let u_i denote player i's payoff function: $u_i(s_1, \ldots, s_n)$ is the payoff to player i if the players choose the strategies $(s_1, \ldots, s_n)$. Collecting all of this information together, the definition of the normal-form presentation is for an n-player game specifies the players' strategy space $S_1, \ldots, S_n$ and their payoff functions $u_1, \ldots, u_n$. This game denotes by $G = \{S_1, \ldots, S_n; u_1, \ldots u_n\}$.

Although, this study stated in a normal-form game the players choose their strategies simultaneously, this does not imply that the parties necessarily act simultaneously: it suffices that each player chooses his or her action without knowledge of others' choices. The normal-form games can represent both static game in which the players all move without knowing the other players' choices and sequential-move game on dynamic issue.

- Iterated elimination of strictly dominated strategies

The definition of strictly dominated that use in this study is in the normal-form game $G = \{S_1,\ldots,S_n;u_1,\ldots u_n\}$, let s_i' and s_i'' be feasible strategies for player i. Strategy s_i' is strictly dominant by strategy s_i'' if for each feasible combination of the other players' strategies, i's payoff from playing s_i' is strictly less than i's payoff from buying s_i'' : $u_i(s_1,\ldots,s_{i-1},s_i',s_{i+1},\ldots,s_n) < u_i(s_1,\ldots,s_{i-1},s_i'',s_{i+1},\ldots,s_n)$ for each $(s_1,\ldots,s_{i-1},s_{i+1},\ldots,s_n)$ that can be constructed from the other players' strategy space $S_1,\ldots,S_{i-1},S_{i+1},\ldots,S_n$.

Rational players do not play strictly dominated strategies, because there is no belief that a player could hold (about the strategies the other players will choose) such that it would be optimal to player such as strategy. The use of such payoff-dominance criteria becomes much more interesting when it is applied iteratively. The iterative dominance method is used on the game where no player has a dominant strategy. This iterative dominance method is a concept to find the best strategy for each player, independently of what other opponents do (Vega-Redondo, 2003).

2.2.2.2 Definition of Nash equilibrium

One way to motivate the definition of Nash equilibrium is to argue that if game theory provides a unique solution to a game theoretic problem then the solution must be Nash equilibrium. Suppose that game theory makes a unique prediction about the strategy each player will choose. In order for this prediction is correct, it is necessary that each player has willing to choose the strategy predicted by the theory. Thus, each player's predicted strategy must be that player's best response to the predicted strategies of the other players. Such a prediction could be called strategically stable or self-enforcing, because no single player want to deviate from his strategy. There are four stage of Nash equilibrium in game theory.

- **Nash equilibrium in static games of complete information**

The Nash equilibrium has q unique solutions to a game theory problem. The definition of this equilibrium is in the n-player normal-form game $G = \{S_1,\ldots,S_n;u_1,\ldots u_n\}$. The strategies $(s*_1,\ldots s*_n)$ are in Nash equilibrium if, for each player i , $s*_i$ is at least tied for player i's best response to the strategies specified for the n-1 other players, $(s*_1,\ldots,s*_{i-1},s*_{i+1},\ldots,s*_n)$:

$$u_i(s*_1,\ldots,s*_{i-1},s*_i,s*_{i+1},\ldots,s*_n) \geq u_i(s*_1,\ldots,s*_{i-1},s_i,s*_{i+1},\ldots,s*_n)$$

For every feasible strategy s_i in S_i ; that is $s*_i$ solves,

$$\underset{s_i \in S_i}{Max}\ u_i(s*_1,\ldots,s*_{i-1},s_i,s*_{i+1},\ldots,s*_n)$$

The Nash equilibrium in static games of complete information is the equilibrium under the simultaneous-move game that all players know about payoff function of each others.

- **Sub game-perfect Nash equilibrium in dynamic games of complete information**

The situation of this game is that the players' payoff functions are common knowledge. However, this equilibrium is under dynamic game that moving of player in the game is known by full history (perfect information). The stage of this equilibrium is sequential stage with the moves in previous stages observed before the next stage begins. This action differs from first equilibrium because the Nash equilibrium in static games is the simultaneous-move game.

- **Bayesian Nash equilibrium in static games of incomplete information**

In the game of incomplete information the situation is different. There are some players having uncertain information about another player's payoff function but they act simultaneously. The equilibrium under incomplete information is called Bayesian equilibrium. In the static Bayesian game of n-player, the players' action spaces are $A_1,\ldots,A_n$, and their type spaces are $T_1,\ldots,T_n$. Their beliefs are $p_1,\ldots,p_n$, and their payoff function are $u_1,\ldots,u_n$. From the assumptions, it can denoted that the static Bayesian game be $G = \{A_1,\ldots,A_n;T_1,\ldots,T_n;p_1,\ldots,p_n;u_1,\ldots,u_n\}$. The players' strategies

$s^* = (s^*_1, \ldots s^*_n)$ will be Bayesian Nash equilibrium if for each player i and for each of $i's$ types t_i in T_i , $s^*(t_i)$ solves

$$\underset{a_i \in A_i}{Max} \sum_{t_{-i} \in T_{-i}} u_i(s^*_1(t_1), \ldots, s^*_{i-1}(t_{i-1}), a_i, s^*_{i+1}(t_{i+1}), \ldots, s^*_n(t_n); t) p_i(\frac{t_{-i}}{t_i})$$

That is no player wants to change his or her strategy even if the change involves only one action by one type.

- **Perfect Bayesian equilibrium in dynamic games of incomplete information**

The strongest equilibrium is Perfect Bayesian equilibrium in dynamic games of incomplete information that occur under incomplete information and dynamic game. The equilibrium was defined in order to refine Bayesian Nash equilibrium in the same way that sub game-perfect Nash equilibrium refines Nash equilibrium.

CHAPTER III

QUALITY-SETTING MODEL

An objective of this chapter is to construct a quality-setting model without quality uncertainty and then to find competitive equilibrium with duopoly firms. This chapter explains the characteristics of utility and cost functions used in the model. Then, the equilibrium outcomes in both price and competition are solved.

Quality-setting model is competition model that firms will consider quality as their main strategy to compete other competitors when game begins. The concept of quality competition is based on Motta (1993) who created models of product differentiation in uncovered markets[1]. The competition model developed here is a two-stage model in which firms select the quality first and then compete in price or quantity in the market. To address these two issues, this study begins with a simple vertical utility function that relates to consumers' taste parameters, quality and price of the product. Suppose that the utility to consumer i of product j is

$$u_{ij} = \theta_i v_j - p_j \qquad (1)$$

where v_j is product quality and p_j is price. Note that this study assumes away about income effects, and utility can be measured in currency. The taste parameter: θ_i is the consumer's willingness-to-pay for quality. This study assumes that θ_i is distributed on the interval $(0,\overline{\theta})$ with θ being uniformly[2] distributed with unit density. There are some consumers, with arbitrary high θ , will pay for an increase in quality to any level of taste parameter. Consumers base their decision making upon their preferences. That is, they decide to buy certain goods if these goods satisfy their preference. The maximum acceptable price (or reserve price) will be used to make the decision. If the actual price of goods is higher than the reserve price, consumers will not buy anything. On the other hand, if the actual price is lower than or equal to the reserve price, consumers will buy at

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[1] In real word, there is a part of not buying consumers in the market namely uncovered market.

[2] From utility of Mussa-Rosen (1978) and Motta (1993) that both assumes the taste parameter of consumers has uniform distribution. To make the equivalent weight of consumers in all levels of income effect, then this study assumes taste parameter of consumers is uninformed distribution.

least one unit of goods. In the term of comparing utility function with consumers' decision rule, $\theta_i v_j$ is a reserve price of product j for consumer i. If the actual price of the good is higher than this reserve price, then consumer i's utility unit has a negative value and thus the consumer i will not buy the product. If instead, the actual price is lower than the reserve price, then the utility unit is positive and the consumer will buy goods.

3.1 Firm's quality of goods and costs concepts

Product differentiation within a category of goods widens the decisions that consumers have to make. They make a decision to choose which goods to buy. Figure 2 shows the process of decision making for consumers.

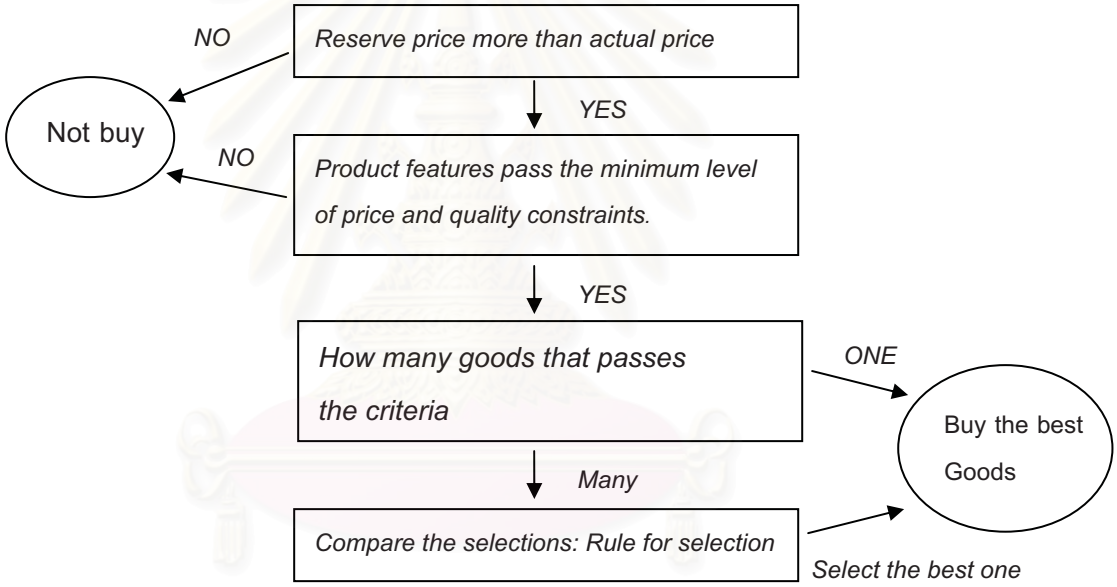


Figure 2 Consumers' decision making process

This process starts with selecting a product that has a reserve price greater than its actual price. Next, consumers focus on the product characteristics that will be measured by two important factors: performance and how easy to use it. The consumers assess these features (of each product) and add them to be the score. Consumers and firms will set the attribute (or the score) of all goods in the market, namely as quality. Furthermore, there are the minimum levels of each feature that is defined by the fashion trend and basic requirements of buyers. The consumers will make sure that the selected products will pass the minimum levels. After that, they rank the remaining qualities and

select the best one based on their preference affected by their income. If there is only one product which satisfies both the price and quality constraints, then that product will be chosen. If there are none, the consumer will buy nothing. If there is more than one product, consumers will use the rule of selection to choose the appropriate one.

There are three rules of selection. First, if only the price is important, the consumer buys the cheapest good that meets minimal quality requirements. Second, if only the quality is important the consumer buys the goods that have the overall highest quality. Last, consumers try to balance price and quality; they will choose the best value for money product. It means that consumers does not individual consider on price or quality. They choose the highest overall quality with respect to the price that is on the suitable range. In a market that has vertically differentiated product, the quality is important. Consumer will buy the best goods he can afford. Given a reserve price, he will buy the good of which overall quality is the highest and of which each feature has a sufficient score.

With regard to the cost, some literatures emphasize on an increase in quality that involve increases in fixed and marginal costs. The relationship between market size and distribution of quality depends on whether the quality is produced primarily through fixed or variable costs. In particular, if fixed cost increases only slowly in quality and thus the cost of the quality is borne largely by variable cost, then high-quality products can use price to undercut lower quality products. It potentially drives the low-quality product out of the market and leads to a situation where there are a limited set of product qualities on offer, including at least one high-quality product.

For simplicity, the model assumes that the cost of production is only variable costs. This study assumes that fixed cost is sunk costs and will not affect the profit of firms. Firms' marginal costs are constant in quantities but increasing in qualities. In equation 2, firms' marginal cost is denoted by *c*. It is constant in quantity (q_j) and is increasing in quality (v_j), so that the variable cost is

$$C(q_j, v_j) = q_j\, c(v_j) \qquad (2)$$

When firms choose qualities, the marginal costs are also determined. The lowest quality in the market is set by the country's regulation. The economy sets minimum quality requirement that the firm must produce to show the standard of industry. Then, the producers will select the price (or quantity) and enter into competition. This study examines the sub-game perfect Nash equilibrium in static games of complete information by using the backward induction method.

3.2 Quality-setting competition models: Duopoly Firms

From utility and cost concepts, this study considers quality-competitive models under both the Cournot and Bertrand models. This model is a two-stage model that firms select the quality first and then compete in price or quantity in the market. The utility function is related to consumers' taste parameters, product quality and price. Concerning the cost function, the quality of the product plays the important role of the cost function because if firms do not invest in new technology at the first time, they are forced out from market. Firms that are fast to adopt a new technology will earn a positive return. The firms that invest more in quality-related technology will produce higher quality products, charge a higher price, and thus earning higher profits.

Our basic models work in a partial-equilibrium framework, focusing on single consumption goods. In the model of this section, both consumers and firms have perfect information. The model assumes duopoly competitors in the market ($j = H \ and \ L$). Firm H has more ability to produce high-quality product than firm L. The competition model is a two-stage game. In the first stage, both firms make decisions on the quality that they want to produce with the possible capacity they have. The quality: v_j that both firms have chosen is greater than zero ($v_j \rangle 0$). Firm H produces a high-quality product and firm L produces a low-quality product, i.e. $v_H \rangle v_L$. This study defines r as the ratio of high quality to low quality: r= $\frac{v_H}{v_L}$, hence r>1.

The taste parameters are generated to the utility function and the choice of the consumer. In duopoly firms, the market has two levels of taste parameters. The first one is θ_{HL} that denotes the taste parameter of consumers who are indifferent between buying high or low quality goods. If consumers are indifferent between buying and not buying a product, they then have the taste parameter θ_{0L}. In the market, firm H produces a product with quality: v_H and sells at price: p_H and firm L produces a product with quality: v_L and sells at price: p_L.

The quality setting game assumes that firm H's marginal cost is $c_H(v_H) = cv_H \ (c<1)$. Firm L can copy firm H's technology from existing products by reverse engineering. When it chooses a quality, it has the same cost function as firm H. Thus, its marginal cost can be written as $c_L(v_L) = cv_L$. Firms will never choose qualities beyond the domain of the linear function. So the marginal cost of firm will not be greater than its quality, i.e. $c_j \le v_j$. This is an important assumption in this study. Because if the firm chooses a quality that bears a marginal cost and aims to make a non-negative profit, Consumers utility will be less than zero for all taste parameters. Consequently, the firms cannot sell any of their products in the market.

From the utility function (equation 1), this study finds the level of taste parameters of consumers that shown in table 1. When consumer chooses to consume high-quality product, his unit utility function is $u = \theta v_H - p_H$ and unit utility function of consumer who prefer low-quality product is $u = \theta v_L - p_L$. Consumer selects product by consider its quality and price. The utility function when select the product can write in the term of taste parameter that depending on price and quality of product.

Table 1 Levels of taste parameters

Selection of product	Taste parameter
Buy good H	$\theta_H = \overline{\theta}$
Buy good H or good L	$\theta_{HL} = \frac{p_H - p_L}{v_H - v_L}$
Buy good L or not buy	$\theta_{0L} = \frac{p_L}{v_L}$

From levels of taste parameter, this study derives demand function of consumers who prefer high or low-quality products from the intersect region of the taste parameters level. This model allows that some consumers will not buy products when their preferences are below θ_{0L}. The characteristic of demand function can be written as

$$D_j = \begin{cases} q_H(p_H, p_L, \theta_i, v_H, v_L) = [\theta_H - \theta_{HL}] = (\bar{\theta} - \dfrac{p_H - p_L}{v_H - v_L}) \\ q_L(p_H, p_L, \theta_i, v_H, v_L) = [\theta_{HL} - \theta_{L0}] = (\dfrac{p_H - p_L}{v_H - v_L} - \dfrac{p_L}{v_L}) \end{cases} \quad (3)$$

The uncovered market demand is a convex function that $\sum D_j(p_j, \theta_i, v_j) \langle 1$ and $D_j(p_j, \theta_i, v_j) \rangle 0$ for $j = H, L$. From the demand function (Equation 3), this study examines cases of competition by considering both quantity and price determination in the second stage and backwardly inducing to the first stage choice of quality. Both firms want to maximize their profits of which function is

$$\prod_j (v_j, q_j, p_j) = q_j(p_j - cv_j) \quad (4)$$

When both firms enter into the competition in the market with different qualities, the competitive equilibrium will be the Nash equilibrium.

3.2.1 Quality-price Equilibrium: Bertrand Competition

Solving for the Nash equilibrium, this study maximizes profits function by differentiating it with respect to price and finds the solutions at equilibrium. The results are as follows.

$$p_H = \frac{v_H(2cv_H + cv_L + 2\bar{\theta}v_H - 2\bar{\theta}v_L)}{4v_H - v_L} \quad , \quad p_L = \frac{v_L(3cv_H + (v_H - v_L)\bar{\theta})}{4v_H - v_L}$$

$$q_H = \frac{2(\bar{\theta} - c)v_H}{4v_H - v_L} \quad , \quad q_L = \frac{(\bar{\theta} - c)v_H}{4v_H - v_L} \quad (5)$$

$$\pi_H = \frac{4(\bar{\theta} - c)^2 v_H^2 (v_H - v_L)}{(4v_H - v_L)^2} \quad , \quad \pi_L = \frac{(\bar{\theta} - c)^2 (v_H - v_L) v_H v_L}{(4v_H - v_L)^2}$$

The competition outcomes show that the high quality firm makes a higher profit than the low one. Quality of firm H has a positive effect to profits. When the quality of product in firm H is raised, both profits of firm H and L will increases. This is because after firm H improves its technology, market will expand due to the positive relation between quantity produced by both firms and quality of firm H. Firms can sell more products and their

profits are raised. In contrast, the quality of product in firm L has only effect on profit of firm L. That is when quality of firm L increases, profit of firm L only will increase. The interesting factor is a degree of product differentiated: $v_H - v_L$ that has a positive effect to both firms' profits. This implies that when products are more differentiated, producers can set up their prices apart with the others. Both firms will set the prices that give them higher profits. Profits of both firms will increases. As usual, firms' profits decrease in marginal cost, this relation shows that when cost of production increases, and profit of firms will decrease.

With price competition, this study tries to explain the behavior of both price functions with respect to the degree of product differentiated. By keeping the value of firm H's quality constant, increasing in quality of firm L implies less degree of product differentiated. Figure 3 plots both price (p_H, p_L) against v_L for the case of $v_H = 1$. At $v_L = 0$, firm H effectively possesses a monopoly, and can set the monopoly price, $p^*_H = \frac{c + \bar{\theta}}{2}$. This behavior shows the price of product is the perfect factor reflecting the quality. When the quality of the product is equal to zero, the price goes to zero too. In addition, as v_L rises, firm H faces increasing competition and the fall in its optimal price. There are two counteracting factors that affect the level of p_L when v_L rises. First, increases in v_L raise the ratio of equilibrium prices $\frac{p_H}{p_L}$ in consumers' view. Second, increases in v_L cause p_H to fall. As long as p_H is high enough, the first effect will dominate, and p_L will increase with v_L. When p_H falls low enough so that increases in the ratio are insufficient to offset decreases in the level of p_H, then the second effect will dominate, and p_L will decrease with v_L.

However, in all cases, p_H is greater than p_L. Firm H price will be zero when L's quality rises to $v_L^{**} = \frac{2(\bar{\theta} + c)}{2\bar{\theta} - c}$. This implies that firm L's quality will rise until it does not differ from firm H's quality in the view of consumers. Consequently, they will buy only firm L's product and the price of firm H's product will become zero. Nonetheless, if firm L's quality will continues rising until it reaches $v_L^{***} = \frac{\bar{\theta} + 3c}{\bar{\theta}}$, this is the point that the

quality of firm L will get higher than consumers expect and they will not consume firm L's product, as a result, p_L will fall to zero. In figure 3, both price functions intersect at point A where both firms have same quality (both qualities are equal to 1), and thus they give the same price p^* that will be equal to the marginal cost of both firms: c. From figure 3, only firm L's price function has local maximum, these optimal vales of price and quality are $p_L^* = \frac{(2\bar{\theta} + \sqrt{3}\sqrt{\bar{\theta}^2 - c\bar{\theta}})(-3c + 3\bar{\theta} + 2\sqrt{3}\sqrt{\bar{\theta}^2 - c\bar{\theta}})}{\sqrt{3}\sqrt{\bar{\theta}^2 - c\bar{\theta}}}$ and $v_L^* = \frac{2(2\bar{\theta} + \sqrt{3}\sqrt{\bar{\theta}^2 - c\bar{\theta}})}{\bar{\theta}}$.

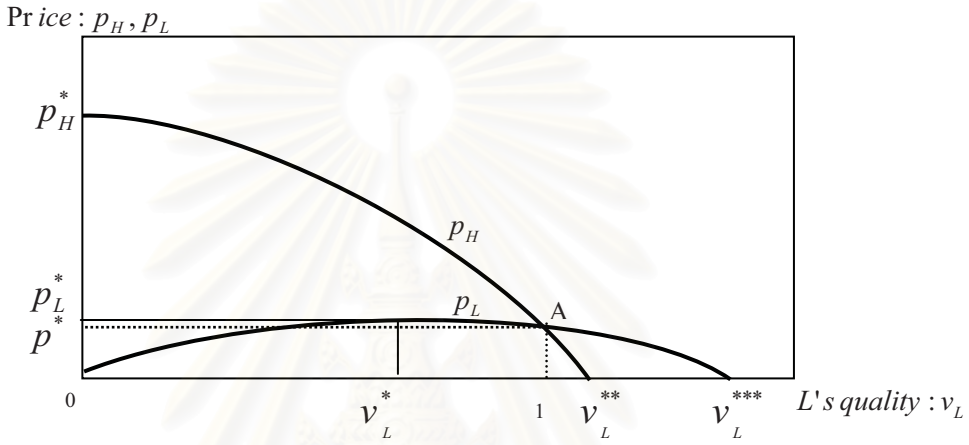


Figure 3 Firm H's and L's prices functions on firm L's quality

As to describe about the relative market shares of high quality and low quality sellers, the total market quantity is given by $Q = q_H + q_L = \frac{3v_H(\bar{\theta} - c)}{4v_H - v_L}$. Both firms are forced by the other using quality strategy. At the equilibrium, firm H has a market share equal to $\frac{q_H}{Q} = 66.67\%$ and firm L has a market share equal to $\frac{q_L}{Q} = 33.33\%$. Firm H has a greater market share than firm L because firm H has set its product quality higher than firm L. In price competition, consumers will think that prices of both products are not much different, but qualities of both firms are much different. More consumers will, therefore, buy product from firm H. In this game, the high-quality product firms will then receive more benefit (higher prices and higher quantity) than the low-quality ones.

Because of quality of product is an important factor that affects the equilibrium outcomes in price competition. However, both firms try to fight the others by use quality

strategy. To consider the relationship of profit and firms' quality, this study finds the first-order condition of profit with respect to its quality as follows.

$$\frac{\partial \pi_H}{\partial v_H} = \frac{4(\bar{\theta}-c)^2 v_H (4v_H^2 - 3v_H v_L + 2v_L^2)}{(4v_H - v_L)^3} \quad > 0 \qquad (6.1)$$

$$\frac{\partial \pi_H}{\partial v_L} = \frac{-4(\bar{\theta}-c)^2 v_H^2 (2v_H + v_L)}{(4v_H - v_L)^3} \quad < 0 \qquad (6.2)$$

$$\frac{\partial \pi_L}{\partial v_H} = \frac{(\bar{\theta}-c)^2 v_L^2 (2v_H + v_L)}{(4v_H - v_L)^3} \quad > 0 \qquad (6.3)$$

$$\frac{\partial \pi_L}{\partial v_L} = \frac{(\bar{\theta}-c)^2 v_H^2 (4v_H - 7v_L)}{(4v_H - v_L)^3} \quad > 0 \qquad if\ v_H > 7/4\, v_L \qquad (6.4)$$

Both profits rise with firm H's quality as shown in equations 6.1 and 6.3 which have positive values. This is expected since firm H's higher quality will raise demand and relaxes competition with more product differentiation. One also finds that equation 6.2 has a negative value. In other words, if firm L's quality increases by given a firm H's quality, the market has less product differentiated. This leads to more intensive in competition so firm H's profit decreases. The last equation is equation 6.4, this solution can not conclude that will be positive or negative. If $v_H > 7/4\, v_L$, then the relationship between profits of firms and its quality will be positive. Nevertheless, for any v_H, firm L has an incentive to set $v_L > 0$ because it's marginal profit from a very low quality is always strictly positive ($\lim_{v_L \to 0} \frac{\partial \pi_L}{\partial v_L} > 0$ for any v_H). Both firms consider the ratio of high to low quality: r= $\frac{v_H}{v_L}$. For firm H, the prospect of reduced price competition as r is increased, taking v_L as fixed, given incentive to increase quality. The tradeoff is that an increase in v_H has an increasing cost resulting from the rising marginal cost of investment in quality.

From the above results, this study specifically analyze both profit function with firm L's quality to see the clear behavior of competition. Figure 4 illustrates equilibrium profits against v_L for the case of $v_H = 1$. When L's quality is equal to zero, the profit of firm H is at its highest π_H *= $\frac{(\bar{\theta}-c)^2}{4}$. Then, as expected, π_H falls monotonically with v_L as firm H faces greater and greater competition. The relationship of π_L and v_L is even more interesting, and is similar to the relationship of p_L and v_L. At first,

π_L increases with v_L, as firm L is able to charge higher prices without losing market share. The local maximum of π_L is $\pi_L{}^* = \frac{(\bar{\theta}-c)^2}{8}$ and L's quality is equal to 4/7. Eventually, as L's quality closes to H's, the price competition becomes so intense that both p_H and p_L fall to low levels. Then, π_L diminishes. As v_L keep increasing until equals to v_H (equal to 1), prices and profits for both firms will tend to zero.

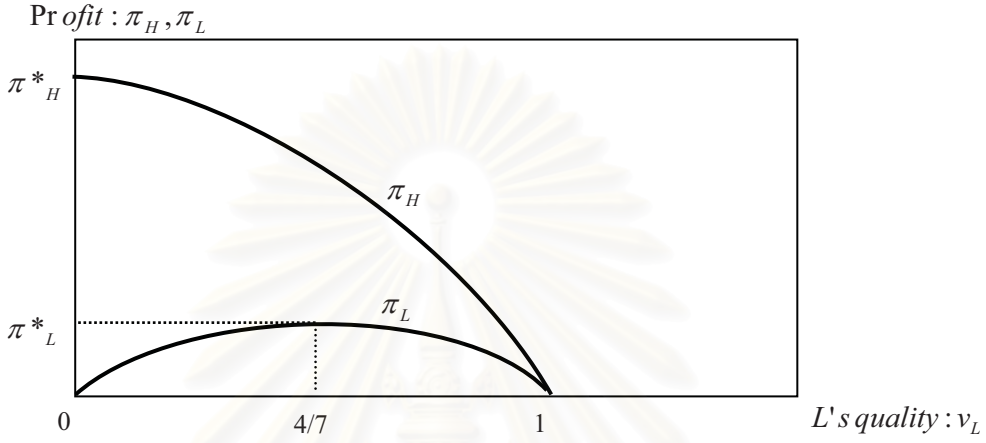


Figure 4 Firm H's and L's profits functions on firm L's quality

To see the rate of increase in qualities to profits of both firms, the second-order conditions will be described as below

$$\frac{\partial^2 \pi_H}{\partial v_H{}^2} = \frac{-8(\bar{\theta}-c)^2 v_L^2 (5v_H + v_L)}{(4v_H - v_L)^4} < 0 \qquad (7.1)$$

$$\frac{\partial^2 \pi_H}{\partial v_H \partial v_L} = \frac{8(\bar{\theta}-c)^2 v_H v_L (5v_H + v_L)}{(4v_H - v_L)^4} > 0 \qquad (7.2)$$

$$\frac{\partial^2 \pi_L}{\partial v_L \partial v_H} = \frac{2(\bar{\theta}-c)^2 v_H v_L (8v_H + 7v_L)}{(4v_H - v_L)^4} > 0 \qquad (7.3)$$

$$\frac{\partial^2 \pi_L}{\partial v_L{}^2} = \frac{-2(\bar{\theta}-c)^2 v_H^2 (8v_H + 7v_L)}{(4v_H - v_L)^4} < 0 \qquad (7.4)$$

Equations 7.1 and 7.4 have negative values. This behavior implies that both profits are concave to their quality. When its quality increases, the profit increases too, but in a decreasing rate. Shown in figure 5 are the reaction functions of both firms that denoted $v_H = \rho_H(v_L)$ *and* $v_L = \rho_L(v_H)$ from firm H and firm L respectively. Both functions have positive slopes that will make the product strategic complements in quality from equations 6.1 and 6.4. When the degree of price competition rises with the increase in v_L, firm H can reduce the degree of price competition by also increasing v_H.

Correspondingly, the reduced competition associated with an increase in v_H allows firm L to better position its product by rising v_L. The second order and stability condition in equations 7.1 and 7.4 ensure that firm L's reaction curve is steeper than of firm H and hence the curves cross at a unique point (show as N). Since r>1, the reaction functions both lie above the 45° line.

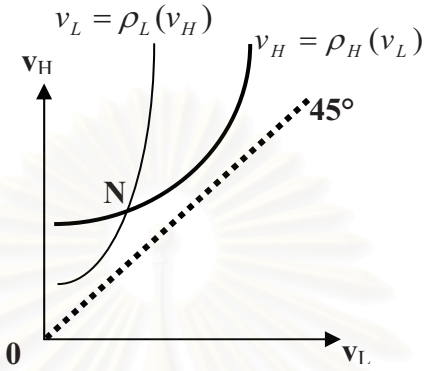


Figure 5 Quality reaction functions: Bertrand competition

Next, this study examines consumers' preference in the equilibrium. Because there are two products in the market, so there are two levels of taste parameter: θ_{HL} and θ_{0L} which consumers will consider when buying products. Theses taste parameters measure from the preferences of consumers. In Bertrand competition, both taste parameters are

$$\theta_{HL} = \frac{2(\bar{\theta} + c)v_H - \bar{\theta}v_L}{4v_H - v_L} \qquad \theta_{0L} = \frac{(\bar{\theta} + 3c)v_H - \bar{\theta}v_L}{4v_H - v_L} \tag{8}$$

Both taste parameters are positive and depend upon qualities of firms, the marginal cost and the upper bound of taste parameter. As expected outcome, the value of θ_{Hl} is greater than θ_{0L}. The gap between them is $\frac{(\bar{\theta} - c)v_H}{4v_H - v_L}$. This space is positive. It can explain the behavior of consumers in such a way that if preferences of consumers lie above θ_{HL}, they will choose high-quality product. If their preferences lie above θ_{0L} but below θ_{HL}, they will choose low-quality product. While consumers have taste parameter below θ_{0L}, they will not buy anything.

The social welfare of consumers derived from integrating the utility function with both levels of taste parameters implies a consumer surplus for taste parameter: θ. The consumer surplus here has two parts. The primary part is derived from the utility function

of consumers preferring low-quality products. It integrates the area of taste parameters: θ_{HL} to θ_{0L}. Another part is derived from the utility function of consumes preferring high-quality products. This area is integrated between the highest level of the taste parameter: $\bar{\theta}$ and θ_{HL}.

$$CS = \int_{\theta_{0L}}^{\theta_{HL}} (\theta v_L - p_L)d\theta + \int_{\theta_{HL}}^{\bar{\theta}} (\theta v_H - p_H)d\theta = \\ = (\bar{\theta}^2/2)v_H - p_H\bar{\theta} - [(\theta_{HL})^2/2](v_H - v_L) + \theta_{HL}(p_H - p_L) - [(\theta_{0L})^2/2]v_L + p_L\theta_{0L} \quad (9)$$

Replacing the Nash solution (equation 5) into consumer surplus (equation 9) attains the consumer welfare in the case of Bertrand competition as follows.

$$CS = \frac{1}{2(4v_H - v_L)^2}\left\{v_H\left\{\begin{matrix} c^2 v_H(4v_H + 5v_L) - 2\bar{\theta}cv_H(4v_H + 5v_L) \\ + \bar{\theta}[v_L^2(1-\bar{\theta}) + 4v_H^2(4 - 3\bar{\theta}) + v_H v_L(13\bar{\theta} - 8)\end{matrix}\right\}\right\} \quad (10)$$

Equation 10 has more unobserved variables. Although to consider the value of this consumer surplus, this study specially assumes that $\bar{\theta} = 1$. The solution is

$$CS = \frac{(1-c)^2 v_H^2(4v_H + 5v_L)}{2(4v_H - v_L)^2} > 0 \quad (11)$$

The social welfare is positive and composed of qualities of both firms and the marginal cost. Consumer surplus has positive relation with quality of firm H. When the quality of product produced by firm H increases, consumers will then be better off due to consume technology enhancement. On the contrary, quality of firm L has uncertain about relation with this surplus. When quality of firm L increases, consumers gain more benefits from this innovation but the less differentiated products will decrease social welfare. If the former factor has greater effects than the latter, consumer surplus will increase when the quality of product produced by firm L increases. On the other hand, if effect of the latter, less differentiated products, is greater than the former, technology improvement, consumer surplus will decrease when the quality of product produced by firm L increases. Nonetheless, the marginal cost has opposite relation with the social welfare. If firms raise their marginal cost, consumers will pay for this increasing cost. Consumers' surplus of buying products will then reduce. To sum, consumers will receive greater benefit from more differentiated product quality. Quality of firm H is a main factor that pushes the consumer surplus, in contrast with quality of firm L that has uncertain effect. This outcome is clearly driven by the choice of quality chosen by the producers.

3.2.2 Quality-quantity Equilibrium: Cournot Competition

Next, this section turns to examine the case of Cournot (quantity competition) in which firms choose quantities rather than prices at stage two after committing to quality levels at stage one.

$$p_H = \bar{\theta} v_H - q_H v_H - q_L v_L$$
$$p_L = \bar{\theta} v_L - q_H v_L - q_L v_L \quad (12)$$

Equation 12 is an inverse of demand function that is derived from equation 3. Like the Bertrand case, this study considers profit functions of both firms. The first order conditions with respect to quantities are derived. Then, this study finds the equilibrium of quantity competition. The Nash equilibrium results are shown below.

$$p_H = \frac{v_H(2cv_H + 2\bar{\theta} v_H - \bar{\theta} v_L)}{4v_H - v_L} \quad , \quad p_L = \frac{v_L(3cv_H - cv_L + \bar{\theta} v_H)}{4v_H - v_L}$$
$$q_H = \frac{(\bar{\theta} - c)(2v_H - v_L)}{4v_H - v_L} \quad , \quad q_L = \frac{(\bar{\theta} - v)v_H}{4v_H - v_L} \quad (13)$$
$$\pi_H = \frac{(\bar{\theta} - c)^2 v_H (2v_H - v_L)^2}{(4v_H - v_L)^2} \quad , \quad \pi_L = \frac{(\bar{\theta} - c)^2 v_H^2 v_L}{(4v_H - v_L)^2}$$

Like Bertrand conclusion, Cournot outcomes follow that higher quality products tend to command higher revenues. Firm H receives more benefit than firm L even though the game is quantity competition. Profits of both firms depend on both qualities and the marginal cost. Like Bertrand case, when product quality of firm H increases, both profits will increases whereas product quality of firm L has only effects on profit of firm L. The product differentiated degree is more important in both profits. Moreover, the increase in marginal cost of firms will decrease both profits. The conclusion of both price and quantity competition is product quality of product is conclusively important factor that effect the solutions at equilibrium,

In the Cournot game, this study examines the effect of product differentiation on quantity of firms. Figure 6 illustrates quantity (q_H, q_L) against v_L for the case of $v_H = 1$. Unlike Bertrand case, at v_L =0, firm H cannot act like a monopoly because there are some consumers who will buy firm L's product. That is when firms compete in quantities rather than price, consumers will not consider in quality alone. They consider both quantity strategy and product quality in theirs decision making.

Nonetheless, there exist some effects of product differentiation in quantities competition. When product quality of firm L is equal to zero, some consumers will buy this product based on quantity strategies. So, quantity of firm L is equal to $q_L^* = \frac{\bar{\theta} - c}{4}$ and that of firm H is equal to $q_H^* = \frac{\bar{\theta} - c}{2}$. When, v_L increases, the quality gap decreases. Firm H will sell fewer products whereas firm L will sell more products. The intersection between both quantities is point B where both qualities are the same ($v_H = v_L = 1$). When consumers know that both qualities are the same, they will give the same price. This action makes both firms receive the same market share that is equal to $q^* = \frac{\bar{\theta} - c}{3}$. After the point of intersection, q_H sharply decreases. If v_L continues rising until its quality is double of firm H's quality, consumers have not incentive to buy firm H's product, q_H goes to zero. In conclusion, consumers may care about quality in quantity competition less than price competition and when both firms produce the product with same quality, they will receive same market share in Cournot game.

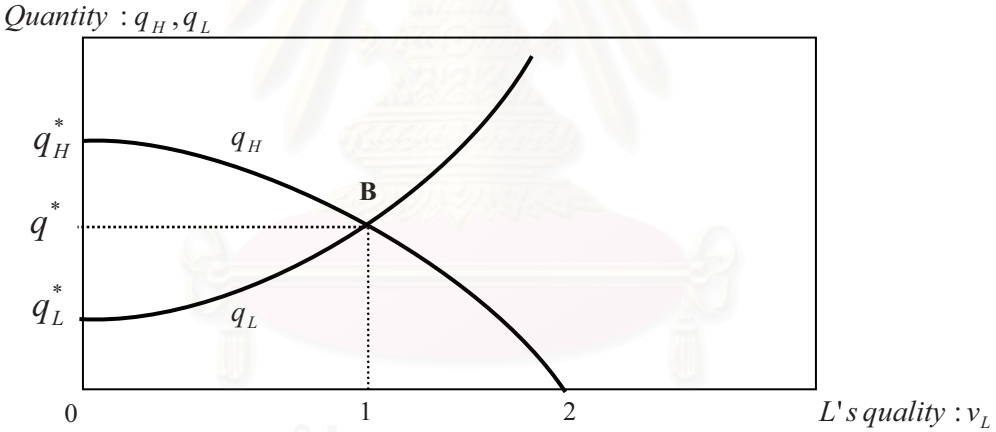


Figure 6 Firm H's and L's quantities functions on firm L's quality

To analyze price equilibrium in this game, the relative prices of high quality and low quality for sellers is $\frac{p_H}{p_L} = \frac{v_H(2cv_H + 2\bar{\theta}v_H - \bar{\theta}v_L)}{v_L(3cv_H - cv_L + \bar{\theta}v_H)}$. To simplify this result, this study substitutes the quality ratio: r of which the value is greater than one. Then, the relative price is $\frac{2cr + (2r-1)\bar{\theta}}{c(3r-1) + r\bar{\theta}}$. This value is always positive and shows that the price of firm H will be higher than the price of firm L even in the Cournot competition. Regarding the market share, the high-quality product firms can sell more than the low quality ones. From price and quantity in quantity competition, firm H will gain more profit than firm L.

Because the quality is an important factor which affects both profits. The analysis examines the behavior of profits with both product qualities. To consider the first order condition of profit with respect to its quality, the solutions are

$$\frac{\partial \pi_H}{\partial v_H} = \frac{(\bar{\theta}-c)^2(2v_H - v_L)(8v_H^2 - 2v_H v_L + v_L^2)}{(4v_H - v_L)^3} > 0 \quad (14.1)$$

$$\frac{\partial \pi_H}{\partial v_L} = \frac{-4(\bar{\theta}-c)^2 v_H^2 (2v_H - v_L)}{(4v_H - v_L)^3} < 0 \quad (14.2)$$

$$\frac{\partial \pi_L}{\partial v_H} = \frac{-2(\bar{\theta}-c)^2 v_H v_L^2}{(4v_H - v_L)^3} < 0 \quad (14.3)$$

$$\frac{\partial \pi_L}{\partial v_L} = \frac{(\bar{\theta}-c)^2 v_H^2 (4v_H + v_L)}{(4v_H - v_L)^3} > 0 \quad (14.4)$$

As shown above, equations 14.1 and 14.4 are positive and equations 14.2 and 14.3 are negative. One also finds that the profits of both firms rise with their product qualities but decrease with the other's product qualities. When firm H increases its quality, the profit of firm H will increase whereas the profit of firm L decreases. Similarly, with a rise in firm L's quality, the profit of firm L increases and firm H's decreases.

Profit function of Cournot competition (figure 7) differs from that of Bertrand cases (figure 4). Curves of firm H's profits look alike but those of firm L's profits look different. In Cournot game, firm L gains more profits when consumers think both products become more similar (v_L increase to near v_H), Differently in Bertrand game, when both qualities are about the same, the profit of firm L goes down. To explain this behavior, let's consider the quality ratio, r. If r increases by an increasing in v_H while v_L is fixed and keep both quantities unchanged, in both Bertrand and Cournot, this increase will shift up the demand curve for firm H's product and raising the willingness of consumers to pay for high quality goods. However, the willingness to pay for low quality goods is unchanged. Under Cournot conditions, firm H responds to this higher demand due to greater separation of products expanding output and firm L then reacts by cutting output (q_H and q_L are strategic substitutes). Since price and output for firm L fall and both rise for firm H, firm L's revenue falls and firm's H's revenue increases (holding q_H *and* q_L fixed). Instead, under Bertrand condition, firm H raises the price to

respond to an increase in r. Because both p_H and p_L are strategic complements, firm L also raises the price causing the revenue of both firms to increase.

Next, this study considers the characteristic of both profit functions. Figure 6 illustrates equilibrium profits against v_L for the case $v_H = 1$. When firm L's product quality is equal to zero, profit of firm H is the highest at $\pi_H^* = \frac{(\bar{\theta} - c)^2}{4}$. Then, as expected, π_H falls monotonically with v_L as firm H faces fiercer competition. The relationship of π_L and v_L is positive. Both profit functions intersect at point C where the optimal profit is $\pi^* = \frac{(\bar{\theta} - c)^2}{9}$ and at this point both firms have the same product quality ($v_H = v_L = 1$).

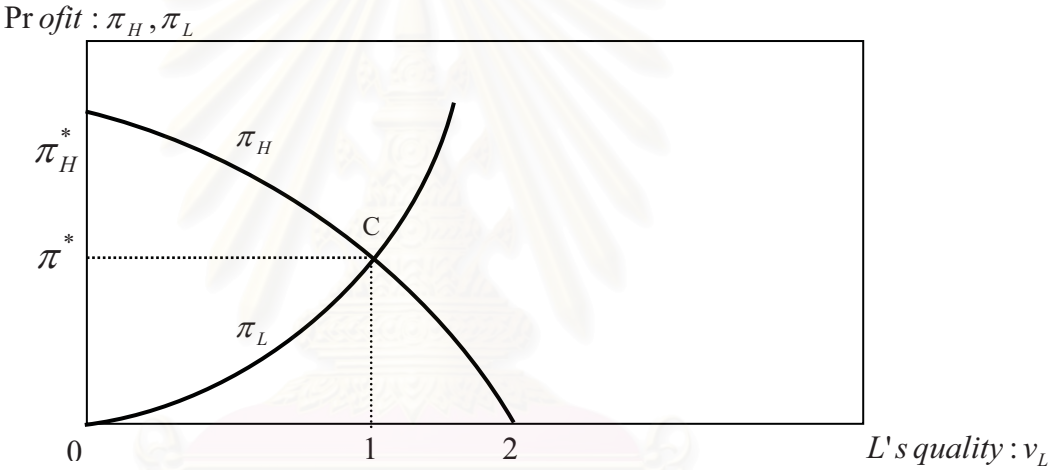


Figure 7 Firm H's and L's profits functions on firm L's quality

Here, this study considers the second order condition of profits with respect to their qualities as follows.

$$\frac{\partial^2 \pi_H}{\partial v_H^{\,2}} = \frac{-8(\bar{\theta} - c)^2 (v_H - v_L) v_L^2}{(4v_H - v_L)^4} < 0 \qquad (15.1)$$

$$\frac{\partial^2 \pi_H}{\partial v_H \partial v_L} = \frac{8(\bar{\theta} - c)^2 v_H v_L (v_H - v_L)}{(4v_H - v_L)^4} > 0 \qquad (15.2)$$

$$\frac{\partial^2 \pi_L}{\partial v_L \partial v_H} = \frac{-2(\bar{\theta} - c)^2 v_H v_L (8v_H + v_L)}{(4v_H - v_L)^4} < 0 \qquad (15.3)$$

$$\frac{\partial^2 \pi_L}{\partial v_L^{\,2}} = \frac{2(\bar{\theta} - c)^2 v_H^2 (8v_H + v_L)}{(4v_H - v_L)^4} > 0 \qquad (15.4)$$

Equation 15.1 is negative while equation 15.4 is positive. This implies that the profit of firm H is concave to its quality, but the profit of firm L is convex to its quality. The rate of

increases in profit of firm H with respect to its quality will decline but the rate of increases in profit of firm L with respect to its quality will raise. The positive cross differential in quality, equation 15.2 implies that firm H continues viewing v_L as a strategic complement to v_H. In addition, the profit of firm H increases by a greater similarity of products. On the other hand, from the result of equation 15.3 shows that firm L views v_H as a strategic substitute to v_L. Considering the choice of qualities, there is tradeoff between competitive effects arising from the extent of product differentiation from the rival's product and the profitability from choosing quality based on revenues and investment cost for given quality ratio: r. Since firm L gains from narrowing of the quality gap, this gives firm L an incentive to raise its quality aims to reduce r, thus holding the rival quality fixed. For firm H, analogously to Bertrand competition, a greater differentiation of products raises revenue, so firm H raises its quality to increase its profit. However, profitability of increase in quality is limited by the rising marginal cost of quality investment. Thus, firm L's reaction function (figure 8): $v_L = \rho_L(v_H)$, has a negative slope whereas $v_H = \rho_H(v_L)$ has a positive slope.

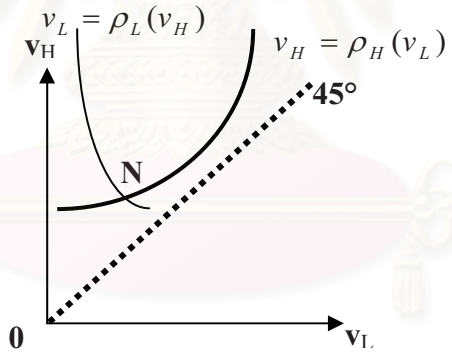


Figure 8 Quality reaction functions: Cournot competition

Then, this study examines the welfare of consumers in quantity game. Consumers set the level of taste parameter at a given price and quality of both products. These levels of taste parameters measure the preferences of consumers that make decision what product they want to buy. Both taste parameters in Cournot competition are

$$\theta_{HL} = \frac{2(\bar{\theta} + c)v_H - cv_L}{4v_H - v_L} \qquad \theta_{0L} = \frac{(\bar{\theta} + 3c)v_H - cv_L}{4v_H - v_L} \tag{16}$$

Like the case of Bertrand, both taste parameters are positive and θ_{HL} is larger than θ_{0L}. These taste parameters depend on qualities of both firms and the marginal costs. To

consider the gap between them, it has positive value and is equal to $\frac{(\bar{\theta}-c)v_H}{4v_H-v_L}$. It is interesting that the gaps of taste parameters (in price and quantity competition) are the same. This implies that percentage of low-quality product buyers is the same in both cases. Although the levels of both taste parameters in Cournot are higher than those in the Bertrand cases.

Like Bertrand case, the measurement of social welfare in the Cournot case can be referred by equation 9. This consumer surplus for taste θ is

$$CS = \frac{1}{2(4v_H - v_L)^2}\left\{ v_H \left\{ \begin{array}{l} c^2(4v_H^2 + v_H v_L - v_L^2) - 2\bar{\theta}c(4v_H^2 + v_H v_L - v_L^2) \\ + \bar{\theta}[v_L^2(1-2\bar{\theta}) + 4v_H^2(4-3\bar{\theta}) + v_H v_L(9\bar{\theta}-8) \end{array} \right\} \right\} \quad (17)$$

This equation is difficult to solve. Therefore, to simplify it, the model assumes that $\bar{\theta} = 1$

$$CS = \frac{(1-c)^2 v_H (4v_H^2 + v_H v_L - v_L^2)}{2(4v_H - v_L)^2} > 0 \quad (18)$$

The positive social welfare depends on qualities of both firms and the marginal costs. Again, quality of firm H: v_H is an important factor to increase consumer surplus. As shown in equation 18, consumers will receive more benefit if there is product quality differentiation.

3.2.3 Compare equilibrium solutions in both competitions

When the market has vertical product differentiation, the competition results at equilibrium relate with qualities of product. Both price and quantity competitions have the same conclusion that quality of product as the important factor that affects profits of firms. However, consumer's concerns about product quality in the Bertrand model are greater than those in the Cournot model. This is because consumers will use price as a signal of quality of product, and thus price has the direct effect to the quality. When firms compete in price rather than quantity, consumers will see the price as the products' quality. If product quality of product goes to zero, firm cannot set its price, then its can not sell product to anyone. On the other hand, if firm compete in quantity that does not directly reflect quality. So, consumers have less concern about quality. When firm's quality is equal to zero, firm is still able to sell some of their product.

Solving the Nash equilibrium of this study, all results (quantity, price and profits) have unique solution. Given some restricted parameters, the result shows that the Cournot output of firm H is smaller than the Bertrand output; however, output of firm L in both cases is the same. The Cournot price is higher than the Bertrand price, and the Cournot profit is higher than the Bertrand profit. In addition, the quantities are positive and equilibrium prices in both games are greater than the unit cost. The results also show that the product differentiation allows firms to relax price competition rather than quantity competition (Shaked and Sutton, 1982). The price and quantity criteria will mainly depend on the quality of both firms.

Concerning consumer preferences, given $\overline{\theta}$, both taste parameters (θ_{HL}, θ_{0L}) in the Cournot case are greater than those in the Bertrand case. Below is figure 9 showing the level of both taste parameters in both competitions. When the initial level of taste parameter is zero and the fixed value of upper bound of taste parameter of both competitions is the same, the gap of each bound can estimate the size of consumers that are buying products in the market. The level of θ_{0L} in the Bertrand model is smaller than that in the Cournot model. That is, a number of consumers who do not buy a product in the price game is smaller than that in the quantity game. As a result, consumers in the price game consider more about the quality of the products and product differentiation will persuade more consumers to stay in the market than in the quantity game.

The difference of both taste parameters represents the number of buyers preferring low-quality products. Because this difference is the same in both competitions, the numbers of buyers preferring low-quality products are equal too. The $\theta_{HL}^{Bertrand} - \theta_{L0}^{Bertrand} = \theta_{HL}^{Cournot} - \theta_{L0}^{Cournot} = \frac{(\overline{\theta} - c)v_H}{4v_H - v_L}$ is the volume of consumers' preference. Meanwhile, the number of buyers who prefer high-quality products in Bertrand is more than that in Cournot. This implies that consumers have more concerns about the product's quality differentiation in the price game than in the quantity game.

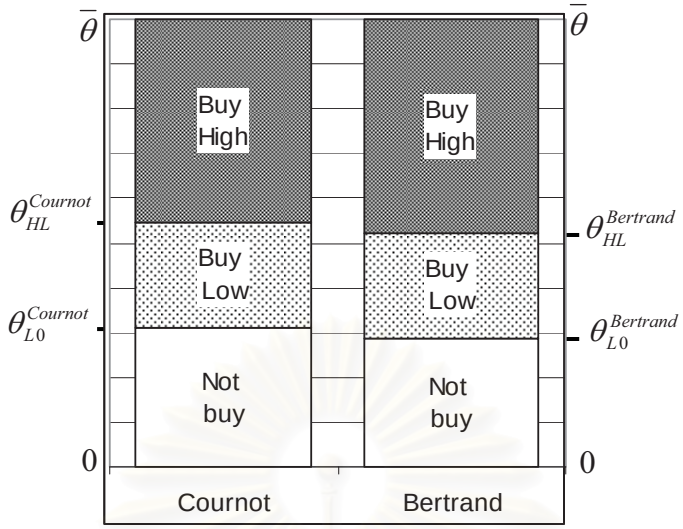


Figure 9 Levels of both taste parameters in price and quantity competition

Regarding the social welfare, consumer surplus in the Bertrand case is higher than that in the Cournot case. Because more consumers will be interested in vertical product differentiation, they tend to choose the best quality of product they buy and thus social welfare increases. Nevertheless, the profit of both firms are in contradiction with consumer surplus, so policy makers have to make the decision based on the trade off between these solutions and select the better competition to both agents.

In sum, this chapter has explored quality-setting model without considers the quality uncertainty concepts. The quality of products plays the important role on this competition model. Both the price and the quantity game have unique solutions when firms certain in the product's quality they produce and thus consumers choose the best quality of product they want to buy. Although in the real world, quality uncertainty can happen when some consumers have incomplete information in product's quality. While the next chapter will consider quality uncertainty that firm creates to deceive some uninformed consumers. Like this section, chapter 4 assumes duopoly firms and aims to explain only firm behaviors in the competition.

CHAPTER IV

THE COMPETITIVE MODEL WITH QUALITY UNCERTIANTY

The study in previous chapter shows the results of the Nash equilibrium in which consumers can distinguish between the product of which one has high quality and that another has low quality. Quality uncertainty does not exist. In fact, it is costly or impossible for some consumers to learn the true quality of an item before making a decision whether to buy it. They will use the products' price as the signal of quality and make their decision based on the price strategy. The price competition results are more sensitive to changes from equilibrium when uncertainty can affect quality than in the quantity competition. For this reason, this section considers only the price competition and uses a very simple information structure for consumers who attempt to distinguish between high and low-quality products.

There are two types of consumers, connoisseurs (informed consumers) and dilettantes (uninformed consumers). An informed buyer always knows the true quality of the firm that they are buying from. On the other hand, an uninformed buyer can only tell these firms apart if they are charging different prices; otherwise, uninformed buyer will face "quality uncertainty". If two firms charge the same price, the dilettantes will be unable to distinguish the high-quality product from the low one, at least until after the purchase. This study allows uninformed consumers to infer information when different price are charged since quality may be learned much more easily in markets where prices convey information. Thus, quality is either positively or negatively related to their price. The assumption here is that when prices of both firms are the same, the uninformed consumers would need costly additional work to distinguish a high-quality product from a low quality one.

Since there are two types of consumers in the market, this chapter analyzes firms' profit and welfare of consumers at equilibrium in different conditions. First, all buyers in the market are informed. Second, all buyers are uninformed. Last, some of them are uninformed. Before finishing this chapter, the study randomly chooses some

variables that have important effects on the equilibrium to investigate to find the pattern of competition outcomes.

The fraction of uninformed consumers in the market is λ, hence $0 \leq \lambda \leq 1$. Figure 10 shows that both types of consumers contain buyers' who prefer either high quality or low-quality product. In terms of tastes, uninformed consumers are drawn uniformly preference like informed ones. This means both types of buyers may care about quality. For example, in the automobile market, all consumers care about safety and reliability. However, connoisseur consumers have better information about quality than dilettante consumers. The full-informed buyers can always tell the firms apart, whether the prices are the same or not. Only the situation where producers set different prices reflecting to the product's quality, uninformed buyers can recognize the firms.

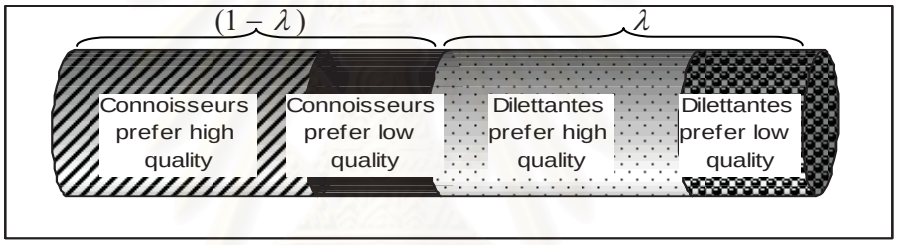


Figure 10 Fraction of each type of consumers in high and low-quality products

Recall the results of the Bertrand competition in chapter 3, firm L has a lower profit than firm H because it sets its price differently from firm H. Consumers can notice the price signal and know that the quality is different. Therefore, firm L gets disadvantage outcomes in the game. Both firms know that consumers use price as a signal for quality. Thus, firm L uses price strategy to increase its profit. Firm L has two strategies to react firm H in game. One, firm L sets its price differently to consumers to reflect the quality difference (separating price strategy). Second firm L sets the same price with firm H to deceive some uninformed consumers (pooling price strategy). Let the superscripts P and S indicate pooling and separating, respectively. When firm L uses pooling price strategy, there is quality uncertainty in the market. The uninformed buyers will face difficulty to recognize each product's qualities. This uncertain in quality will affect on firm H's outcomes of the competition because uninformed consumers does not have skill to distinguish both qualities. Firm H's will lose some buyers to firm L.

Consequently, firm L's strategies (separating price or pooling price) have a direct effect to firm H's profit.

When both firms know that firm L aims to make dissimilar profits' of firm H. Then, the famous question will be what is strategy that firm L will use. Firm L must consider the fraction of uninformed consumers in the market before selecting its strategy. If market full contains of informed consumers, firm L will not choose pooling price strategy because consumers will know that firm L deceives them. On the other hand, if all consumers are uninformed, it is the best choice for firm L to choose pooling price strategy. Moreover, there is another significant factor should be considered together with fraction of uninformed. It is the probability that firm L will successfully deceive uninformed consumers. Therefore, this chapter aims to examine the effect of quality uncertainty on market with different fraction of uninformed buyers by simultaneously considering this probability.

4.1 Competitive game with only informed consumers

If the market has only informed consumers ($\lambda = 0$), then both firms will know that all consumers have full information about quality. Firm L will not use pooling price strategy because no consumers willing buy its product. Both firms will set their price differently with their quality. The game has no quality uncertainty. However, the probability that firm L will successfully deceive uninformed consumers will not be considered because no consumers are deceived. This action will bring the equilibrium solutions will remain the same as in chapter 3. When all consumers are informed, firms will use separating price strategy. As a result, the firm that produces higher quality product will gain more profit than the one that produces low-quality product.

4.2 Competitive game with only uninformed consumers

When all consumers in the market are uninformed buyers ($\lambda = 1$), consumers does not have the skill to differentiate between the qualities of the products. They will guess quality based on the products' price and purchase goods according with their

preference. Firm L knows that all consumers are dilettantes. It, therefore, chooses price strategies to increase its profit.

If firm L uses the separating price strategy, the dilettantes can only tell these producers apart because sellers charge different prices for different product qualities. The game has no quality uncertainty, and their purchase decisions will be the same as those of the connoisseurs. When separating price strategy is used for both types of consumers, the demand function for both firms is equation 3 because consumers can specify the quality clearly from different price. The results of competition when firm L use the separating price strategy are thus the same as in chapter 3.

On the other hand, if firm L uses a pooling price strategy, $p_L = p_H$, in the market that all consumers are uninformed, they can recognize the producer. This is because consumers will not clearly see the difference of product quality and they are willing to pay the same price: p_H. So, consumers will expect the quality of both firms' products to be the same and be equal to the average of high-low quality: $v_E = \frac{v_H + v_L}{2}$. The utility function is

$$u_{ij} = \theta_i v_E - p_j \qquad (19)$$

For this situation, the taste parameter of consumers will be one level: θ_{0E}. This taste parameter denotes the taste parameter of consumers who are indifferent between buying expected quality or not. Like the decision making above, consumers will select the products that have a reserve price greater than the actual price. More formally, when all consumers face a single price, p_H, an uninformed buyer will buy if $\theta_{0E} v_E \geq p_H$; otherwise he will not buy it.

Although, if product quality of firm L is lower than the expected quality, firm L will try to mislead some consumers that its quality is the same as expected. The techniques to trick an uninformed consumer include advertisement or giving misleading information to consumers. The probability that firm L will successfully deceive consumers is α. If α =0, it means that no uninformed consumers will be deceived by firm L. On the other hand if $\alpha = 1$, it means that all uninformed consumes will be deceived by firm L. This

probability is an important factor that firm L concerns before choosing its strategy. Even though all consumers are uninformed, but this probability can be equal to zero, and no one will buy product from firm L. So, the probability of firm L's deceive should be considered into profit functions. These profit functions are

$$\pi_H^P = (1-\alpha)[\bar{\theta} - \theta_{0E}] = (1-\alpha)(\bar{\theta} - \frac{p_H}{v_E})(p_H - cv_H)$$

$$\pi_L^P = \alpha[\bar{\theta} - \theta_{0E}] = \alpha(\bar{\theta} - \frac{p_H}{v_E})(p_H - cv_L) \quad (20)$$

At equilibrium both prices are similar and equal to $\frac{v_e(\bar{\theta}-c)}{2}$. The equilibrium profits of firms depend on the value of α, the upper bound of taste parameter, the marginal costs of firms, the expected quality and its actual quality. If probability of firm L's deceiving: α is equal to 0.5, so both firms will receive the same market share but the cost for both firms is different. Firm H will have higher costs than firm L, and then firm H gain less pooling profits than firm L.

In this situation, a surplus of consumers depends on the value of α too. If the value of α is high, more consumers will be deceived by firm L. They actually receive the products that have a lower quality than the expected quality. They will suffer more from consuming the low-quality product with higher price. This utility of consumers will be negative. Consumer surplus is worse off.

4.3 Competitive game with some uninformed consumers

When the market has both types of consumers and λ is the fraction of uninformed consumers, the competition game will have two parts. The first part is for connoisseur consumers who behave in a certain way. They choose truly quality of firms because they have full information about quality. And they do not purchase a product of which price is higher than its proper quality. Although, the second part is for dilettante consumers who will be faced a situation where both producers set the same price. This group of consumers will face the quality uncertainty and are possible deceived by firm L. The dilettantes are forced to choose a producer randomly, and only purchase the

goods if their expected utility of this random purchase is non negative. The probability that firm L will successfully trick some dilettante consumers is α.

In this framework, the sequential price-setting rule is appropriate to explain the behavior of both firms. With the possibility of firm L fooling some consumers, firm L has an incentive to wait until firm H has already set its price and then firm L will set its price. In the extreme case that all consumers are dilettantes, firm L has nothing to lose by waiting for firm H to set its price first since no dilettante will buy from firm L if the prices are different. While firm H often has little to lose by going first. This instance is price leadership by firm H in the market. Thus, in the next step firm H will consider firm L's strategy and set the price to maximize its profit against firm L's price strategy (firm H's re-response). This game is called sub-game competition equilibrium of both firms where firm L sets its strategy based on firm H's historical price first and then firm H takes account of firm L's strategy to maximize its profits.

4.3.1 Firm L's response

About firm L's benefits, when it is firm L's turn to set prices, it knows that it can choose a pooling or separating equilibrium. If firm L chooses a separating equilibrium, then all consumers (both informed and uninformed) will be able to tell the producers apart, and firm L's profits will then be the same as what is shown in chapter 3. Then, firm L's price and profit in terms of firm H's price are

$$p_L^S = p_L = \frac{(p_H - cv_H)v_L}{2v_H} \tag{21}$$

$$\pi_L^S = \pi_L = \frac{(p_H - cv_H)^2 v_L}{4v_H(v_H - v_L)} \tag{22}$$

If firm L deceives consumers by setting the same price equal to firm H's price, the equilibrium will be a pooling equilibrium. Uninformed consumers who count for λ, a ratio to all consumers have a utility function shown in equation 19 and the profit function of firm L that is made up of uninformed will be

$$\pi_L^P = \alpha\lambda(\bar{\theta} - \frac{p_H}{v_E})(p_H - cv_L) \quad ; v_E = \frac{v_H + v_L}{2} \tag{23}$$

This profit function depends only on the purchase of uninformed consumers. Informed consumers that prefer low-quality product will not buy product of firm L as they think that the price of a low-quality product is too high relative to its quality. There is no maximum in equation 23 since there is only one pooling price, $p_L = p_H$. If firm L selects the pooling price, it will only sell to uninformed buyers who have positive expected utility for purchasing the good. The (1-α) of these uninformed consumers will not be deceived by firm L as they choose high-quality products. The proportion α of the uninformed consumers will be deceived by firm L as they choose low-quality product.

Firm L's decision, then, is made on whether to choose the separating profits given in equation 22 or the pooling profits given in equation 23. With the ratio of high to low product quality: r, defined that $v_H = r\, v_L$, firm L will choose the separating profits, and a separating equilibrium will result if $\pi_L^S \geq \pi_L^P$. This condition implies that

$$p_H \geq \frac{\left[\begin{array}{l} crv_L^2(r+1) + 4\alpha c\lambda r v_L^2(r-1) + 2\alpha\lambda r v_L^2 \overline{\theta}(r^2-1) + \\ \sqrt{\{rv_L^4\{-c(r+1)[1+r+8\alpha\lambda r(r-1)][cr+4\alpha\lambda\overline{\theta}(r-1)] + \\ r[c(1+4\alpha\lambda(r-1)+r)+2\alpha\lambda\overline{\theta}(r^2-1)]^2\}\}} \end{array}\right]}{v_L(1+r+8\alpha\lambda r(r-1))} \qquad (24)$$

As equation 24 is very complicated, so this study tests for the positive value in parentheses. The results show that if $r \geq 2 \cap \overline{\theta} \geq 1.19c \cap \alpha \geq \frac{0.25}{\lambda}$, the value in parentheses will be positive that means equation 24 would be positive, too. That is, there will be a cut-off level of p_H, with above which firm L will always prefer to separate price strategy. At below the cut-off level firm L will prefer pooling price strategy while at the cut-off level firm L will be indifferent. The intuition for this is straightforward: firm L's optimal separating price is always a proportion of p_H, so when p_H is low, firm L's separating profits will be low as well.

Figure 11 shows the optimal separating profits compared to pooling profits as a function of p_H as a special case. As p_H rises, the separating profits with stand at $p_H = p_H^{S*} = c$ and then it rises monotonically, whereas the pooling profits first rises and then falls as is typical for a monopoly. Although the pooling profits will set the price at $p_H = p_H^{P*} = 0.5c$. When the price of high-quality product increases

until $p_H = p_H^{p***} = 0.75\bar{\theta}$, the separating profit will be a large amount and firm L will not choose the pooling price strategy. As shown in figure 11, the pooling profits reach their maximum at $\pi_L^{P*} = 0.02(1.5\bar{\theta} - c)^2$ where $p_H = p_H^{P**} = \frac{(c + 1.5\bar{\theta})}{4}$.

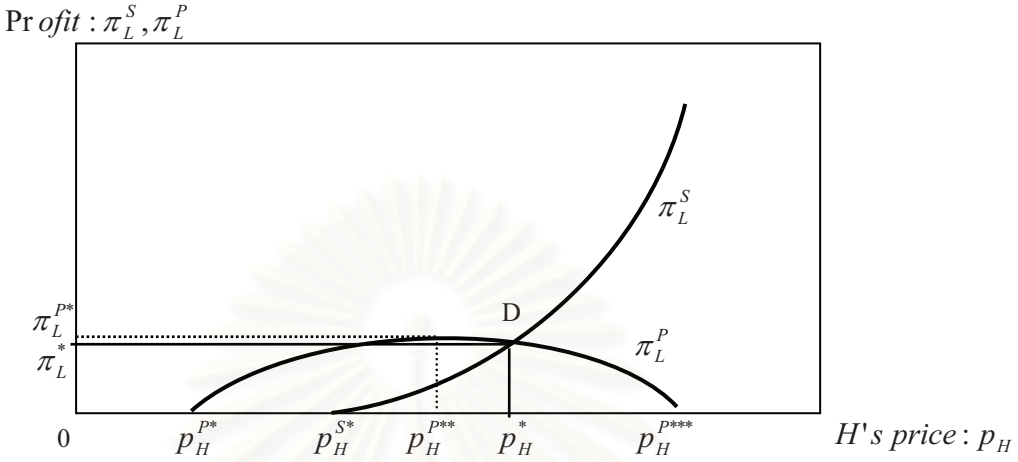


Figure 11 Profits for firm L as a function on firm H's price

Theses two curves intersect at point D where $p_H = p_H^*$. At this point both separating profit and pooling profit of firm L will be the same and have profit value are equal to $\pi_L^* = 0.25\left(0.43c - 0.21\bar{\theta} - 0.14\sqrt{2.25\bar{\theta}^2 + 1.5c\bar{\theta} - 5c^2}\right)^2$.

Because π_L^S is the profit of firm L when the market does not have quality uncertainty. For the low levels of p_H, firm L is better off to use pooling price strategy because the low price set by firm H does not leave much room for firm L to earn profits by attracting low preference customers with a spill lower price. Firm L is thus better off at the old equilibrium.

4.3.2 Firm H's re-response

The next step is to solve for firm H's optimal p_H, given firm L's known optimal response. Firm H knows that its act can bring about either a pooling or separating equilibrium, depending on its choice of p_H. Firm H's optimal price is defined by solving its for the maximum profit of both separating and pooling equilibriums. When firm H chooses an optimal separating price of firm L, it maximize

$$\pi_H^S = (\bar{\theta} - \frac{p_H - p_L^S}{v_H - v_L})(p_H - cv_H) \qquad subject\ to\ p_H \geq p_H^* \tag{25}$$

The constraint must be included because if firm H sets its price lower than p_H^* (that is too low), then firm L will choose to use the pooling price strategy. If firm L chooses this strategy, firm H will have part of both informed and uninformed consumers in its profits function. All informed consumers that have $(1-\lambda)$ ratio to all consumers will purchase the high-quality products and $(1-\alpha)$ of uninformed consumers will buy the low-quality product because these consumers can be deceived by firm L. To simplify the analysis on equation 25, the equation is rewritten with the ratio of high to low quality. Then, firm H's price and profit when firm L applies separating price strategy are

$$p_H^S = \frac{rv_L(r-1)(\bar{\theta}+c)}{2r-1} \tag{26}$$

$$\pi_H^S = \frac{rv_L(\bar{\theta}+cr-r\bar{\theta})^2}{4r^2-6r+2} \tag{27}$$

This separating price of firm H will be greater than the constraint price. This ensures that if the price of firm H is over p_H^*, firm L will use a separating price strategy to get a higher profit. To attain optimal pooling profits, firm H must maximize

$$\pi_H^P = (1-\lambda)(\bar{\theta}-\frac{p_H}{v_H})(p_H-cv_H)+(1-\alpha)\lambda(\bar{\theta}-\frac{2p_H}{v_H+v_L})(p_H-cv_H) \tag{28}$$
$$subject\,to\ p_H \le p_H^*$$

The first term in equation 28 is firm H's profits obtained from selling products to connoisseurs. The lower bound of taste parameter in this term changes from $\frac{p_H-p_L}{v_H-v_L}$ (as it was in chapter 3), to $\frac{p_H}{v_H}$. The second term is firm H's profits obtained from selling products to dilettantes, another group of consumers in the market. Firm H has to share this market with firm L. Here, the constraint ensures that firm H chooses a price low enough to have firm L will actually choose to pool. A pooling (separating) equilibrium is a constraint if firm H's profits cannot be pushed higher without inducing firm L to separate (pool). The pooling price when firm L uses a pooling price strategy is

$$p_H^P = \frac{rv_L\left[c(r-\lambda+1-2\alpha\lambda r+\lambda r)+\bar{\theta}(\alpha\lambda-1)(r+1)\right]}{2(r-\lambda+1-2\alpha\lambda r+\lambda r)} \tag{29}$$

The profit of firm H when a pooling price strategy is

$$\pi_H^P = \frac{rv_L\left[c(r-\lambda+1-2\alpha\lambda r+\lambda r)+\bar{\theta}(\alpha\lambda-1)(r+1)\right]^2}{4(r-\lambda+1-2\alpha\lambda r+\lambda r)(r+1)} \tag{30}$$

If firm H's separating profits as shown in equation 27 are higher than its pooling profits (equation 30), then firm H will choose the higher price in a separating equilibrium. If

separating profits are lower, then firm H choose the optimal pooling price, and quality will beget quantity. Whenever the duopolies have relatively close qualities, the equilibrium will be a pooling equilibrium. The intuition is simple. As qualities converge, the competition becomes more intense in the separating equilibrium. Both firms will set the prices lower, and profits for both firms will fall. At the limit, profits fall to zero due to a sequential-move variant of the Bertrand competition. Thus, firm H has an incentive to try to reduce this competition by avoiding the low-profit separating equilibrium. Firm H does this by setting a price so low that firm L might as well engage in a pooling equilibrium.

4.3.3 Social welfare with quality uncertainty

The social welfare of consumers is derived by integrating the utility function depending on levels of taste parameter. If firm L uses a separating price strategy, consumer surplus is in the same as equation 9. However, if firm L wants to cheat uninformed consumers by using a pooling price strategy. Informed consumers who prefer a high-quality product will buy from a high quality firm selling high-quality products but the people who prefer a low-quality product will leave go out from the market because the price is high but the quality is low. For uninformed consumers, consumers face θ_{0E} as the taste parameter that consumers will be faced with. Then, the consumer surplus can be divided into three parts. First is connoisseurs depended part holding a fraction equal to $(1-\lambda)$. The last two parts are dilettantes depended part that have firm L's deceived probability in the functions. Especially, the second part explains the effect of uninformed consumers who cannot be deceived by firm L. They buy a product having reasonable quality than they expected, $v_H > v_E$. On the other hand, the third part explains the effect of uninformed consumers who are deceived. These consumers buy a product that has a lower quality than they expected.

$$CS = \{(1-\lambda)(\int_{\theta_{0H}}^{\bar{\theta}} [\theta v_H - p_H]d\theta)\} + \{(1-\alpha)\lambda(\int_{\theta_{0E}}^{\bar{\theta}} [\theta v_H - p_H]d\theta)\} + \{\alpha\lambda(\int_{\theta_{0E}}^{\bar{\theta}} [\theta v_L - p_H]d\theta)\}$$

$$= (1-\lambda)\left[v_H \frac{\bar{\theta}^2}{2} - p_H\bar{\theta} - v_H \frac{\theta_{0H}^2}{2} + p_H\theta_{0H} \right] + (1-\alpha)\lambda\left[v_H \frac{\bar{\theta}^2}{2} - p_H\bar{\theta} - v_H \frac{\theta_{0E}^2}{2} + p_H\theta_{0E} \right] \quad (31)$$

$$+ \alpha\lambda\left[v_L \frac{\bar{\theta}^2}{2} - p_H\bar{\theta} - v_L \frac{\theta_{0E}^2}{2} + p_H\theta_{0E} \right] \quad ; \theta_{0H} = \frac{p_H}{v_H} \; and \; \theta_{0E} = \frac{p_E}{v_E}$$

The consumer surplus equation contains more unobserved variables, so this study uses imitation methods to simulate these unobserved variables by setting the value with in a possible range. And then, both profits and consumers surplus are found for each situation that will occur in the market

4.4 Competitive equilibrium with quality uncertainty

As have just been mentioned, the outcomes in the section above include unobserved values. So, it is difficult to explore their influence on equilibrium. Therefore, this section aims to replicate the values of these unobserved variable at different level of firm H's price to find competitive equilibrium with quality uncertainty as well as the effects on both firms' profits and social welfare shown in equations 22, 23, 27, 30 and 31. When this study simulates all variables that will be in their possible range, the behavior of equilibrium outcomes will be explained. There are 6 unnoticeable factors in both profits and consumers surplus equations, namely $\overline{\theta}, c, v_L, r, \lambda$ and α. The detail, meaning and possible ranges of them are listed in table 2.

Table 2 Detail of unobservable variables in profits functions and consumers surplus

Variables	Description	Range
$\overline{\theta}$	Upper bound of consumer's taste parameter	≥ 1
c	Firms' marginal cost that fixed with period	$0<c<1$
v_L	Quality of firm L	>0
r	Ratio of high-low quality	>1
λ	Fraction of dilettantes	$0 \leq \lambda \leq 1$
α	Probability that firm L will success trick some uninformed	$0 \leq \alpha \leq 1$

From previous results, the effects of $\overline{\theta}, c \; and \; v_L$ are exogenous unobserved variables that both consumers and firms do not decide to force them. These variables will only increase or decrease the absolute value of profit and welfare. They do not change the curves. They do not have the outstanding effects on the competitive equilibrium. To reduce the unknown effects, this section sets the value of $\overline{\theta}, c \; and \; v_L$. After giving the certain value to these variables, both firms' profits and social welfare

equations have become simpler. Providing the unobserved values, the detail, meaning and range of them will be considered. The upper bound of consumers' taste parameter: $\overline{\theta}$, represents the highest preference of consumers in the market, so firms can not be directly forced to it. This section will mark this value to simplify the model by fixed $\overline{\theta}$=1. In addition, the marginal cost: c is kept constant in a short period of production. The main factors that change marginal cost are major change in engine and reformation of factory. This section assumes that marginal cost in this period is fixed with the value 0.1.

Another exogenous variable is the products quality of firm L, v_L. This variable is the minimum quality in market so it is a qualitative variable. However, many studies try to measure the quality of product into the quantitative variable. Confirmatory factor analysis is a method to measure this attribute. When computing quality choice, there are serious problem about the unit measurement to measure this variable. To find the behavior of firms' quality to profit results, this study uses a special case that sets $v_H = 1$. It means that this study mentions the fixed in the highest quality and then allows the flexible in the low quality. So in this section, the effect of firm's qualities can be explained through the ratio of high to low qualities: r instead of direct value of quality.

Regarding other variables r, λ, and α, these variables are interested because they have direct effect on pooling profits of both firms and can change the curve of firms' profits. In the imitation process, their values are varied to find the behaviors of equilibrium outcomes. Because of there are three variables to be considered, this study investigates four cases of imitation. In case 1, the value of r which can affects all profits is simulated by setting value of both λ and α are equal to 0.5. That is, the proportions of informed and uninformed consumers in the market are assumed to be the same. Additionally, the probability that firm L will successfully deceive the dilettantes is set at 0.5. In case 2, this study replicates λ's values is replicated by fixing the value of r equal to 2.35 at which separating and pooling profits of firm H are the same, and α is equal to 0.5. From this case, there are two extreme points of imitation that are so interesting. These two extreme points are λ=0 and λ=1. When λ=0, all consumers are informed consumers. The equilibrium solutions will be the same as in section 4.1. The result

shows that the probability that firm L will successfully deceive uninformed consumers cannot affect these outcomes. In the game that all consumers are uninformed (λ =1), changing value of α will have more influence to the equilibrium.

Emphasizing the effect of α on competition results, its value are imitated in case 3 and the fluctuation of profits and welfare of consumers are found. In this case, this study sets both values of r and λ are equal to 2.35 and 0.5, respectively. Changing the value of α represents the deceiving power of firm L to uninformed consumers. High values of α represents more success of firm L in deceiving dilettantes. If α is equal to zero, it means that firm L will not able to deceive anyone in the market. When all consumers are uninformed, the outcomes can be affected more. Case 4 is thus a special case where (λ =1) and then switch value of α to analyze the competition solutions.

As a result of imitation, the value of r (case 1) is shown in figure 12. Assuming value of r is equal to 1.1, this small value demonstrates that the gap from high quality to low quality is very small (only 0.1). In figure 12(a), firm L's pooling profit is a pink line and separating profit is a red line. The curve of both pooling and separating profits of firm L agree with figure 11 (the mathematic approach).

At point $p_H \leq p_H^*$, the pooling profit of firm L is greater than the separating profit. On the other hand, after point $p_H \geq p_H^*$, the separating profit sharply increases and is greater than the pooling profit. When $r = 1.1$, the quality ratio is too small, and thus the separating profit of firm H (a dark blue line) is less than zero. When the price of high-quality products increases, the separating profit of firm H is lower. As consumers know that the high quality is not much different from the low one, consumers will buy the low-quality product instead when the price of high-quality product is very high.

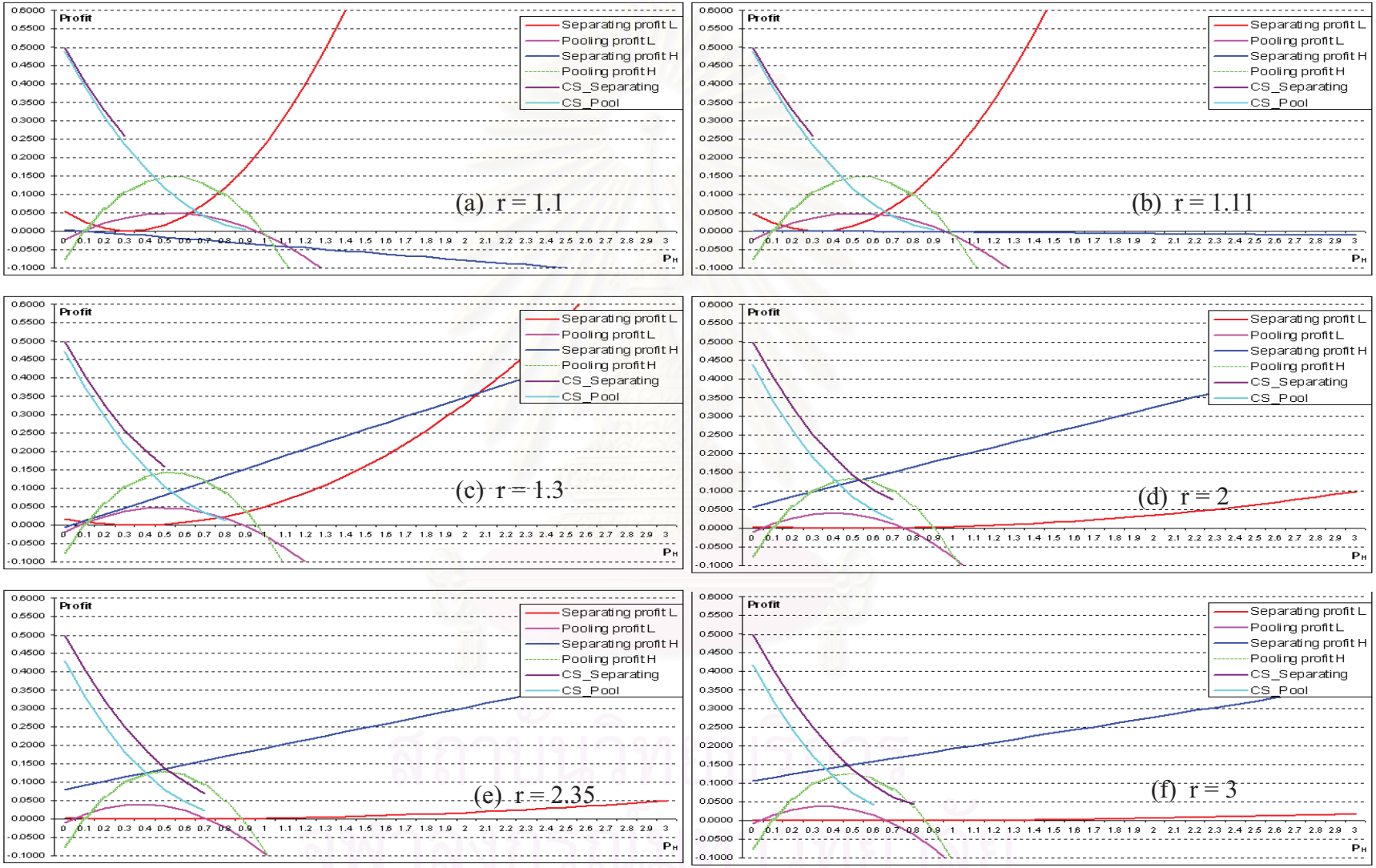


Figure 12 Profits and consumers surplus with imitation in r given $\lambda = 0.5$ *and* $\alpha = 0.5$

In figure 12 (b), this study slightly raise the value of r to explore the effect on separating profit of firm H: (r=1.11). The result shows that the separating profit of firm H become positive value when value of r is slightly increased. When consumers acknowledge a distinct between high to low qualities, they will begin to buy products from both firms. However, the separating profit of firm L is little decreased because firm L loses their share to firm H when the increasing quality gap is realized by consumers.

Figures 12(c)-(f) show the effects of increases in value of r on both separating profits. When value of r rises, a little gap between both qualities will clearly affect consumers. Still, consumers notice the difference between these two qualities. The slope of the separating profit of firm H is increased but that of firm L's is decreased. Some high-quality products are more preferred by high preference consumers because they think a high price is reasonable for a high-quality product. The gap of separating profit of both firms will increase along with the qualities differentiation. When the degree of product differentiation is high, firm L gains less profit. The results on both separating profits agree with the result in chapter 3. More specifically, the profit of the firm that produces high-quality products is greater than the firm that produces low-quality product when price are not the same.

Figure 12(d) shows the result of setting firm H's pooling profit (a green line) is equal to its separating one. In this situation (r=2.35), there is a point where firm H is indifferent between choosing a separating and a pooling profit. To consider the curve of firm L's separating profit in this situation, is nearly horizontal. With a continuous raise in value of r to 3, the results shows that firm H's only strategy is to choose a separating profit because the entire range of the pooling profit is less than the separating profit. The gap of the separating profits of both firms is very wide. It shows that consumers acknowledge the difference of quality. Thus, firm H can set its price high concurring with its product quality, and make more profit.

When firm L uses a pooling price strategy and if both qualities are little different, the pooling profits for both firms look similar. Both pooling profits (firm H and firm L)

increase when the firms' product qualities increase (v_H *or* v_L increase). Given a fixed value of firm H's quality (v_H), when value of r is increased, there will be a decrease in v_L. Both pooling profits will decrease a little when v_L decreases. However, in all cases, the value of firm H's pooling profit is greater than firm L. These are caused by two factors: the fraction of uninformed consumers and the probability that firm L will successfully deceive uninformed consumers. Half of the consumers cannot distinguish the differences in qualities. Therefore, the shapes of both pooling profits are the same caused by the deceived dilettantes part in equations, but the higher level of pooling profit of firm H comes from the connoisseurs and non-deceivable dilettantes part.

To simulate consumers' surplus, this study considers both consumer surpluses when firm L uses a separating price, denoted by CS_separating (a purple line) and when firm L uses a pooling price denoted by CS_pooling (a light blue line), especially with the possible range of the taste parameter ($\theta_i \leq 1$). If the taste parameters are not in the possible area, the graph of the consumers' surplus will not exist. The consumer surplus imitation in figure 12 explains the behavior of r when value of λ and α are equal to 0.5. Both consumers' welfares are found to have negative slopes. The surpluses will decrease when the price of firm H's product increases. While the cost of purchase increases, consumers' wealth decreases as does their welfare.

By fixing value of v_H, increases in value of r induce a decrease in v_L. Figures 12 (a)-(f) show the characteristics of welfares. CS_seperating has not changed when value of r increases because firms will set the price according to its quality (price is different) and consumers will be clearly able to define both qualities (high or low). When quality decreases, price will decrease too. CS_seperating in all figures are the same. On the other hand, CS_pooling is different. If the value of r increases, the product quality of firm L and welfare of consumers will decreases. Due to firm L's adopting a pooling profit strategy, some uninformed consumers will be deceived by low quality firm. When firm L's product quality decreases while keeping its price is constant, consumers will suffer more by consuming bad quality product. The consumers' surplus will decrease more when they realize that the product quality they buy is worth less than they expected.

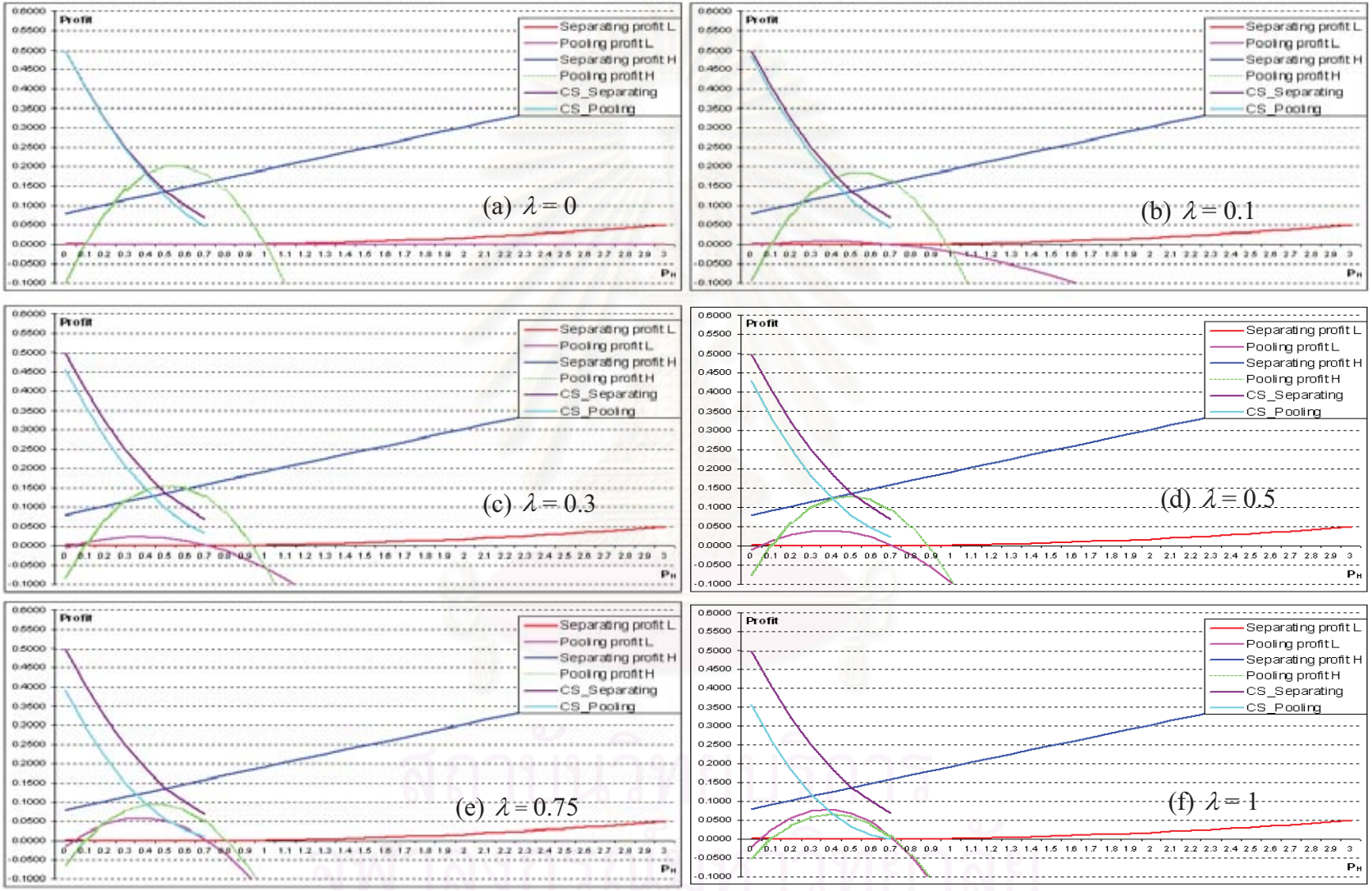


Figure 13 Profits and consumers surplus with imitation in value of λ given $r = 2.35$ *and* $\alpha = 0.5$

Considering figure 13, it shows the imitation the value of a fraction of uninformed consumers: λ that will affect the equilibrium results. Range of these λ's values is between zero and one. Concerning the actions of λ, the study sets the value of r equal to 2.35 at which the situation where firm H's separating and pooling profits are the same and the value of α is set to equal to 0.5. Changing value of λ can only change pooling profits of both firms and CS_pooling. When $\lambda = 0$, consumers in the market are informed consumers. Firm L therefore cannot use a pooling price strategy. Because there are no consumers will buy its product. This firm may be stubborn by using a pooling price strategy, but its pooling profit will be equal to zero. However, when the market has all informed buyers, the pooling profit of firm H will be the largest because when the price is the same, all informed buyers will buy from firm H.

On the other hand, when $\lambda = 1$, all consumers are uninformed. Then, the effect of firm L's deceiving power will be concerned. This case assumes that α is equal to 0.5. A half of uninformed consumers will be deceived by firm L. Thereby, when firm L uses a pooling price strategy in this situation, half of them will buy form the deceiving firm. Moreover, both firms will receive the same market share. From figure 13(f), the pooling profit of both firms looks alike. The difference in profits comes from the different costs. Firm H has higher costs than firm L, so it can make less profit. When all consumers in the market are dilettantes and the price is the same, both pooling profits will almost be the same. Even though the price of firm H's product is very high and marginal cost is equal to 0.1, both pooling profits' graphs are overlapping. Then, the different of both graphs caused by cost effect is decreasing. Pooling profits for both firms become equal at the firm H's high price, as shown in figure 13(f).

Figure 13(b)-(e) show the equilibrium outcomes when the value of λ increases. All graphs demonstrate that the pooling profit of firm H will decrease when the fraction of uninformed consumers increases. This can be explained in such a way that when more consumers do not have the complete information about qualities. They are misled easily by firm. The pooling profit of non-cheating firms will reduce whereas that of firm L will increase.

Without uninformed consumers in the market: $\lambda = 0$, CS_separating and CS_pooling are the same (the difference in both graphs at high price of firm H results comes from the decimal calculating). Like profits, λ will only affect the CS_pooling. If the number of uninformed buyers rises, CS_pooling will be more different from CS_separating. Its' value will sharply decrease. In a situation that all consumers in the market are dilettantes: $\lambda = 1$, the value of CS_pooling will be a half of CS_separating. This is caused by the deceiving power of firm L is 0.5.

Next, case 3 (figure 14) considers the effect on profits by simulating values of the probability that firm L will successfully deceiving dilettantes: α. Like behavior of λ, α only affects the pooling profit of both firms and its range is between zero and one. Like case2, this study sets both values of r and λ are equal to 2.35 and 0.5, respectively. If $\alpha = 0$, no dilettantes can be deceived by the fooling quality of firm L. From figure 14 (a), firm L cannot cheat anybody. The result shows that there is only a pooling profit of firm H. When prices are the same and consumers are not cheated, everybody will buy the product from firm H because of its higher quality. Although, for this situation, the value of firm H's pooling profits is less than case 2 (figure 13(a)).

Figures 14(b)-(d) show the increase in value of α due to an increase in the pooling profit of firm L, and a decrease in pooling profit of firm H. The deceiving power of firm L is raised by doing an advertisement or giving misleading information to consumers. This causes firm L gains more profit and due to less profit for firm H. In the extreme situation where $\alpha = 1$ shown in figure 14(e), all dilettantes can be deceived by firm L. The pooling profit of firm H will be a little higher than the pooling profit of firm L. This is because the pooling profits of firm H will contain the part of informed consumers purchasing. At the low level of p_H, the pooling profit of firm L is greater than that of firm H. This is because the lower price of firm H nearly fits with its' low-quality product. More consumers will choose the low-quality product.

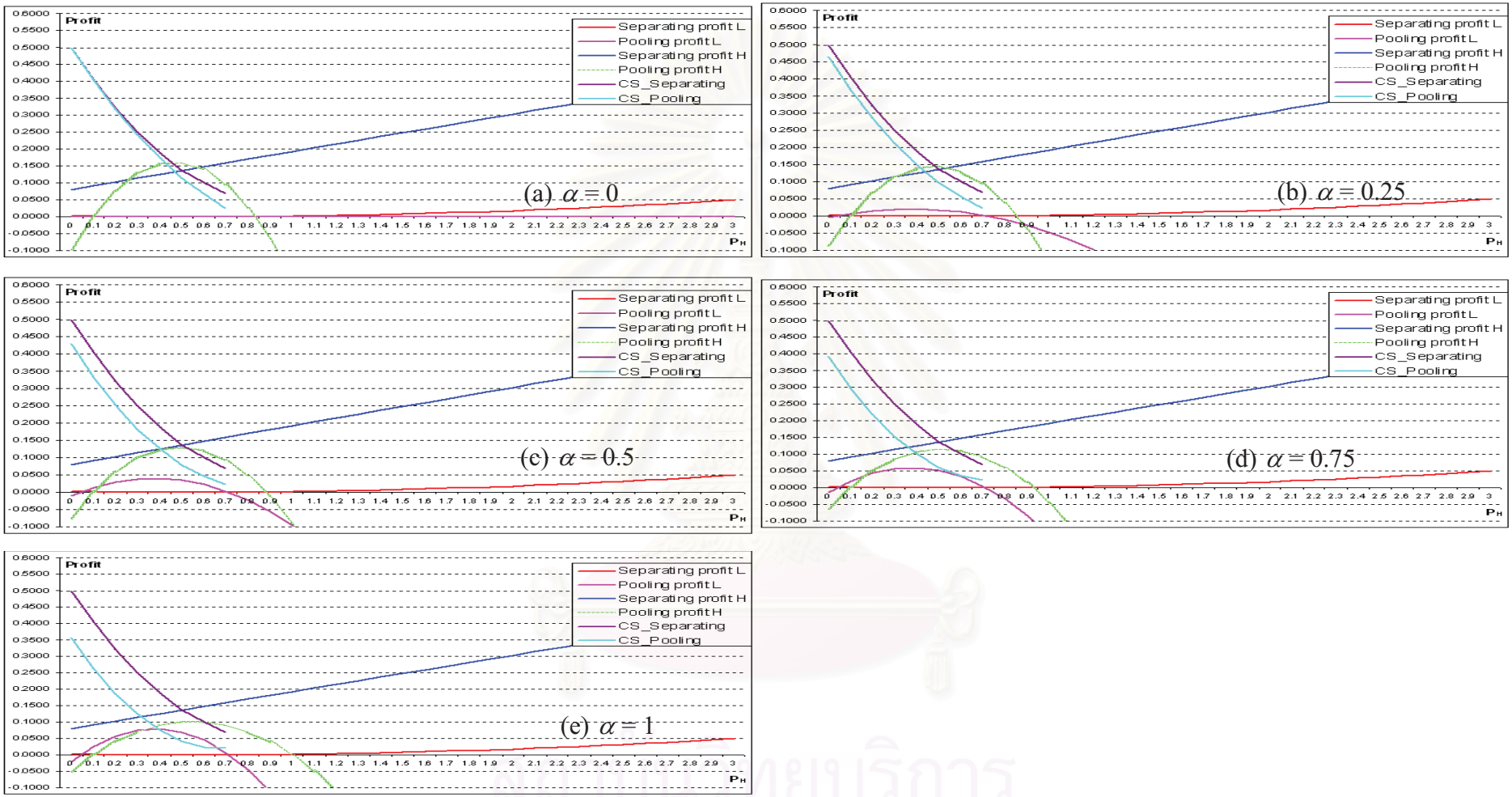


Figure 14 Profits and consumers surplus with imitation in value of α given $r = 2.35$ *and* $\lambda = 0.5$

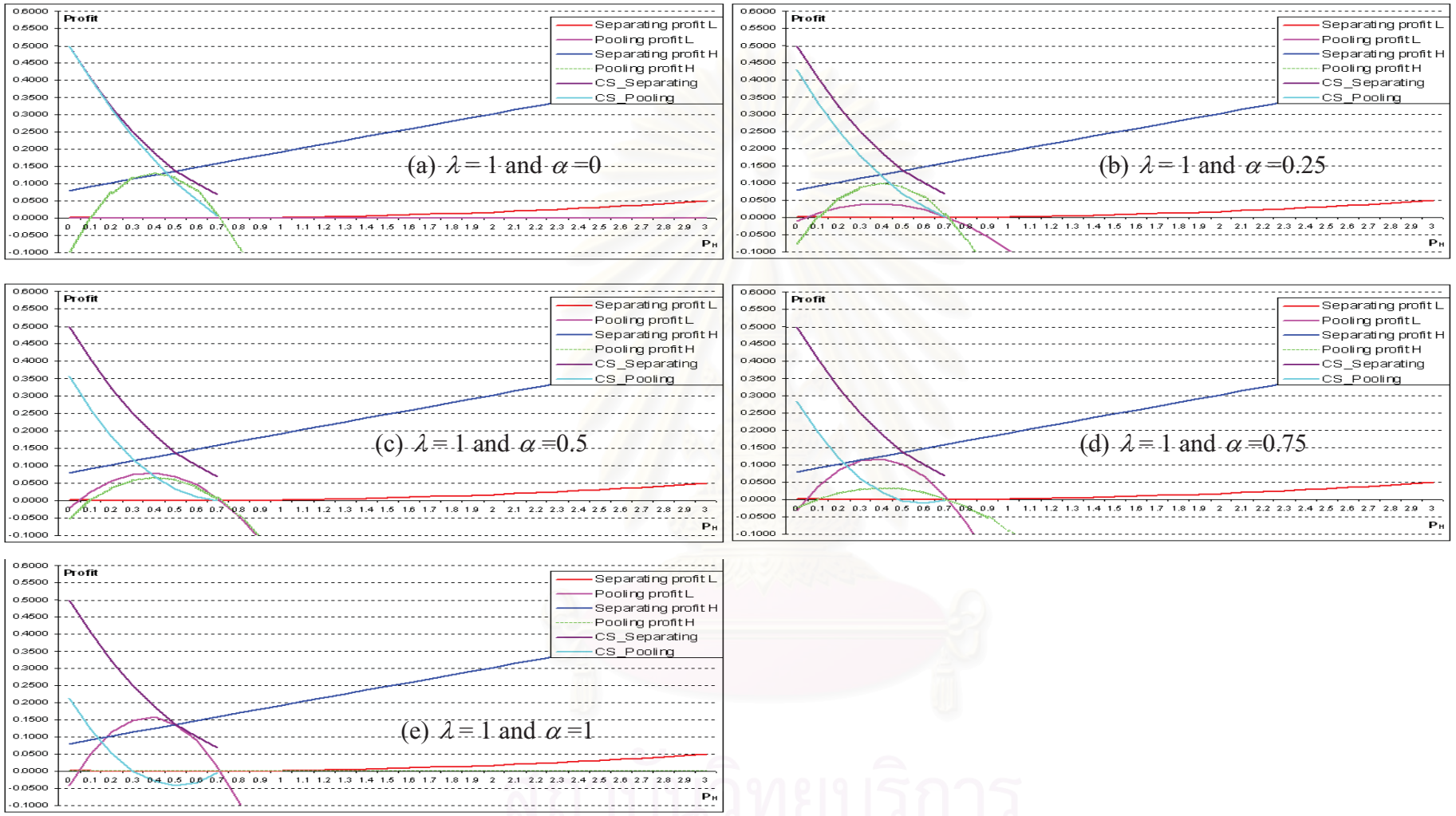


Figure 15 Profits and consumers surplus with imitation in value of α (only uninformed market) given $r = 2.35$

Welfare of consumers when a half of the buyers are uninformed will depend on the cheating power of firm L. When α=0, both surpluses will be the same. However, there are some uninformed consumers in the market that firm L can not deceive. So buyers can buy true quality with a reasonable price. Like behavior of λ, increasing in the value of α will affect only on CS_pooling. With an increase in α, pooling profits of firm L increases but that of firm H decreases.

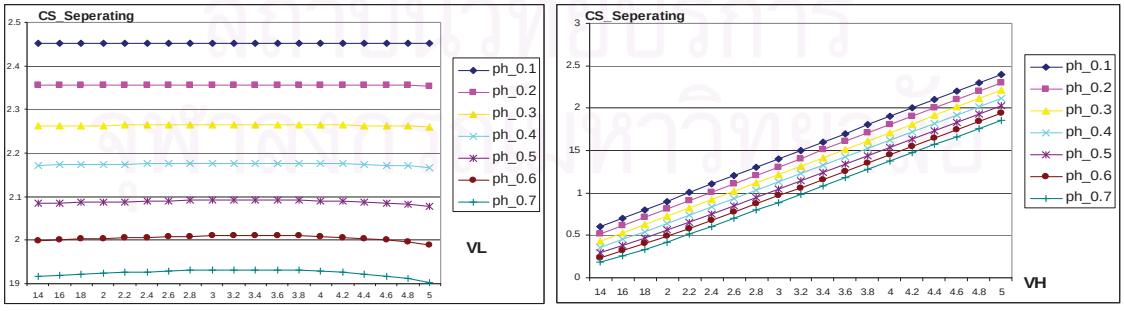
The special case: case 4 (figure 15) that considers the profits and welfare outcomes when the value of α is replicated for the market that has only uninformed consumers ($\lambda = 1$) given value of r is equal to 2.35. This situation does not have quality uncertainty. If the price is different, both separating profits are unchanged. But if firm L deceives its consumers by setting the same price, the solutions will depend on the deceiving power of firm L. When firm L can not cheat anybody, $\alpha = 0$ (figure 15(a)) and the prices are the same, there exists only a pooling profit of firm H in the market which value is less than case 3 (figure 14(a)), because there are not any informed consumers in this situation.

When value of α increases, firm L's pooling profit will increase. If α is less than 0.5, the pooling profit of firm L will be less than firm H but if α is greater than 0.5, the pooling profit of firm L will be larger. At the point that α=0.5, both pooling profits look alike. The slight difference between both graphs results comes from different costs of both firms. Firm H has higher costs than firm L, so it has less profit. In the extreme situation (figure 15(e)), firm L has full cheating power ($\alpha = 1$), so only the pooling profit of firm L will exist. The pooling profit of firm H is equal to zero because there is no informed consumer that knows the true qualities in the market and firm H cannot successfully show its quality to all uninformed buyers. In this case, the interesting issue is the value of firm H's pooling profit when α=0 as it is less than firm L's pooling profit when α=1. Because firm H has higher costs than firm L, so firm L has a big higher profit when there is only its product in the market.

When all consumers are dilettantes ($\lambda = 1$) is when value of α is greater than 0.5. It means that firm L can deceive more than half of all consumers. When the price of firm H is high, firm L therefore can deceive consumers with high price. Then, the mismatch between price and quality of firm L is much larger. Consumers will suffer, and the consumer surplus will tend to be reduced.

From all behavior of consumer surplus, the results show that most of consumers surpluses when both firms use separating price strategy is greater than consumers surplus when firm L use pooling price strategy. These actions will concern the policymakers to consider the factor that affects the consumer welfare when both firms use separating price strategy. Analyzing this surplus, all graphs of consumer surplus are look alike. Only an increase in p_H can decrease this welfare. In addition, an adjusting in quality of firm L's product has only small effect on the consumer welfare.

Figure 16 (a) shows that modifying the value of v_L does not change CS_separating in each level of p_H. Curve of this welfare at low p_H is linear in all level of quality of firm L. However, if p_H is high, CS_separating will be sharply decreasing with increases in v_L. That is, when firm H set a high price to find more profits, consumers in the market have less ability to consume them. They thus change their behavior to buy the low price product. If firm L tries to increase its quality to gain more profits simultaneously. Some consumers who have a very low preference cannot buy any product. Consequently, consumers surplus will decrease.



(a) (b)

Figure 16 Consumers surplus of firm H with quality of firms H and L

Considering the product quality of firm H instead of firm L, figure 16 (b) shows the relationship between CS_separating at each price of firm H and the product quality of firm H. All curves' slope is upward. This implies that when the quality of firm H increases, CS_serparating will increase.

All imitation result shows the possible situations that may occur in the real market. Quality of product will directly affect both the separating and pooling profits of both firms. The ratio of high to low quality is the main deciding factor that firm L will use in choosing between separating or pooling profit strategy. If the value of r increases, the degree of product differentiation will increase, firm L will try to use a pooling price strategy because its separating profit is very low. As a result, firm L will apply a pooling price strategy. As discussed in chapter 3, the possible range that firm L can apply pooling price strategy is limited by the price of firm H's product.

With regard to the effect of fraction of uninformed consumers, λ, and the probability that firm L is successfully cheat uninformed consumers, α, both factors only affect pooling profits of both firms. When value of λ increases, the pooling profit of firm H will decrease but that of firm L will increase. The value of λ will be rising until all of the market has only uninformed consumers ($\lambda = 1$), both pooling profits will be the same. Firm H and L will have the same profits. On the other hand, if the market has some part of informed consumers, the pooling profit of firm H will exist in the market at all levels of α. In contrast, if there is an extreme case that the market has only uninformed consumers and firm L has full deceivable power, firm H does not gain any profit from the competition.

The study above shows the characteristics of both profits and welfare of consumers with at each levels of firm's H price. The pattern of pooling profit and separating profits of both firms agrees with the mathematic approach shown in figure 11. If price of both firms are at equilibrium as shown in equation 29, the profits and consumers surplus are affected by the ratio of high to low quality, the fraction of

uninformed and the probability of firm L will successfully deceive uninformed consumers.

The competitive equilibrium when the price of firm H is set with the Nash equilibrium condition is illustrated in figure 17. It shows the plots of equilibrium profits, consumer surplus and welfare for social. The x axis in each graphs show the effects of increases in the ratio of high to low quality. When r increases, all profits increases with the decreasing rate. Each column of graphs shows the cases with the same value of the fraction of uninformed. The first column shows the case of that all consumers are informed (λ=0). The second and third columns show the case of that a half of consumers are uninformed and the case of that all consumers are uninformed. The horizontal rows of graphs show the case with the same value of the cheating power of firm L. The first, second and thirds rows refer the case that no uninformed consumers will be deceived by firm L, that a half of them will be deceived by firm L and that all of them will be deceived by firm L.

Regarding the consumers' perspective at the Nash equilibrium, consumer surplus will decrease when the degree of product differentiation increases. Moreover, the consumer surplus when firm L uses a separating price strategy is certain in all stage and its value is more than the consumer surplus when firm L uses a pooling price strategy. Even though in firm L's view, it is different. Meanwhile, firm L considers both the fraction of uninformed consumers in the market and the power of deceiving uninformed consumers. As shown in the graph, if all consumers are informed or the power of cheating is equal to zero, firm L will use a separating price strategy. This is because at the equilibrium firm L's separating profit is greater than firm L's pooling profit at all levels of product differentiation. Moreover, if firm L chooses a pooling price strategy, it will lose some consumers to firm H. This is because consumers who have full information about both qualities will not choose firm L's product. Then, firm H will be forced to have separating profits, too. Welfare of both agents is high in this case and has a certain value across all degrees of product differentiation.

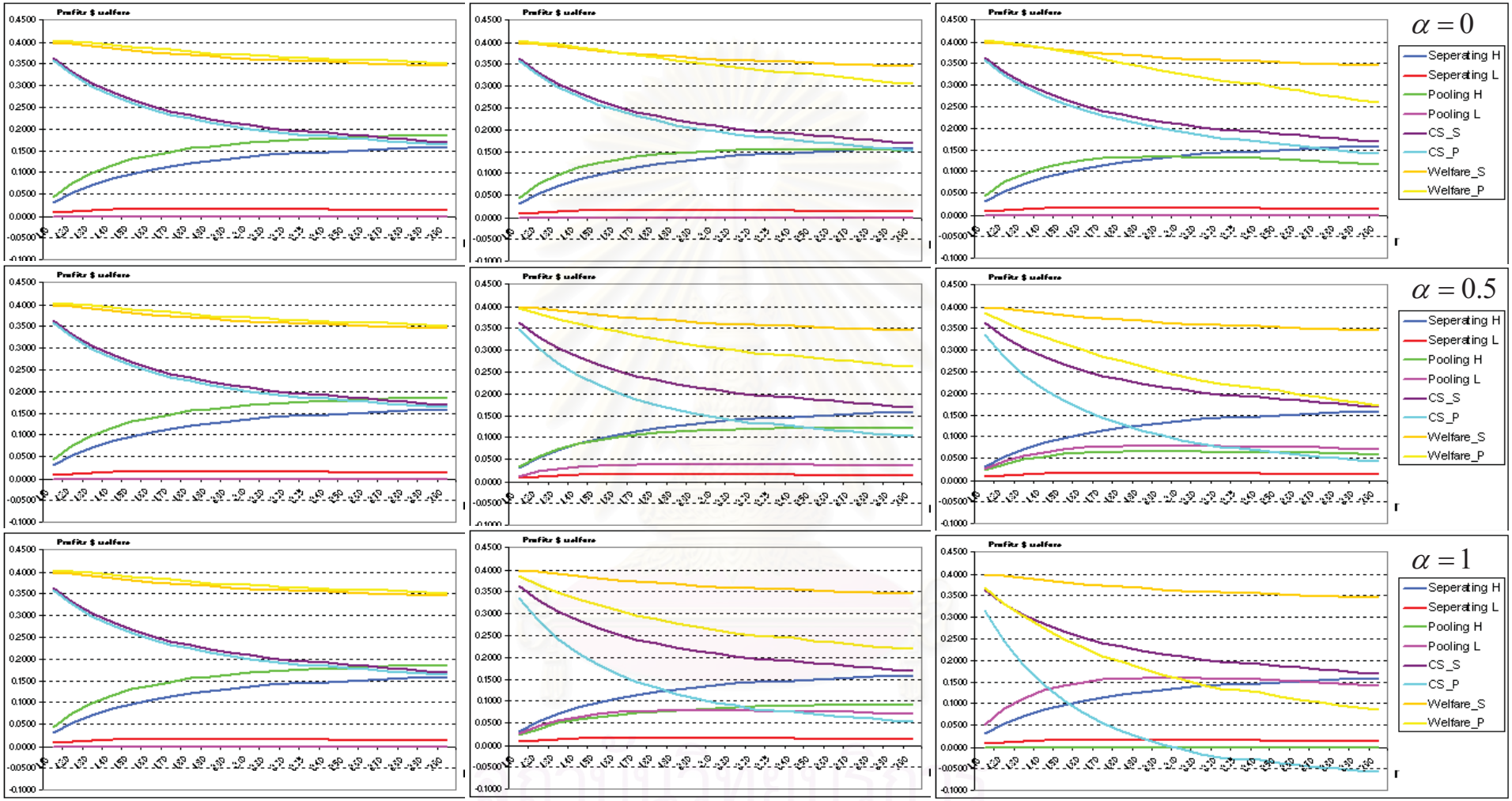


Figure 17 Profits and consumer surplus at competition equilibrium

. When the market has a half of uninformed consumers and the power of deceiving is more than zero. Firm L has motivation to select a pooling price strategy. A main reason is that its separating profit is less than pooling profit in all value of r. When firm L uses a pooling price strategy, firm H does not have a choice to react. Then, firm H will gain pooling profits. However, if the degree of product differentiation is low, (r is too low), pooling profits of firm H are not much different from separating profits. Beside, when firm L uses a pooling price strategy, consumer surplus will decrease. Buyers will suffer more from consuming low-quality products with such a high price because they have incomplete information about quality. If the degree of lack of information is very high (the situation that λ=1 and α=1), consumer surplus with the high degree of product differentiation will be negative.

In conclusion, information knowledge of both qualities is important. The problem that both agents (consumers and firms) have unequal qualities is brought about by many reasons called asymmetric information. This asymmetric information on quality will only happen when the market has uninformed consumers. If these consumers purchase goods at period one and at the end, firm H will be worsen. Although, there are repeated purchases by consumers in the market, so consumers will adjust their expectation about qualities of product they purchase in the last period. This behavior will create the famous question that if uninformed consumers can adjust their expectation about qualities in the next period, what equilibrium outcomes will be?

CHAPTER V

MARKET RESULTS BY MONTE CARLO SIMULATION

In the next chapter, this study will increases more product that have different level qualities in the market (firms are more than two), and then finds the competition equilibrium. Finally this study tries to explain the equilibrium of firms' profit and consumers' welfare when uninformed consumers adjust their preference already.

In fact, there are many firms competing in the market. Each firm will individually set its quality and price. If firms do not have some motivation to deceive, they will set their price according to their products' quality. So, consumers in the market use price as a signal of quality. Again, there are two types of consumers: informed and uninformed consumers. The informed consumers that have complete information about the quality so they do not need to estimate the quality based on product's price. They would examine the true property of products, compare with their price and then choose giving the best value by considering an income effect. On the other hand, consumers who do not have complete information about the quality of products have to use the price of product as a signal of product quality. Because all firms know this, some of them will use the pooling price strategy to increase their profits. They can trick some buyers who have poor information. Uncertainty about quality occurs. This study uses simulation techniques to estimate the results of equilibrium when the market has four firms.

5.1 Simulation by the Monte Carlo method

The competition model with quality uncertainty that has four firms in the market is too complicated to explain. This study use simulation method to reproduce the behavior of agents and find the equilibrium outcomes. The Monte Carlo method is one of the popular simulation methods. This procedure uses a random number to find out the solution when there is uncertainty action in the model. This study uses the Monte Carlo technique to generate data set that has an assumed distribution. The procedure of Monte Carlo simulation begins with generating the random numbers. These random

numbers have a uniform distribution and range between zero and one. Each random number set has a dependent correlation to others. Then, these numbers is applied to create random variables that have the desired distribution. Next, this study applies these random variables into the model of competition to find the solutions at equilibrium.

Using a simulation technique, this study runs the simulation 500 times of each case and assumes the number of both agents (firms and consumers). The model that used in this section is the quality-setting model. Although in this chapter, the model will concern both sides of agents (consumers and firms) in an agent-based model. Like the previous chapter, to simplify the results, this study sets the upper bound of the taste parameter: $\overline{\theta}$ is equal to 1 and marginal costs of each firm are the same and equal to 0.1. This study uses a standard model of quality differentiation in which consumers purchase at most one unit of a differentiated product. At beginning, this study explains the behavior of consumers with taste parameters and the firms' product qualities.

5.2 Consumers' behavior

Consumers in the market make a usual decision to choose products. Because both firm and consumer are the typical agents in a basic agent-based model, this model considers consumers to be bounded rational with given information. The basic choice of a consumer is, once he has a need and he knows that a certain good could satisfy his needs. Then he makes a decision whether to buy the good or not. The maximum acceptable price (or reserve price) will be considered to make a decision. The quantity that the individual will buy is zero or one according to the distribution of the reserve prices that affects all consumers. The distribution of reserve price can influences the shape of the demand curve. This study mentions reserve prices to quality, so the equation of demand will have quality choice in it. The relationship of the reserve price and the income of consumers will be positive (Besanko et al., 2003). Higher reserve prices would thus be the willing-to-pay prices of the rich people, whereas lower reserve prices would be that of the poor. If people equally shared their budget for a different class of goods, then a higher income would mean a higher reserve price in each class.

In a simulated market, this study generates one thousands consumers' taste parameters randomly with uniform distribution as shown in figure 18. Then, consumers make the decision rule by examining the product features and its price. The levels of the taste parameter that comes from the consumers' decision are related with the number of firms in the market, products' qualities and prices.

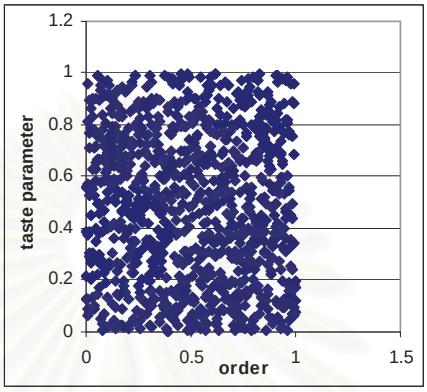


Figure 18 Uniform distribution of 1000 taste parameters of consumers

Like chapter 4, this section denotes that the fraction of uninformed buyers by λ. Because uninformed consumers have a lack information that comes from they can not go to gain fruitful data from external sources such as advertisements or personal advice. So, these consumers will be easily deceived. Recall that the power of cheating an uninformed consumer is denoted by α.

5.3 Firms' quality

There are four firms in the market that have various qualities. The product of firm 1 has the highest quality in the market followed by product of firm 2, firm 3 and firm 4. Furthermore, the numbers of firms in this section are not ranked by type of qualities but by the order of qualities in the consumers' view. When competition rises, all firms present their product quality and prices to consumers. Consumers arrange these product qualities with the product they produce from highest quality as firm 1 and down to the others as firm 2-4. This study will assume the possible range that all firms can choose their qualities between 0.75 and 1.65. However, the selecting process that a firm will use to choose its product quality assumes to be a random process (see appendix A)

All firms compete in the market with price competition and all firms have two strategies: separating price strategy and pooling price strategy to react to competitors. A separating price strategy is when a firm will set its price according to its product quality. When a firm uses this strategy, all informed and uninformed consumers can tell these firms apart because they are charging different prices (the separating price strategy). Because of the lower quality firms will gain less profit, so some of the firms have try to deceive some consumers by using a pooling price strategy. The deceitful firms will set the same price for its product as the higher quality firms. However, this study assumes that a lower quality firm wants to use the same price as a higher quality firm, they will not jump to use price of next higher quality firm because consumers would easily to detect the lies. Then in each situation, all firms have to choose to use a separating price strategy or use a pooling price strategy to compete higher quality firms.

Because there are four firms in the market, there are 8 possible situations (A-H) as shown in figure 19. Situation A is that all firms use a separating price strategy, and that they thus set different prices for their product quality. Situation B is that firm 2 tries to deceive uninformed consumers by using a pooling price strategy and that it thus sets its price equal to the price of firm 1 by not changing its quality. Firm 2 makes quality uncertainty in the market. Situation C is that firm 3 using a pooling price strategy by setting its price equal to firm 2 by not changing its quality; however, others firms use a separating price strategy. Furthermore, situation D is that both firms 2 and 3 use a pooling price strategy at the same time. Nonetheless, both firms do not exactly know others strategy. They expect that others opponents will use separating price strategy. Then firm 2 sets price equal to price of firm 1 but firm 3 set price equal to price of firm 2 by not knowing that firm 2 change its price. Quality uncertainty from firm 2 and 3 exist in the market. Situation E is that firm 4 deceives uninformed consumers by using pooling price strategy. Like situation D, situations F is that both firms 2 and 4 try to deceive uneducated buyers by using others price as their price. In this situation, there are still two price-level, p_1 and p_3 in competition. Situation G, two of low quality producing, firms 3 and 4, try to deceive uneducated buyers. The last one is situation H where all firms except firm 1 use a pooling price strategy to deceive consumers. This situation is the

serious situation that many firms make quality uncertainty to their consumers. More products in the market are deceiving products. Uninformed consumers will suffer more when consume these products.

From all situations, only firm 1 has a single strategy that is a separating price strategy because firm 1 produces the highest-quality product in the market. So, it does not need to trick anyone by charging an unreasonable price. Firm 1 will set its price according to its quality. But for the other firms, in some situations they use a separating price strategy, and in some situations they use a pooling price strategy. This behavior causes the quality uncertainty in the market.

	Firm 1		Firm 2		Firm 3		Firm 4	
A	S	P1 V1	S	P2 V2	S	P3 V3	S	P4 V4
B	S	P1 V1	P	P1 V2	S	P3 V3	S	P4 V4
C	S	P1 V1	S	P2 V2	P	P2 V3	S	P4 V4
D	S	P1 V1	P	P1 V2	P	P2 V3	S	P4 V4
E	S	P1 V1	S	P2 V2	S	P3 V3	P	P3 V4
F	S	P1 V1	P	P1 V2	S	P3 V3	P	P3 V4
G	S	P1 V1	S	P2 V2	P	P2 V3	P	P3 V4
H	S	P1 V1	P	P1 V2	P	P2 V3	P	P3 V4

Figure 19 Strategy of firms in price competition with qualities differentiation

5.4 The process of simulation with an agent based model

This study applies the Monte Carlo simulation to an agent based model that considers both consumers' and firms' behavior. The simulation process is not complicated but it creates competition in the market with some random numbers that can represent the actions of both sellers and buyers. This agent based model (figure 20) will generalize the reaction of both sides of agents in the competition model.

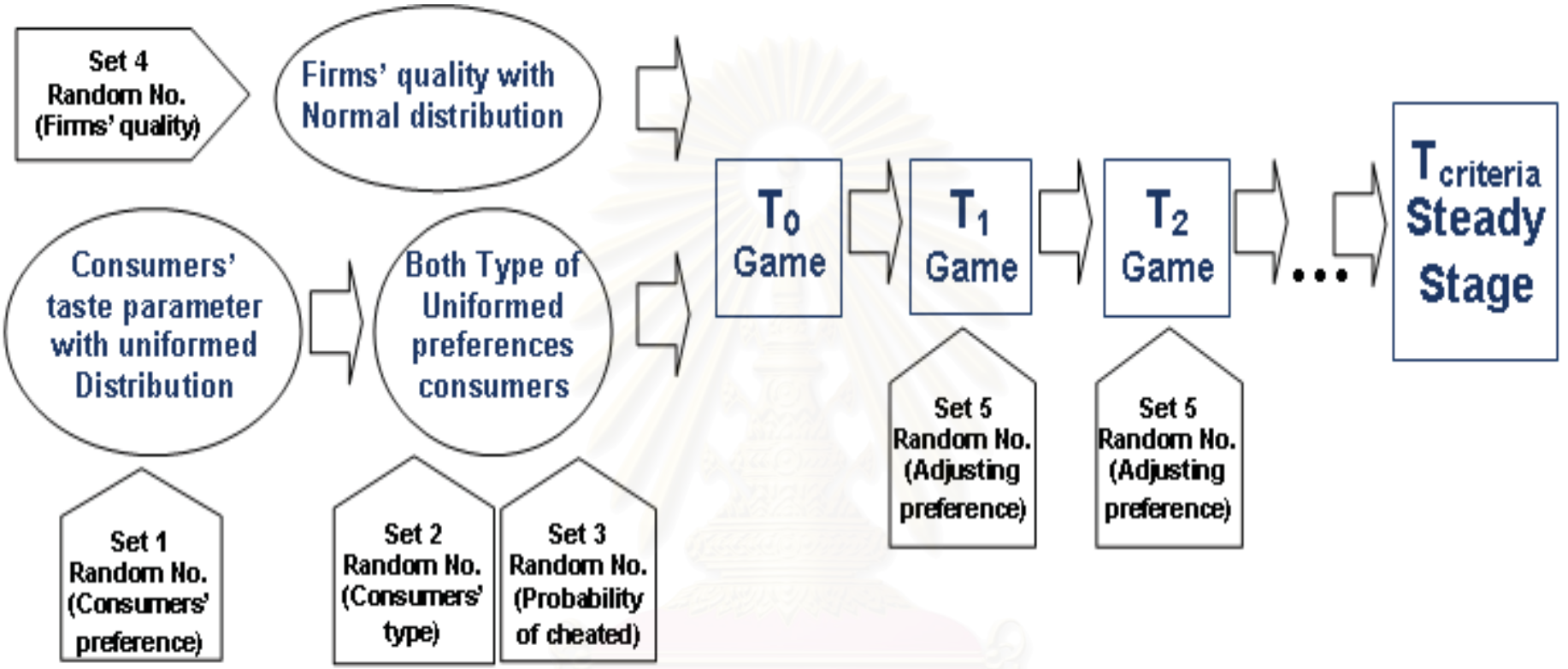


Figure 20 Agent based model of quality competition

The computer simulation of this study uses an MS excel worksheet to generate 5 sets of random numbers. The first one is to generate consumers' taste parameters. The second set is composed of the consumers' types. If the second set of random numbers is greater than λ, this study assumes that consumers will be informed. The third series is a set of probabilities that consumers will be deceived by firms. This number will be involved with the second set in such a way that the third set of random numbers will be applicable only on a condition that the second series is less than λ (only uninformed buyers). When informed shoppers buy a product, they will not be deceived. Whereas, when uninformed consumers are buying products and if the third sequence is less than α , they will be cheated. Forth set is a set of random qualities (rq_i in appendix A) of products that are assumed to have normal distribution. The last one is a set of adjustment of consumers' preference. When consumers buy a product in the first period, if they know that the product quality is not proper for its price, they will adjust their taste in the next period. The loop will continue until consumers buy the appropriate goods at criteria time.

The simulation process begins with generating 1000 consumers' preferences (taste parameter) with a uniform distribution and the four firms' product qualities with a normal distribution by randomizing numbers with random numbers set 1 and 4. The type of each consumer will be marked with randomly numbered in set 2 and 3. Then, both consumers and firms enter the competition at time t0. The game will continue and in each period is adjusted the preference of consumers by the random index in set 5 until it reaches the steady stage where no one will be cheated by firms. The example of the four firms' qualities and consumers' preferences that are used in the Monte Carlo simulation are in appendix B.

Inside the game, consumers choose a product following a decision making process (figure 2). Consumers will compare their reserve price with the actual price and make a decision to choose the goods of which quality is the overall highest and each feature has a sufficiently high score. In the competition, there are different cases that firms will face depend on types of consumers in the market. From chapter 4 in which the

outcome of equilibriums with duopoly firms is found by imitation methods, the results can be grouped in 6 cases.

1. *All consumers are informed ($\lambda = 0$) for all level of α*
2. *A half of consumers are uninformed (λ=0.5) and firm producing low-quality product can deceive a half of them (α=0.5)*
3. *A half of consumers are uninformed (λ=0.5) but firm producing low-quality product can deceive all of them (α=1)*
4. *All consumers are uninformed (λ=1 but firm producing low-quality product can deceive a half of them (α=0.5)*
5. *All consumers are uninformed (λ=1) and firm producing low-quality product can deceive all of them (α=1)*
6. *Firm producing low-quality product has no deceiving power (α=0) for all fraction of λ*

These 6 cases are different in the fraction of informed and uninformed consumers and the probability that firm will successfully deceive the uninformed consumers. Because of the behavior of these variable can affect the competitive equilibrium and welfare of consumers. This study will analyze the solution of each case in each situation. It finds that case 6's results will be the same as that of case 1, so this study examines 8 situations within 5 cases and finds the results of each case.

The example of the excel simulation result of case 2 in situation B is shown appendix B. The competition simulation starts at t0. This study randomly chooses qualities of firms and consumers and then goes to the stage of competition. From the price signal, each consumer selects the product according with their level of the taste parameter. The sales volumes, profits and utility at t0 are calculated. In situation B, firm 2 will deceives uninformed consumers by setting its price equal to price of firm 1's product but it does not change its quality. At t0, cheated consumers will suffer from buying the deceiving products and trying to adjust their taste parameter to buy other products at t1. This study assumes that deceived consumers will adjust their taste parameter with 10% of the random number in set 5. The game will continue until no one

buys a product from firm 2 in the 13th period. This is a steady stage period where every one will move from this point.

For the whole outcome of simulation, this study constructs 500 tests for each case and finds the average values of quality and prices of the four firms, levels of taste parameters, and ratios of qualities, profits and utility. The example of simulation results of case 2 under situation B are in appendix B.

5.5 Results of simulation

Situation A: All firms use a separating price strategy

When all firms choose their own strategy to set the price according to their product quality, there exist four qualities and prices in the market. Consumers can distinguish the products with their different prices. They arrange the qualities of each product and bring these qualities and prices to set the level of the taste parameter. Because there are 4 products in the market, so there are 5 levels of taste parameters. The first one is the upper bound of taste parameter, $\overline{\theta}$ which is this study assumes it equal to 1 since the distribution of the taste parameter is a uniform distribution. Other taste parameters: θ_{12} , θ_{23} and θ_{34} denote the taste parameters of consumers who are indifferent between buying product's 1 or 2, 2 or 3 and 3 or 4, respectively. The last taste parameter is θ_{04} that denotes the taste parameter of consumers who are indifferent between buying product's 4 or not buying. Both informed and uninformed consumers will face the same level of taste parameters because all firms set different prices according to their product quality. Consequently, no one has been deceived in this case.

Situation A is the normal situation of the competition without quality uncertainty discussed in chapter 3. The number of consumers who buy a product, profits of firms and the welfare of consumers will not be related with both λ and α because consumers can differentiate the qualities from dissimilar priced. Figure 21 shows firms' profits and the percentage of buying goods in situation A. From the left-side graph of figure 21, bar graphs denoted profits and line graph denoted product quality of each firm. Decreasing

in the line graph dues to decreases in the bar graphs. That is, like the results in chapter 3, firms that have the highest product quality will get the highest profit, followed by the firms that have next lower product quality.

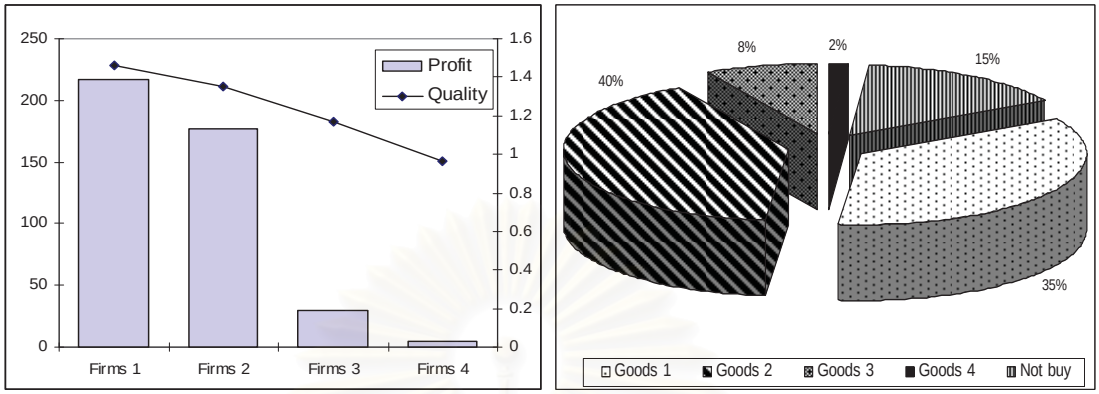
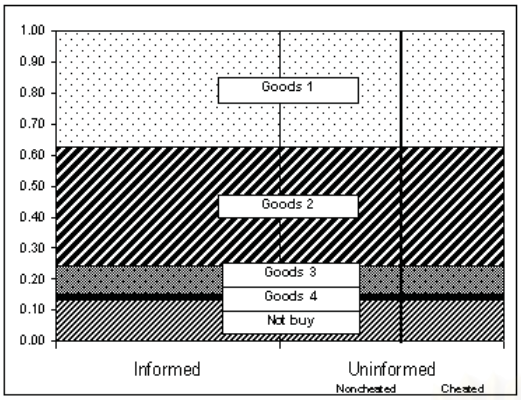


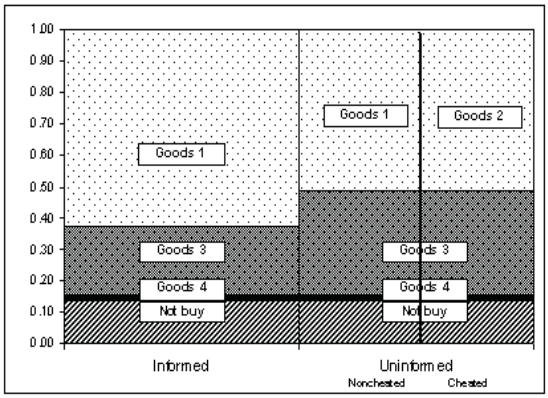
Figure 21 Firms' profits and percentage of buying all products in situation A

For the right-side graph of figure 21 as shown the percentage of buying products, goods 2 has the largest market share, followed by goods 1, 3 and 4. The percentages of buying products come from the level of taste parameter of consumers. However firm 1 gains more profits since its quantity is less than quantity of goods 2. It implies that product quality of goods 1 is higher than product quality of goods 2, so firm 1 can set its price higher than price of goods 2, so firm 1 gain higher profit than firm 2.

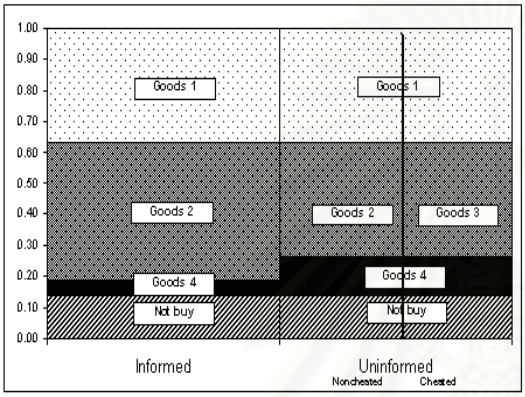
Regarding the level of the taste parameters, θ_{12} is about 0.6276, θ_{23} is about 0.2408, θ_{34} is about 0.1524 and θ_{04} is about 0.1363. Assuming that λ and α are equal to 0.5, the level of taste parameter is graphed in figure 22 (a). The flat line between products represents the level of taste parameter. From this figure 22 (a), goods 4 has the smallest range of taste parameter. This is due to fewer consumers who want to buy this product (only 2% in the pie graph). The bigger range of taste parameter describes more consumers will purchase these goods. In this situation, more consumers will purchase from firm 2 (40%) because it has product with middle-to-high quality, followed by firm 1 (35%), firm 3 (8%) and firm 4 (2%). Interestingly, the percentage of consumers who not buy the products is about 15%. This group has the level of θ_{04} is about 0.1363. The solutions at equilibrium of situation A is shown in table C1 in the appendix C. The table shows that all cases have a similar solution.



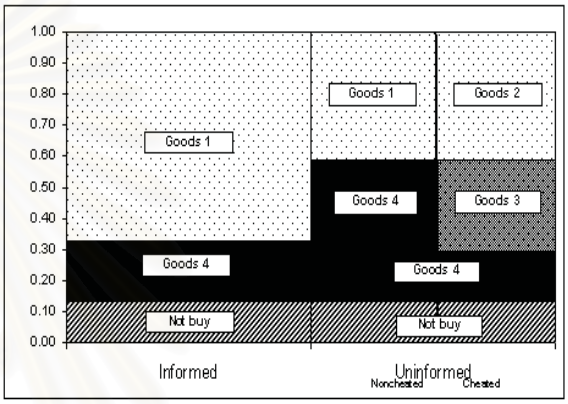
(a) Situation A



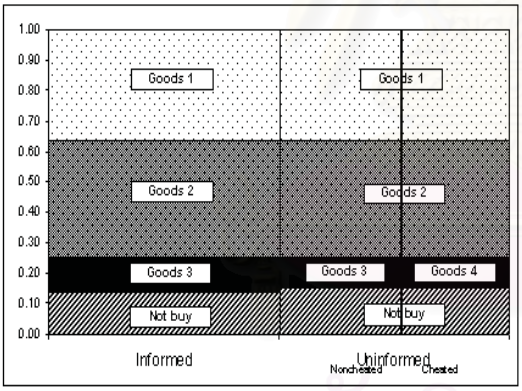
(b) Situation B



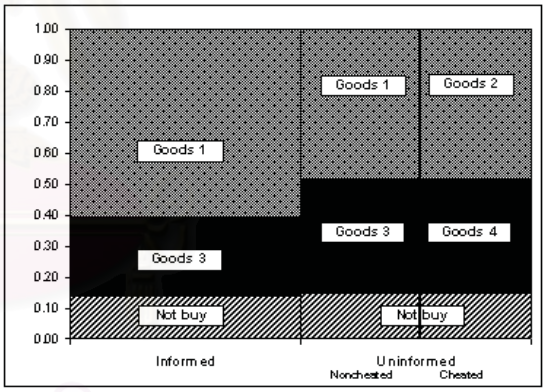
(c) Situation C



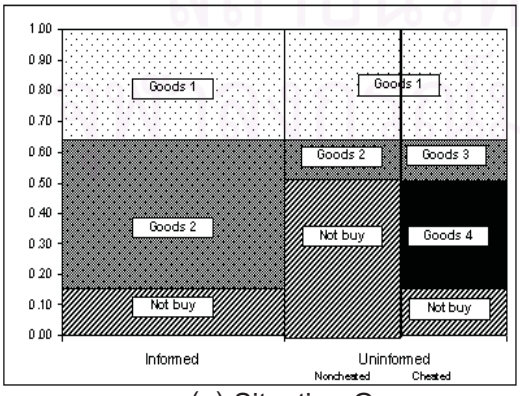
(d) Situation D



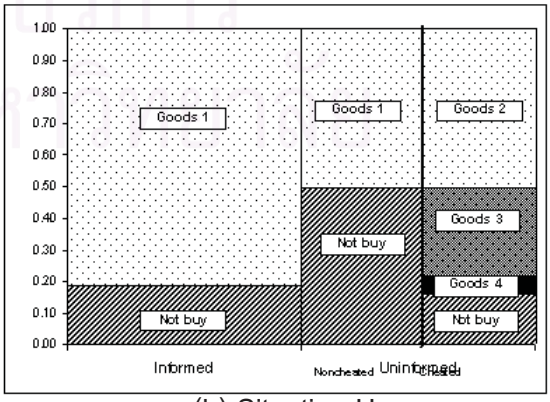
(e) Situation E



(f) Situation F



(g) Situation G



(h) Situation H

Figure 22 Taste parameters in different situation

Even if λ and α do not affect the results of competition in situation A, there still are informed and uninformed buyers in the market. Table C2 in the appendix C shows the number of both types of consumers in each case. For case 1, all consumers are informed consumers. Case 2 and case 3 have a half of the consumers are uninformed. However, case 2 shows that a half of the uninformed consumers are deceived whereas case 3 shows that all the uninformed consumers are deceived. Cases 4 and 5 have all consumers in the market are uninformed. Nonetheless, case 4 has a half of them deceived while case 5 has all of them are deceived.

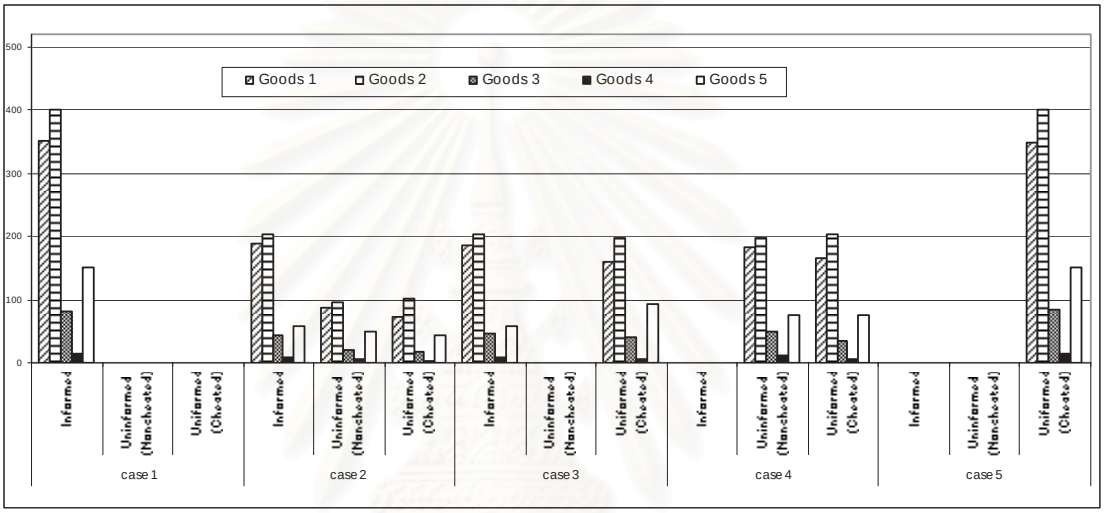


Figure 23 Portion of informed and uninformed consumers in 5 cases

Bar graph in figure 23 shows the portions of informed and uninformed consumers in 5 cases. Case 1 has only uninformed buyers with 351 consumers buying goods 1, 401 consumers buying goods 2, 81 consumers buying goods 3, 15 consumers buying goods 4 and 151 consumers do not buy at all. When having a half of the consumers are uninformed in case 2, there are numbers of informed consumers buying goods 1, 2, 3, and 4, and not buying are equal to 190, 202, 44, 9 and 59, respectively. Non-deceivable uninformed buyers who buy goods 1, 2, 3, and 4, and not buy goods are 88, 95, 20, 5 and 50, respectively. Meanwhile, cheated uninformed buyers who buy goods 1, 2, 3, and 4, and not buy any of these products are 73, 103, 17, 2 and 42, respectively. The proportion of informed and uninformed consumers will spread over products.

Like case 2, case 3 has the same ratio of informed and uninformed consumers buying the products but there are full weights in cheated uninformed consumers. Case 3 has informed consumers who buy goods 1, 2, 3, and 4, and not buy the products at all are 187, 203, 46, 9 and 59, respectively. Beside, deceived uninformed buyers buying goods 1, 2, 3, and 4, and not buying any products are 159, 198, 39, 7 and 92, respectively. In case 4, all consumers are uninformed. In this case, non-deceivable buyers buying goods 1, 2, 3, and 4, and not buying the products are 182, 197, 48, 10 and 75, respectively. Whereas, cheated buyers who buy products 1, 2, 3, and 4, and not buying are 166, 205, 35, 5 and 76, respectively. Case 5 is an extreme case that has only deceived uninformed buyers. Numbers of these consumers buying goods 1, 2, 3, and 4, and not buying at all are 348, 401, 84, 16 and 151, respectively. The total of consumers in each case can is equal to 1000.

The important analysis in this study is to consider the utility of consumers when the market has product differentiation. As shown in table C1 in appendix C, social welfare of situation A is high. The average welfare of all cases is about 121.89 but the range is very wide (162.78). This means that there are some tests of simulation that give a low utility. When the simulation generates the qualities of four firms as tiny values that is near the lower bound of the quality, the utility is so small. The lowest welfare of consumers is in case 3 (35.02) in which the simulation produces the quality of firm 1 is equal to 0.9560, quality of firm 2 is equal to 0.8967, quality of firm 3 is equal to 0.7822 and quality of firm 4 is equal to0.7631. Although, these qualities do not reach the lower bound of quality but they have a value near it in the same time. The utility of consumers is the lowest. For the highest utility, it is in case 4 (229.42) in which the simulation generates the quality of firm 1 is equal to 1.6480, quality of firm 2 is equal to 1.6167, quality of firm 3 is equal to 1.4391 and quality of firm 4 is equal to 1.0411. All qualities have a value close to the upper bound of quality in the same time. As a result, the utility is the highest. This study concludes that when all firms have an increasing trend of their qualities, this also favors for buyers. Policy maker will plan the policy that aims to motivate all firms in the market to increase their qualities which would lead to increase in social welfare.

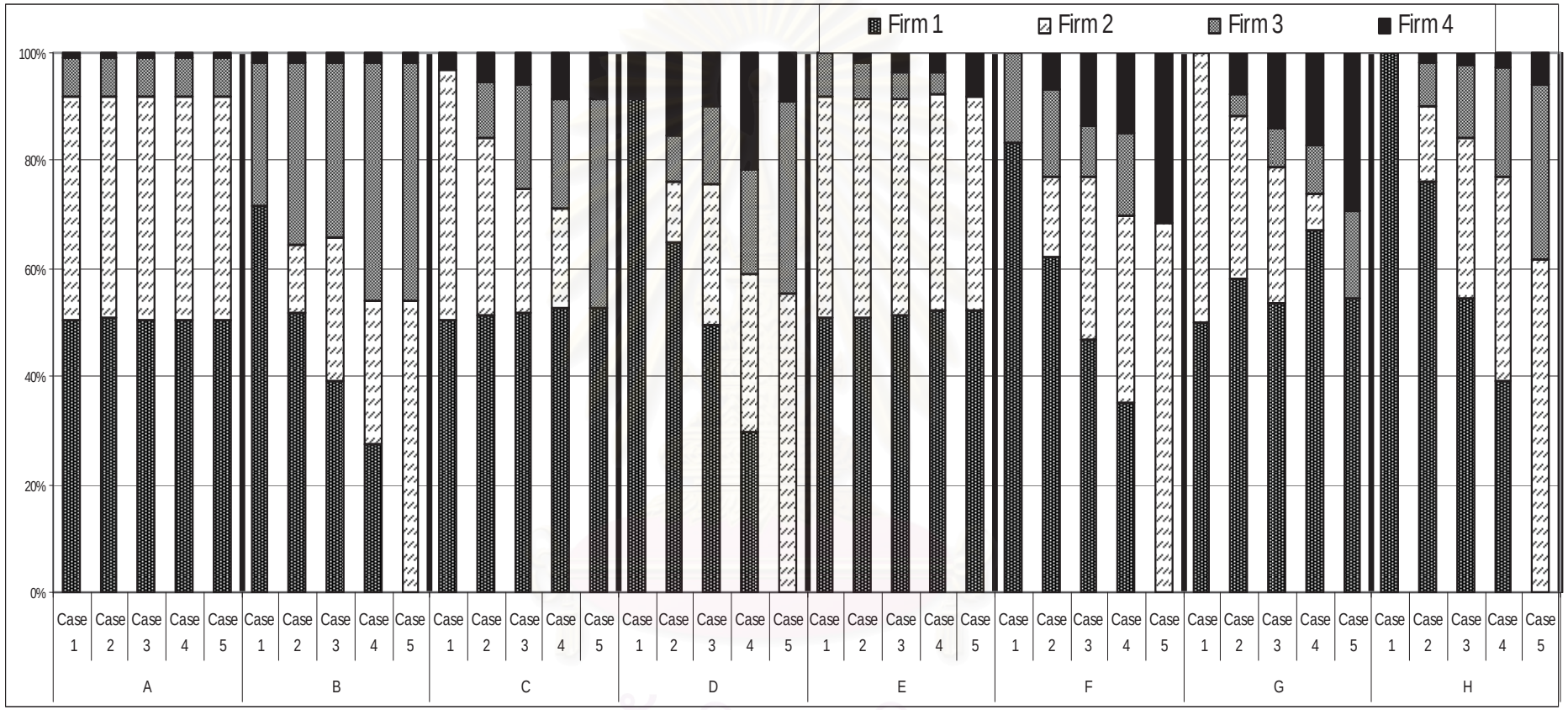


Figure 24 Sales profits of all firms in each cases of all situations

Figure 24 shows that all firms' profit in each situation. In situation A, profit of firms will be similar in all cases. This means both λ and α do not have any effect on firms' market share when they set the reasonable price (a separating price strategy), the market does not have quality uncertainty. In situation A, firm 1 earns a profit of about 216.73, firm 2 earns about 177.44, firm 3 earns about 29.87 and firm 4 earns about 4.67. Like the chapter 3's results, firm 1 gains more profit than the others because it produces a product that has the highest quality. This top quality is not enough to create the high profit. The large gap between the highest quality and the lowest quality introduce the high ratio of highest quality, and the others will guarantee the higher profit. For example the highest profit of firm 1 is in case 5 (322.80), this high profit comes from the widest gap of quality (0.87) and the highest ratio between the quality of firm 1 and 2 (2.14). Both factors drive the profit of firm 1. Similarly with other firms, when the gap of its quality and the lowest quality in the market is the biggest and the ratio between its quality and the lower is the highest, the firm's profit is also the highest.

Regarding the average utility as shown in figure 25, the utility levels of situation A are similar because all firms use a separating price strategy. Both informed and uninformed consumers can distinguish these producers. Consumers can buy the products that have reasonable prices relating to the qualities. All consumers' utilities in this situation will thus be high. Here, case 1 has little higher utility due to all consumers in the market being informed. They buy the product that is suitable for their income and do not have to adjust their preferences to buy the right thing. The preferences in this case will be fully used.

In the market that has quality uncertainty; uninformed consumers will adjust their preferences to eliminate this effect. They finish this adjustment at criteria time. At this time the market does not have quality uncertainty. The line graph of figure 25 shows the level of utility at criteria time. In situation A, consumers does not face quality uncertainty. Moreover, the utilities of all cases at time t0 are the same with utilities at criteria time.

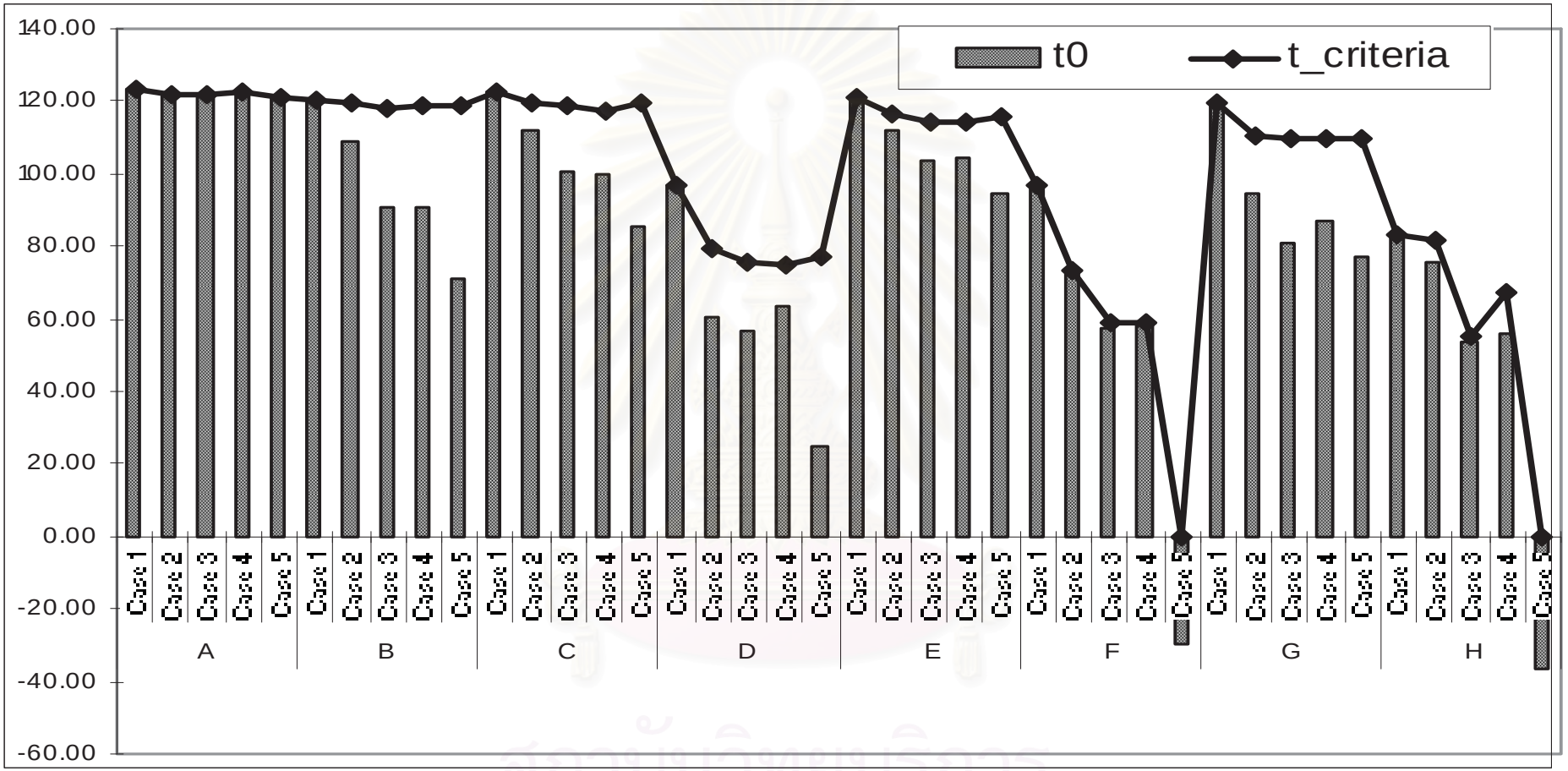


Figure 25 Utilities at t0 and criteria time in each situation

Situation B: Firms 1, 3 and 4 use a separating price strategy but firm 2 uses a pooling price strategy

In this situation firm 2 wants to gain more profit, so it applies a pooling price strategy by setting its price equal to the price of firm 1's product. From figure 19 that shows qualities and prices in situation B, all qualities are the same as situation A but firm 2 tries to deceive uninformed consumers. It sets the price equal to firm 1 (p_1) to act like its quality is high; however, the other firms set their price according to their qualities. When this situation occurs, informed and uninformed consumers will face different levels of the taste parameter (shows in figure 22(b)). Because informed consumers have full information about all firms' qualities, they also know that firm 2 sets its price over its quality. None of the informed consumers will buy firm 2's product. They cut firm 2's product out of their buying decision. The levels of taste parameters for informed consumers are θ_{13}, θ_{34} and θ_{04}. On the contrary, uninformed consumers do not have complete information about all qualities. When firm 2 increases its price equal to the firm 1's product price, uninformed buyers do not know the true qualities of firm 1 and 2. These consumers will only expect the qualities of both firms by averaging them and then compare this expected quality with others that have true qualities (firm 3 and 4 because the price is different). The expected quality between firm 1 and 2 is $v_1 + v_2 / 2$. This expected quality will be considered in the uninformed consumers' decision making. The levels of taste parameters for uninformed are θ_{e12_3}, θ_{34} and θ_{04}. The new level of taste parameter θ_{e12_3} denotes the taste parameter of consumers who are indifferent between buying products that have expected quality between firm 1 and 2, or buying product 3. Table C3 shows the simulation results of situation B that contain the average of taste parameters' level from simulation. The values are as follows θ_{13} is about 0.3707 while θ_{34} is about 0.1554, and θ_{04} is about 0.1367. Finally, θ_{e12_3} is about 0.4850.

In case 1, all consumers are informed, the set of uninformed consumers' level of taste parameter has disappeared and it agrees with shown in the bar graph of figure 22 (b). That is, no one will buy the product of firm 2. Table C3 shows the simulation results of situation B. When the market has only informed consumers, firm 1 gets maximum

profit (367.26); whereas, firm 2 gains nothing. The utility when there is no uncertainty effect is the highest (120.18). As shown in figure 24, the much higher profit of firm 1 in this case is irregular compared with situation A that is standard behavior when it does not have quality uncertainty. It results from firm 2 deciding to abandon its position in the market. It wants to raise its profit by seizing firm 1's market share. However, if the market has informed consumers, the results will change. Firm 1 will gain some of the market share of firm 2 that connoisseurs will not consider it. The profit of firm 1 is thus extremely high. Surprisingly, a number of consumers who buy product 3 is increasing as well. A rise in the market share of firm 3 will lead to the growth in its profit. This action comes from the expanding of taste parameter from θ_{13}. This is because informed consumers cut product 2 out of their decision. Consumers that usually prefer product 2 will no longer choice to choose. They select product 1 or 3 instead. Thus θ_{13} in situation B is less than θ_{12} in situation A and more consumers choose goods 3.

For case 2 of this situation where a half of consumers are uninformed and a half of them are deceived by firm 2, this firm will increase its buyer by catching some market share of firm 1. Comparing case 1 with case 2 the bar graphs are shown in figure 24. It shows that in case 2 profits of firm 1 is decreasing but profits of firm 2 is increasing. Firm 2's higher profit is due to firm 1 losing its consumers to firm 2 when the number of uninformed consumers and power of deceiving increases. This action diminishes the profit of firm 1 from case 1 (367.28 to 271.49) which will continue decreasing when the fraction of uninformed increases (case 4 and 5) or the power of deceiving increase (case 3). In contrast, when the numbers of uninformed consumers increase or firm 2 can deceive more consumers, its profit will continue to increase. Again, the profit of firm 3 increases and it is greater than firm's 3 profit in case 1. Considering the level of taste parameter of uninformed block (right block of figure 22 (b)), θ_{e12_3} is greater than θ_{13}. An uninformed consumer rather than an informed one will tend to choose product 3. This behavior causes by the uninformed consumers can not exactly know both qualities (firm 1 and 2). They only expect these qualities that will be below the highest ones: $v_1 > {v_1 + v_2}/{2}$. Thus, consumers make the new levels of taste parameter, they will make θ_{13} less than θ_{e12_3}. More uninformed consumers will switch to consume product 3

instead the approximate ones. In the same way, when the probability of success in deceiving is rising to 1 (case 3), firm 2 can deceive all uninformed consumers. In case 3, there will be more increases in buying firm 2's goods. The profit of firm 2 will increase when the power of deceiving increases. However, firm 1's profit decreases as no ones buy product of firm 1 because all uninformed consumers are deceived, they buy products from firm 2. Hence, profit of firm 3 in case 3 is similar with case 2, because the fraction of uninformed is the same.

Cases 4 and 5 are the cases that all consumers are uninformed. For case 4, then going back to the level of taste parameters, if all consumers are uninformed, the left block is disappearing. Firm 2 can only deceive a half of uninformed consumers, the profits of firm 1 and firm 2 will be the same. It is not surprising that firm 3 will gain have more consumers. However, its average profit is less than firm 2. Consumers consume more products 3 because they are not certain in quality of product 1 and 2. Choosing the certain quality of product 3 is the safe way when quality is uncertainty. If the power of deceiving is raised to 1 (case 5), firm 1 cannot sell its product. On the contrary, firm 2 can sell to all of consumers that have high preference. It results in the profit of firm 2 becoming the highest in this case (294.40), on contradict with consumers' utility that will be the lowest (70.75). The utility of consumers will decrease when fraction of uninformed or power of cheating increases. Although, the utility of case 4 in nearly similar to that of case 3 because the number of cheated consumers is similar. The low utility is due to quality uncertainty. It causes a more serious problem in the market. Consumers will change their behavior to avoid this problem.

The above results are about competition at t0. Firm 2 will deceive some uninformed consumers. Although when consumers already buys product 2, they know that this product does not have the right quality compared with its price. This study assumes that all firms will not change their product qualities and price strategy. Consumers use the price signal to update their perceptions by reducing their preferences and buy products in t1. However, these consumers do not receive full information about qualities. They only reduce their taste and can be easily deceived by

firm 2. In period t1, consumers who buy product 2 at t0 adjust their preferences. If these new preference are less than θ_{e12_3}, they will buy goods 3 and then gain the proper utility since product 3 sets its price along with its quality. These consumers stop reducing their preference and concede to consume goods 3. The quality uncertainty for this group disappears. However, if consumers cannot change their preference to find the right quality, they will suffer from buying goods 2 again. The process of simulation will continue until convergence to the period that nobody buys firm 2's product. This time is called criteria time or steady stage. Table C4 shows the number of buying consumers, firms' profits and consumers' utility at time t0 and at criteria time. For all cases except case 1 that does not have quality uncertainty, the utility at the criteria time is greater than the utility at time t0. This shows that all consumers will be better off when the quality uncertainty does not exist. Not only are the profits of firm 3 increasing because consumers will adjust theirs preferences to consume the product that has a reasonable price, firm 3's product will also support the consumers' needs. Firm 3 gains more margin while firm 1 profit are unchanged when t0 but it will still gain higher profits than others.

The interesting issue is the order of convergence. All cases have the similar convergent period (about 16 periods), except case 1 that does not have quality uncertainty. This means that there are some consumers who will slowly adjust their choice of taste. They know that buying goods 2 is inappropriate but they will use heavy force to change their behavior. Situation B can be concluded that if there is quality uncertainty in the market and only firm 2 will deceive uninformed consumers, case 2 and 4 will then need 15 periods to converge to the stage that does not have quality uncertainty. Case 3 needs 17 periods and case 5 needs 16 periods. The utilities at time t0 and at criteria time of situation B are shown in figure 25. The utilities after criteria time are increasing and tend to near highest point. This point is where the market does not have quality uncertainty. It means that consumers will be better off when quality uncertainty is gone. Although, consumers who adjust their preference and switch to consume goods 3 (situation B) will receive lower quality product than they will receive in situation A. Nevertheless, from line graph of figure 25 that show utility at criteria time,

there are some little different utilities of case 2, 3, and 4 compared with case 1. At criteria time, the utility after the adjustment of consumers' preference is smaller than utility of case that no one change their preference (case1). There are some lost of adjusting preference.

Situation C: Firms 1, 2 and 4 use a separating price strategy but firm 3 uses a pooling price strategy

Like situation B, there is one firm trying to cheated uninformed consumers. Firm 3 sets its price equal to firm 2 (p_2) but it does not change its quality. Again, both types of consumers will face different levels of taste parameter. Therefore, informed consumers are not interested in firm 3's product because its price is over fit. The levels of taste parameters for theses consumers are that θ_{12}=0.6313, θ_{24}=0.1903 and θ_{04}=0.1364. On the contrary, uninformed consumers do not have complete information about all qualities. When price of firm 2 and 3 are the same, they only expect the average quality of firm 2 and 3. Furthermore, the levels of taste parameters for uninformed will differ from informed consumers. These levels are θ_{12}=0.6313, θ_{e23_4}=0.2660 and θ_{04}=0.1364. Both different taste parameters' indices are shown in figure 24 (c).

Figure 25 show the sales profits at t0 of situation C. For case 1, all consumers are informed, no one will buy from firm 3. Profit of firm 3 is then equal to zero. Although in others case when both λ and α are increasing, consumers will buy more goods 3 and decrease their purchase of goods 2. This is caused by that firm 3 is deceiving some uninformed consumers and stealing some market share from firm 2 that due to increase in profit of firm 3 and decrease in profit of firm2. Even though, profits of firms 1 are the highest in overall cases but sale volume is fewer than the sale volume in situation B. Firm 1's profit in situation C is the standard profit (when compared with situation A). The irregular action is on the profit of firm 2 and 4 that profit of firm 2 in case 1 has extremely increased and sharply reduced with case 2-5 because the catching market share of firm 3. Once again, firm 4 will receive some higher profit coming from the expanded range of taste parameter in the uninformed group. Profit of firm 4 thus continues rising.

Table C5 shows the simulation results of situation C. All over again, case 1 has the biggest utility because all consumers are informed. In this situation, this utility is less than that in situation B. Firm 2 produces a product which has higher quality than the product of firm 3. The number of consumers who want to buy this higher quality is greater. The welfare loss when firm 2 cheats the uninformed consumers in situation B will be greater than when firm 3 cheats the uninformed consumers in situation C. Social will be worse off when the firm producing a high-quality product tries to deceive some consumers. Furthermore, the interesting result is the utilities in case 4 nearly similar to case 2 and case 5 nearly similar to case 3. This implies that the fraction of uninformed consumers in this situation does not have a greater effect on the utility. There are some gaps of utilities at t0 and at criteria time that comes from adjusting preference of consumers. This caused from consumers will change their preference from consuming goods 3 to not buying any products. Especially in case 5 that more consumers will adjust their taste, so consumers who not buying any products will increase.

At t0 competition, some consumers who buy firm 3's product will suffer more. They change the preference and find a new product. The process to eliminate the quality uncertainty continues until no one will buy from firm 3. Like situation B, the orders of convergence of all cases are near but the period in this situation is shorter than that in situation B. It means that consumers adjust their preferences quickly to get rid of the quality uncertainty. The graphs of figure 25 shows all cases when quality uncertainty is gone have utility at criteria time increase and tend toward the point where all consumers are informed (case 1).

Situation D: Firms 1 and 4 use a separating price strategy but firms 2 and 3 use a pooling price strategy

Both firm 2 and 3 try to cheat some uninformed consumers. However both firms do not know who wants to cheat consumers. They have only information about what are suitable prices at which others firms will set if they use a separating price strategy. When this situation occurs, firm 2 will set its price equal to p_1 and will not change its

quality. Although firm 3 does not known that firm 2 will change its price, so it thinks that firm 2 will use a separating price strategy. Consequently, it sets the price equal to p_2. The different levels of taste parameter are shown in figure 22 (d). For informed consumers, these levels are θ_{14} =0.3271 and θ_{04} =0.1373 because consumers that have full information will cut the product of firm 2 and 3 out off their decision. For uninformed consumers, these levels are θ_{e12_23} =0.5894, θ_{e23_4} =0.2950 and θ_{04} =0.1373. Figure 24 of situation D show that in case 1, sale volume firm 2 and firm 3 is zero because all consumers have full information about qualities of firms. Profit of firms 1 and 4 are irregular high because they receive market shares from firms 2 and 3. Like other situations, when fraction of uninformed or power of cheating increases, profits of cheated firms increase. In case 2, some consumers who do not have complete information buy product from firms 2 and 3 and do not buy from firm 1. Thereby, profits of firm 2 and 3 increase and firm 1's profit decreases. And this behavior will continue occur with other cases.

The interesting point of firm 4's profit from figure 24 is the sales profits of firm 4 vary. This is caused by the levels of taste parameter in each case being different due to the fluctuated number of the product 4's buyers in each case. In case 4, profit of firm 4 reaches the highest level because this case has only uninformed buyers and the probability that firm will successfully cheat uninformed consumers is 0.5. The left block level of taste parameter (figure 22 (D)) has disappeared. Firm 4 has more consumers buying its goods. Its profit is therefore high. For non-cheated uninformed consumers that the lose product of firm 2 and 3 in their mind will choose the product of firm 4. The preference range of buying goods 4 for these buyers is widened (between θ_{e12_23} to θ_{e23_4}). When firm 2 and 3 try to deceive uninformed consumers, firm 4 will gain more benefit from firm 3 abandoning its position. Market share of firm 4 will increase causing a rise in its profit.

The utilities of the game at time t0 in all cases are very little and less than the situations discussed before. The message of this behavior tells us that consumers will suffer more when firm producing product in the middle-high quality range try to deceive

them. It is so terrible when all consumers do not have complete information about qualities (case 5). This case gives the lowest utility that is close to zero. Although when buyers adjust their preference to avoid having the negative utility, they use about 20 periods to relieve this pain. The utility when quality uncertainty is gone will become higher.

The order of convergence in this situation is about 20 times. More consumers slowly adjust their taste to eliminate the quality uncertainty. When the number of cheating firms increases, the iteration that consumers will change their action to the steady stage become longer.

Situation E: Firms 1, 2 and 3 use a separating price strategy but firm 4 uses a pooling price strategy

In this situation, firm 4 produces the lowest quality of product and tries to cheat uninformed buyers. Firm 4 always receives little profit in the competition. Then, firm 4 is motivated to increase its profit by setting its price equal to firm 3's price even though it does not change its quality. Like the previous case, both types of consumers will face different levels of taste parameter which is shown in figure 24 (e). For informed consumers, they will cut firm 4's product out of their choice. They face the levels of taste parameters that θ_{12} =0.6367, θ_{23} =0.2526 and θ_{03} =0.1385. For the group of uninformed consumers, some consumers cannot truly anticipate the qualities of firm 3 and 4 because they set the same price. They only estimate the average qualities of both firms' product and the levels of taste parameter they face are θ_{12} =0.6367, θ_{23} =0.2526 and θ_{e34} =0.1512. The indices of preference between buying products of firm 1 and that of firm 2 will not differ for both informed and uninformed buyers. So, both firms 1 and 2 are not affected in this situation. The sales profits of both firms in all cases are the same as shown in bar graph of figure 24.

Only firm 3 will get benefit or loss when firm 4 tries to deceive consumers. In case 1, no one buy from firm 4 because they have full information about quality, so firm 3 earns irregular profit. On contradict with other cases, when λ and α increase, profit of firm 3 continues decreasing while the profit of firm 4 continues increasing. Table C9 shows simulation results of situation E. The utilities of the game at time t0 in all cases are quite high and greater than that in other situations if only firms 2 or 3 deceive. This means that the situation of high quality producing firm deceiving will cause consumers to suffer more than situation with low quality producing firm deceiving. When buyers adjust theirs preference to avoid bad action, they take about 5 periods to learn this deception. The utility will increase and tend to reach the same levels as other cases when quality uncertainty is gone.

Situation F: Firms 1 and 3 use a separating price strategy but firms 2 and 4 use a pooling price strategy

Like the fourth cases, there are two firms trying to cheat uninformed consumers: firm 2 and 4. Now, firm 2 applies the price of firm 1's product as its own price and firm 4 applies the price of firm 3's product. The levels of taste parameter that informed consumers face are θ_{13}=0.3916 and θ_{03}=0.1393. Uninformed consumers face different levels of taste parameters. These index are θ_{e13}=0.5195 and θ_{e34}=0.1515. The simulation results of this situation are in table C11 in appendix C. This situation is unique in such a way that informed and non-cheated uninformed consumers will have only two goods to buy: goods 1 and 3. On the other hand cheated uninformed consumers will have only goods 2 and 3 to buy. No product will cross with other consumers. To clarify see this, figure 22 (f) shows the levels of taste parameters that grouping four goods into two groups. The bar graph in figure 24 also supports this action. When all consumers are informed (case 1), only goods 1 and 3 are still sold in the market because no one will buy from deceiving firms. Profit of firm 1 is higher than profit of firm 3 since buyer think goods 1 has a higher quality than goods 3. Nonetheless, both profits are irregularly high compared with in situation A. For the opposite case, when all uninformed consumers are cheated (case 5), the market has only goods 2 and 4. Consumers suffer

more in this case because they buy the product that does not have proper quality. Although, firms 2 and 4 can sell their product at time t0 because no one knows that the products have lower quality relative to their price, profit of firm 2 is higher than firm 4 because firm 2 set its price higher than firm 4.

For cases 2, 3 and 4, all products can be sold in the market but their profits change in different direction. Profits of firms 1 and 3 decrease along these cases. This is caused by increase in the fraction of uninformed and the power of deceiving. Firms 2 and 4 have more probability to cheat more consumers successfully. Firm 2's and firm 4's profits thus increase, unlike firm 1's and firm 3's profits.

This study examines utilities that have positive values at time t0 of all cases except case 5. This implies that when there is more than one firm cheating consumers, the consumers will suffer more from buying products. The utilities tend to have negative values. Welfare of buyers at time t0 in case 1 is the highest because all consumers have complete information about the qualities of products. They select the right products. The utility will not be negative in this case. When the number of uninformed consumers increases, some consumers will be deceived by firms 2 or 4. They get negative utilities when consuming these products. The utilities of cases 2, 3 and 4 are less than case 1. The serious case is case 5 where the market has all consumers uninformed and deceived. Market has only deceived products. The utilities of all consumers will be negative. In the next periods, consumers will change their preference to avoid negative utilities. Because firm 2 produces the middle-high quality, buyers take a long time to reach the steady stage. The convergence of this situation takes about 24 periods. This time-consuming result come from the wide range of taste parameters of product 2 that will use more periods to go out from it. The utility after the criteria time of case 1 is same as the utility at t0 because no consumers will adjust their preferences. For cases 2, 3 and 4, these utilities increase a little after learning through adjustment. If consumers buy goods 2 first, after criteria time they will buy from firm 3 or will not buy anything. If consumers first buy goods 4, at the end they will not buy anything. The percentages of not buying will rise. Note that the utility of not buying product is equal to zero. Therefore,

utilities after criteria time have a tiny increase because some consumers will not buy a product at the end.

The interesting case is case 5 in which the utility at t0 is negative. It takes 25 periods to remove quality uncertainty. Because this case has only deceiving products in the market, at the steady stage buyers want to get rid of the negative utility by not consuming the product. They leave the terrible market. The utility after criteria time is zero. No firms in the market can sell products and all profits are equal to zero.

Situation G: Firms 1 and 2 use a separating price strategy but firms 3 and 4 use a pooling price strategy

Firms 3 and 4 try to cheat uninformed consumers to increase their profit. Like the previous case, both firms do not know who want to cheat consumers. They have only information about what is a proper price that others firms should set if they use a separating price strategy. When this situation occurs, firm 3 will set its price equal to p_2 but not change its quality. Although firm 4 does not know that firm 3 will change its price, it thinks that firm 3 will use a separating price strategy. Thus, it sets price equal to p_3. Similar to other cases, both types of buyers will face different levels of taste parameters. The taste parameters for informed consumers are θ_{12} =0.6367 and θ_{02} =0.1509. Whereas, the taste parameters for uninformed consumers are θ_{12} =0.6367, θ_{e23_34} =0.5052 and θ_{e34} =0.1521. This situation is better than situation F because the high-quality and middle-high-quality will not cheat consumers. Firm 3 and 4 that try to cheat consumers do not produce the high-quality one. From levels of taste parameters (figure 22 (g)), goods 1 is sold out to all consumers in all cases. Then, a serious case where the market has only deceiving products will not occur. While, the percentage of not buying will increase because two of four products try to cheat uninformed consumers, both products are for low preference consumers. These consumers have no product to consume when they know that goods 3 and 4 do not have a proper quality compared with the price. They go out form the market as the utility of not buying is equal to zero.

Considering firms' profits (figure 24) and consumers' welfare at time t0 (figure 32), all consumers are informed in case 1. They cut goods 3 and 4 out off their choices because they are deceiving products. It is a surprise that the profit of firm 2 is close to that of firm 1. Described the simulation results (Table C13 in appendix C), the number of consumers buying goods 1 is little less than of consumers buying goods 2. This is caused by the wide range of θ_{12} and θ_{02}. Although the price of product 2 is less than that of product 1, more consumers consume goods 2. The bar graph of figure 24 in case 1 shows the same shape of both profits. For other cases, profits of firm 1 are stable, unlike profits of firm 2 that decreases when the fraction of uninformed and the power of cheating increase. The reduction of firm 2's profit result comes from firm 3 stealing its market share. Profit of firm 3 thus increases instead. The interesting point is the profit of firm 4 also sharply increases. When firm 3 abandons its position to compete with firm 2, firm 4 gain benefits by selling their products to buyers who do not have enough money to buy goods 3. Firm 4 raises its price to equal to firm 3 and receives more profits, especially when the number of uninformed consumers and power of cheating increase. As some consumers with very low preferences do not have a proper product that they could buy. They go out from the market. The number of not buying consumers then increases.

For the utilities at time t0, all firms have positive average utilities in all cases. Case 1 has the highest utility and followed by case 2, 4, 3 and 5. Some consumers who are deceived will adjust their preference in the next period of buying. The average convergence order of this situation is about 15 times. This short period results from the characteristic of the deceitful product. Both are not be the high quality ones. Therefore, consumers take a little time to eliminate the quality uncertainty. The utilities after criteria time are again increased.

Situation H: Only firm 1 uses a separating price strategy but firms 2, 3 and 4 use a pooling price strategy

The serious situation is situation H where all firms except firm 1 try to deceive uninformed consumers. Like other case, cheating firms do not know who want to cheat consumers. They have only information about what is a proper price that others firms should set if they use a separating price. When this situation occurred, firm 2 will set its price equal to p_1 by not changing its quality. Although firm 3 does not know that firm 2 will change its price, it thinks that firm 2 will use a separating price strategy. As a consequence, firm 3 sets price equal to p_3. Analogously, firm 4 does not know that firm 3 will change its price. It sets its price equal to p_3. Informed consumers have only goods 1 to consume or choose not buying. There is one level of taste parameter that show in figure 22 (h) for informed buyers is θ_{01}=0.1856. This wide range of taste parameter causes more informed consumers to buy goods 1. The bar graph of figure 24 in case 1 shows that only firm 1's profit exists in the market. For uninformed buyers, the levels of taste parameters are θ_{e12_23}=0.4974, θ_{e23_4}=0.2147 and θ_{e04}=0.1609. In other cases, profits of firm 2, 3 and 4 increases when the fraction of uninformed and the power of cheating increases, contradict with firm 1 that profit decreases. Firm 2 tries to catch the market share of firm 1. When the market has more uninformed, firm 2 has more chance to gain more profits. The sharply increasing profits of firm 3 and 4 result from an abandon the position of firm 2 and 3 in the market. Like situations F and G, the percentage of not to buying rises. This is caused by informed buyers and non-cheated uninformed buyers having only goods 1 or not to buy as their choice. Furthermore, the level of θ_{01} is very small, so there are only few informed consumers who do not buy anything. However, for non-cheated uninformed buyers is contradict. The level of θ_{e12_23} is big. There are more consumers who will not buy anything when competition starts.

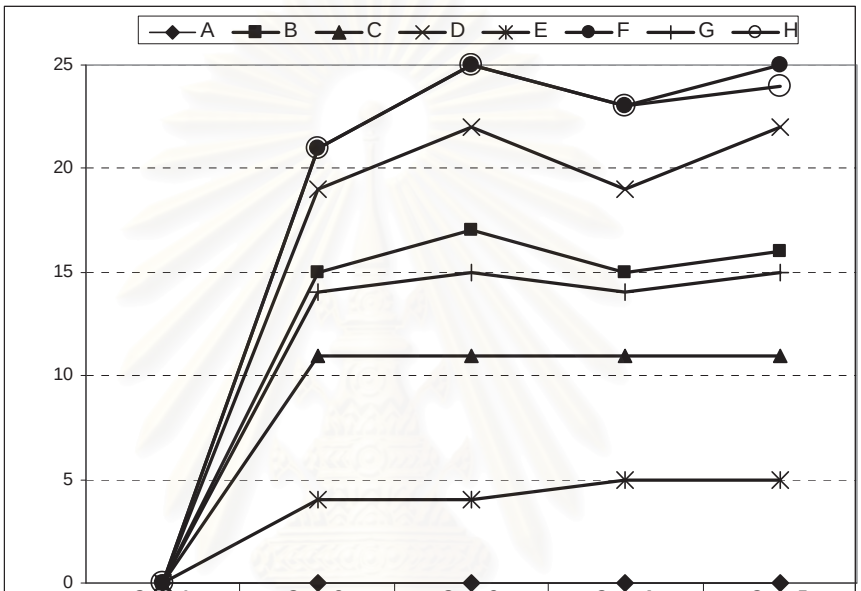
Like situation F, case 5 is a serious case here. When all uninformed consumers are deceived, the market is full of deceitful goods (goods 2, 3 and 4). Consumers suffer more in this case where the products they buy do not have a proper quality. Nonetheless, firms 2, 3 and 4 can sell their product at time t0 because no one knows

that the products are worse. Profit of firm 2 is therefore higher than others because its price is the highest.

Considering the utilities at time t0 (figure 25), all cases have positive utilities except case 5. This negative value is bigger than that in situation F. That is, when all firms except firm 1 try to deceive consumers, buyers will suffer more from buying their products. The utilities tend to be even more negative values. Again, welfare of buyers at time t0 in case 1 is the highest because all consumers have complete information about qualities of product. They select the right products. The utility will be non-negative in this case. When uninformed consumers increase, some consumers will be deceived by firm 2, 3 or 4. They get negative utilities when they consume these products. The utilities in case 2, 3 and 4 are less than that in case 1. In case 5, the market is full of all uninformed consumers who can be cheated. The market has only deceitful products. The utilities of all consumers are negative. In next periods, consumers adjust their preference to avoid negative utilities. Because firm 2 produces middle-high quality, buyers need a long time to go to the steady stage. The convergence time of this situation take about 24 periods. Time-consuming is due to the wide range of taste parameter of product 2 that will use more periods to go out from it. The utility of case 1 after the criteria time is the same as that utility at t0 because no consumers will adjust their preferences. For cases 2, 3 and 4, theses utilities will increase little after adjustment. If consumers first buy goods 2, after criteria time they will buy from firm 3 or not buying. . If consumers first buy goods 3, after criteria time they will buy from firm 4 or not buying. If consumers first buy goods 4, at the end they will not buy anything. The percentages of not buying will rise. The utility of not buying product is equal to zero. Therefore, utilities after criteria time have a tiny increase because some consumers will not buy product at the end.

The interesting case is case 5 where utility at t0 is negative. It takes 24 periods to go out from quality uncertainty. Because this case has only deceitful products in the market, at steady stage buyers avoid having the negative utility by not consuming products. They leave the terrible market. The utility after criteria time tends to zero. No firms in the market can sell products and all profits are equal to zero.

Figure 26 shows all convergence order of each situation. The line graphs demonstrate that situation F and H have the highest order of convergence periods (except case 5 that only situation F is the highest). This implies that in situation with more high quality producing firm try to deceive uninformed consumers, theses consumers takes a long time to eliminate quality uncertainty. Nonetheless, in case 3 and 5 have high convergence order, this means that the power of deceiving has more effect on the convergence periods than the fraction of uninformed consumers in the market.



	Case 1	Case 2	Case 3	Case 4	Case 5
A	0	0	0	0	0
B	0	15	17	15	16
C	0	11	11	11	11
D	0	19	22	19	22
E	0	4	4	5	5
F	0	21	25	23	25
G	0	14	15	14	15
H	0	21	25	23	24

Figure 26 All convergence order of each situation

5.6 Nash equilibrium of competition

All firms in the market are interested in profits that they will receive when competition occurred. Although, the fraction of uninformed consumers: λ and power of cheated: α are information that firms could anticipate before competition begins. Beside, all producers will expect the percentage of uninformed buyers in the market. Then, they set their strategy (separating or pooling price) to have the optimal output. All strategies that firms choose will be combined to be the situation that will happen and are

referred to calculate the utility that social will gain. To find the Nash equilibrium, this study finds the dominance strategy of each firm or use iterative dominance method to specify the results. However, from the examination above, there are five cases that distinguished by the number of λ and α that present the types of consumers in the market.

If firms know that all consumers have complete information about qualities of products, producers know that the results of case 1 will happen. Payoffs matrix (table 3) shows the earning profits of firms in all cases. The superscripts at the right upper corner of each result present the strategy where S refers separating price strategy and P refers pooling price strategy. For case 1, table 3 (a) shows the dominant strategy of all firms are separating price strategy because the separating profits of all cases are greater than pooling profits. When all firms use a separating price strategy that means the Nash equilibrium is situation A.

Table 3 Payoffs matrix of firms in all cases

	Firm 1	Firm 2	Firm 3	Firm 4
A	216.07^{S}	177.67^{S}	29.39^{S}	4.57^{S}
B	367.26^{S}	0.00^{P}	69.07^{S}	4.25^{S}
C	215.18^{S}	198.39^{S}	0.00^{P}	13.72^{S}
D	453.42^{S}	0.00^{P}	0.00^{P}	43.14^{S}
E	217.32^{S}	176.28^{S}	33.74^{S}	0.00^{P}
F	405.27^{S}	0.00^{P}	81.45^{S}	0.00^{P}
G	216.59^{S}	215.27^{S}	0.00^{P}	0.00^{P}
H	484.64^{S}	0.00^{P}	0.00^{P}	0.00^{P}

(a) Case 1

	Firm 1	Firm 2	Firm 3	Firm 4
A	217.40^{S}	177.72^{S}	29.05^{S}	4.78^{S}
B	271.49^{S}	69.33^{P}	93.15^{S}	4.82^{S}
C	220.51^{S}	139.00^{S}	44.47^{P}	24.06^{S}
D	298.17^{S}	53.26^{P}	38.54^{P}	71.19^{S}
E	221.12^{S}	176.16^{S}	28.94^{S}	7.22^{P}
F	285.71^{S}	68.32^{P}	74.63^{S}	30.84^{P}
G	238.61^{S}	124.62^{S}	17.70^{P}	30.00^{P}
H	318.38^{S}	57.26^{P}	34.58^{P}	7.29^{P}

(b) Case 2

	Firm 1	Firm 2	Firm 3	Firm 4
A	215.62^{S}	176.17^{S}	30.70^{S}	4.75^{S}
B	202.70^{S}	142.55^{P}	96.96^{S}	4.96^{S}
C	226.07^{S}	100.57^{S}	83.75^{P}	25.72^{S}
D	231.03^{S}	121.82^{P}	67.06^{P}	45.47^{S}
E	225.77^{S}	174.76^{S}	20.89^{S}	16.50^{P}
F	214.61^{S}	140.44^{P}	42.62^{S}	62.27^{P}
G	237.50^{S}	111.14^{S}	31.74^{P}	62.33^{P}
H	256.60^{S}	140.20^{P}	64.60^{P}	10.15^{P}

(c) Case 3

	Firm 1	Firm 2	Firm 3	Firm 4
A	218.45^{S}	178.83^{S}	30.13^{S}	4.54^{S}
B	153.58^{S}	151.20^{P}	117.58^{S}	5.80^{S}
C	226.38^{S}	79.41^{S}	87.60^{P}	36.94^{S}
D	123.14^{S}	120.64^{P}	78.81^{P}	90.09^{S}
E	229.23^{S}	176.78^{S}	19.31^{S}	14.90^{P}
F	150.34^{S}	148.36^{P}	65.74^{S}	63.48^{P}
G	245.52^{S}	24.73^{S}	32.54^{P}	63.50^{P}
H	140.40^{S}	137.20^{P}	72.07^{P}	9.74^{P}

(d) Case 4

	Firm 1	Firm 2	Firm 3	Firm 4
A	216.09^{S}	176.82^{S}	30.06^{S}	4.71^{S}
B	0.00^{S}	294.40^{P}	126.78^{S}	6.07^{S}
C	227.90^{S}	0.00^{S}	168.58^{P}	37.36^{S}
D	0.00^{S}	251.87^{P}	160.57^{P}	41.44^{S}
E	231.55^{S}	174.07^{S}	0.00^{S}	36.63^{P}
F	0.00^{S}	298.94^{P}	0.00^{S}	136.51^{P}
G	232.06^{S}	0.00^{S}	68.20^{P}	125.36^{P}
H	0.00^{S}	338.98^{P}	180.18^{P}	31.11^{P}

(e) Case 5

The equilibrium when all consumers are informed (case 1) is that all firms will use a separating price strategy as their main strategy and receive profits as follows. Each firm set its price according to its quality. From simulation outcomes, the profit of firm 1 is 216.07, that of firm 2 is 177.67, that of firm 3 is 29.33 and that of firm 4 is 4.57. For utilities in case 1, situation A that does not have quality uncertainty will have the highest utility: 123.16. Nonetheless, the utility at criteria time is the same as the beginning. Both consumers and firms gain more benefit from this competition and no ones are motivated to leave from this point. Therefore, situation A in case 1 is the Nash equilibrium and the best point for social.

Table 4 Utilities of all cases at time t0 and criteria time

	Case 1		Case 2		Case 3		Case 4		Case 5	
	t0	t_criteria	t0	t_criteria	t0	t_criteria	t0	t_criteria	t0	t_criteria
A	123.16	123.16	121.67	121.67	121.62	121.62	122.25	122.25	120.77	120.77
B	120.18	120.18	108.85	119.52	91.10	118.22	90.82	118.79	70.75	118.77
C	122.25	122.25	111.80	119.76	100.75	118.45	100.09	117.23	85.38	119.53
D	96.86	96.86	60.72	79.23	56.70	75.75	63.43	75.20	24.55	77.30
E	121.31	121.31	112.18	116.85	103.41	114.13	104.42	114.24	94.83	115.89
F	96.67	96.67	72.25	73.46	57.15	58.84	58.52	59.14	-29.52	0.00
G	119.50	119.50	94.66	110.31	81.15	109.59	86.95	109.75	77.22	109.77
H	83.21	83.21	75.59	81.74	53.79	55.49	56.10	67.15	-36.73	0.00

When the market has a half of uninformed consumers (λ=0.5) and the probability that firm will successfully deceive uninformed consumers is equal to 0.5 (α =0.5), case 2 will happened. The payoffs of each firm in this case are shown in table 3 (b). Only firms 1 and 2 have a dominant strategy. Both firms use a separating price strategy as their main strategy. However, firms 3 and 4 do not have a dominant strategy because some of their pooling profits are greater than their separating profit. Therefore, when firms 1 and 2 use a separating price strategy, it means that only situations A, C, E and G will take place. This study uses iterative dominance methods to cut off some situations from the decision range. Considering only 4 situations mentioned before, firm 4 will have a pooling price strategy as dominant strategy because pooling profits (situations E and G) are greater than separating profits (situations A and C). Firm 3 knows that from iterative dominance method, firm 4 will use a pooling price strategy. Consequently, it chooses the separating price strategy because its strategy because it gives the higher profit than the pooling price strategy.

The Nash equilibrium is situation E that firms 1, 2 and 3 apply a separating price strategy but firm 4 applies a pooling price strategy with firm 3's price. Firm 1's profit is 221.12, firm 2's profit is 176.16, firm 3's profit is 28.94 and firm 4's profit is 7.22. The lowest quality producing firm 4 gains more benefit because it's only one firm deceiving consumers. The utility of this case is equal to 112.18 lower than the quality the steady stage. Although situation E is Nash equilibrium of competition, there is no guarantee that it is the best point for the social. Some consumers will suffer more from consuming bad goods (goods 4). They adjust their preference. The utility when quality uncertainty is gone is higher than the utility at time t0. No one buys a product from firm 4 and welfare of buyers at criteria time is increased (equal to 116.85).

In case 3, a half of consumers are uninformed whereas the probability that firms will successfully cheat consumers is equal to 1 ($\lambda = 0.5, \alpha = 1$). All firms know that the power of deceiving is increasing that means if firms try to cheat consumers; the percentage of success is high. From the pays off matrix table 3 (c), only firm 1 has a separating price strategy as a dominant strategy. The other firms are not certain about their strategies. To find the equilibrium, the iterative dominance method is used again. When fixing a strategy for firm 3, this study examines the profits of firms 2 and 4. If firm 3 uses a separating price strategy, firm 2 will use a separating price strategy as the dominant strategy, but firm 4 will use a pooling price strategy as the dominant strategy. The solution is situation E where firms 1, 2 and 3 use a separating price strategy while firm 4 uses pooling price strategy. On the other hand, if firm 3 uses a pooling price strategy, firm 2 switches to use the pooling price strategy. For firm 4 then picks the separating price strategy instead. The outcome changes to situation D that firms 1 and 4 use the separating price strategy while firms 2 and 3 use a pooling price strategy. Examining result of both situations, firm 3 is the main sudden behavior. If firm 3 chooses a separating price strategy, the result is situation E. If firm 3 uses the pooling price strategy, the result will be situation D. To consider firm 3's behavior, situation D gives more profit to it than situation E. Thus, firm 3 will choose a pooling price strategy and the Nash equilibrium is situation D.

This iterative dominance method is a concept to find the best strategy for each player, independently of what other opponents do. The use of such payoff dominance criteria becomes much more interesting when it is applied iteratively. This method can be used to find the results when each player does not have a dominance strategy at first time. In situation D, profit of firm 1 is 231.03, that of firm 2 is 121.82, that of firm 3 is 67.06 and that of firm 4 is 45.47. The results of this situation show that both the highest quality producing firm (firm 1) and the lowest quality producing firm (firm 4) select a separating price strategy because their qualities can be easily to distinguish from others. When there are more than two firms in the market, consumers especially uninformed buyers are not easily able to distinguish the mid quality product. As a result, firms 2 and 3 choose to trick some uninformed consumers. However, from loosing market share to firm 3, firm 2 gains less profit than expected. The utility of situation D is 56.70. Many consumers suffer from being deceived. They adjust their preferences to remove quality uncertainty. Eliminating goods 2 and 3 out of the market will increase utility to 69.75 at criteria time.

Similar to case 3, case 4 has all consumers are uninformed but the probability that a firm will successfully cheat consumers is 0.5. Firms know that all consumers cannot access the source of data. They do not have the complete information about product qualities in the market. But a half of them are lucky to choose good products. Form table 3 (d), only firm 1 has a dominant strategy (a separating price strategy). The other firms are not certain about their strategies. Like above results by using iterative dominance method, this study start with setting the strategy for firm 3 to find outcome of this case. If firm 3 uses a separating price strategy, firm 2 will use a separating price strategy while firm 4 will use a pooling price strategy as the dominant strategy. Again, the solution is situation E. Changing strategy of firm 3, only firm 2 will switch to a pooling price strategy. Meanwhile firm 4 picks the separating instead. Situation D will happen. Firm 3 has the famous behavior that stimulates the equilibrium. Situation D give more profit to firm 3 than situation E. Thus, the Nash equilibrium is situation D. Results of equilibrium is that firm 1 gains 123.14, firm 2 gains 120.64, firm 3 gains 78.81 and firm4 gains 90.09. The utility of this case is 63.43 that increase when consumers change their

taste. The utility at criteria time is 85.20. Although, if case 3 and case 4 have the same pattern of Nash equilibrium but case 4 gives more welfare to consumers than case 3.

The serious case is case 5 that all consumers are uninformed and the probability that firm will successfully cheat uninformed consumers is equal to 1. Figure 32 (e) shows the pay offs profits in this case. Even if firms 1 and 2 have the dominant strategy at beginning, but the strategy of both firms are different. Firm 1 chooses a separating strategy but firm 2 chooses a pooling price strategy. With both dominant strategies of both firms, situation B, D, F and H are possible to occur. Firms 3 and 4 will set theirs pays off in the range of these four situations. Firm 3 has an iterative dominant strategy (a pooling price strategy) and firm 4 knows that firm 3 will choose a pooling price strategy. Because both firms 2 and 3 present unclear product qualities to their consumers, firm 4 will choose a separating price strategy to clearly split its quality out off the others and receive more profit. The Nash equilibrium is situation D where firms 1 and 4 use a separating price strategy and firms 2 and 3 use a pooling price strategy. Firm 1 cannot get anything in this situation. Firms 2, 3 and 4 receive more profit than expected when there is no quality uncertainty. Their profits are 251.87, 160.57 and 41.44. The utility of this case is the lowest at 24.55. However, the utility after consumers modify their preferences is very high 107.30. That is when uninformed consumers change their behavior to buy the good product (goods 4), social welfare is much better off. Even though this situation is not the best points for social, consumers will relief the pain compared with what they have at beginning time.

In situation D, The uninformed consumers are easily cheated by firms. When all producers know that some consumers do not have complete information about quality. The middle quality firms have motivated to create the unclear quality to consumers by using a pooling price strategy to make higher profits. On contrast with the highest quality firm and lowest quality firm, they can not use a pooling price strategy because there are the top and bottom quality in consumers minds. It is so difficult to cheat some consumers. These producers will use a separating price strategy. The utility of consumers in this situation is not be the best point because some consumers suffer

more from consuming low quality with higher price. Consumers will adjust their taste to eliminate quality uncertainty. They use about 20 times to relief this pain. Welfare of buyers at criteria time is better although there are some losses from cheating action get by firms. This utility is lower than utility of market that does not have quality uncertainty.

In sum, from the previous result, there are three types of Nash equilibrium due to the fraction of uninformed consumers and the deceiving power of low quality firms. First, if all consumers are informed, the best situation is all firms will set reasonable price with their quality (separating price strategy). The Nash equilibrium of case 1 is situation A. The utility is the highest compared with other cases. Second, if the market has fewer fractions of uninformed consumers and low deceiving power of firm, the Nash equilibrium is only the lowest quality producing firm will use pooling price strategy. The Nash equilibrium of case 2 is situation E. The utility is decreasing. There are some profit distortion among firm 3 and firm 4. Last, in the market with more uninformed consumers or high power of deceiving, the Nash situation is firms that produce the highest quality and the lowest quality will use separating price strategy. However the firms that produce medium quality products will use a pooling price strategy. The Nash equilibrium of case 3, 4 and 5 is situation D. The middle quality firms have incentives to create the unclear quality to consumers by using a pooling price strategy to increase profits. The utility of consumers in last two situations are not maximized because some consumers suffer from consuming low-quality products with high price. They will adjust their taste to eliminate quality uncertainty. Welfare of buyers at criteria time that no ones will be deceived is better although there are some losses from deceiving. This utility is lower than in a utility of market that does not have quality uncertainty.

In a real world, all consumers are difficulty to have full information about product quality. They use simple ways to get the information such as reading a guide book, searching in internet or asking the specialists. Although, there is impossible that all consumers can attain these sources, therefore the market that buyers have complete information (case 1) does not exist. Usually, case 1 will exist in the market that product quality is common knowledge and easy to detect the different. This caused the less

percentage of uninformed consumers and low power of deceiving. The example of market that has close to case 1 is vegetable and fruit market. Fruit that comes from the famous source can set higher price than that comes from unknown one. Durian from East side of Thailand can set the high price than that come from others. Because consumers know that its quality is the best. All producers set its price according to its quality.

When the market has less fraction of uninformed consumers and low power of deceiving, the Nash equilibrium is only the lowest quality producing firm will use pooling price strategy. The example of this market is durable market such as automobile, mobile phone and computer. Because these products show income status of buyers, so consumers does not appreciate to buy the lowest product quality. Then, firm that produces the lowest product quality will make an unclear quality to deceive uninformed consumers.

An emerging market is the example market of case with more uninformed consumers or high power of deceiving. The new launching product will make the incomplete information to consumers. More consumers will be uninformed and easily to be deceived. The producer who aims to launch a new product will not set its quality to be the lowest. He sets the product quality in the highest or medium range. If he sets the highest product quality, he will set its price according to its quality to signal to consumers. However, if he sets product quality in the medium range, he can easily deceive consumers by give the misleading information. Thus, this producer gains more profit.

The quality competition when there are more than two firms in the market is so complicated, especially when quality uncertainty appears in the market. However, both consumers' utilities and the Nash equilibrium can be found by using iterative dominance methods. For the case that all consumers are informed, the outcomes are the best point for social. Other cases have some bad effects due to quality uncertainty that makes lower utilities than the best point.

CHAPTER VI

CONCLUSION OF THE STUDY

This study develops a quality–setting model (derived from utility and costs functions) that explains firms' and consumers' behavior in the Nash equilibrium. The major conclusion is that the quality of a product is a significant factor determining equilibrium outcomes of the competition. When firms compete in either price or quantity competition, they will concern with the quality of product that they want to produce since high-quality product firms will receive more benefit (higher price and higher quantities) than the low quality ones. However, the effect of product differentiation in the Cournot model is less than that in the Bertrand model. This cause from consumers will use the price of a product as a signal of quality. When firms compete in price, consumers more directly consider the products' quality.

Solving for the Nash equilibrium for in a market without quality uncertainty shows that both prices and profits are greater in the Cournot case than in the Bertrand case, while the opposite is true for outputs and consumers surplus. More consumers are interested in vertical product differentiation. They will choose the best quality for themselves. The social welfare will then increase. Since profits of both firms are in contradiction with consumer surplus, policy makers will trade off between these solutions and select the better competition to both agents.

A simulated situation, with two types of consumers namely informed and uninformed, is analyzed. An informed buyer always knows the true quality of the product. Whereas, an uninformed buyer will face quality uncertainty if two firms are charging the same price since consumers use price as a signal of quality. If some consumers do not have complete information about the quality of products, firms have the opportunity to deceive uninformed consumers by increasing price without changing its quality to increases profit. Again, these unfair profits will exist because consumers cannot see that the true quality of firm L which is lower than the quality of firm H. Firm L suffers a disadvantage in the game when it sets a different price. Therefore, to increase

its profits, firm L will make a decision to choose the separating or the pooling price strategy. Before the beginning of the game, firm L will consider the fraction of uninformed consumers and the probability that firm L will successfully cheat uninformed consumers. If the market contains only informed consumers, firm L does not choose the pooling price strategy because consumers will know that firm L deceives them. On the other hand, if all consumers are uninformed, it is the best choice for firm L to choose the pooling price strategy.

If the market has some uninformed consumers and the power of deceiving success of firm L increases, firm L is likely to choose the pooling price strategy because more consumers will choose its products. The results of all imitation markets show that the quality of a product will directly affect both separating and pooling profits of both firms. However, the fraction of uninformed consumers and the probability that firm L can successfully cheat uninformed consumers will only affect the pooling profits. The ratio of high to low product quality is the main deciding factor that firm L will consider in choosing the strategy. If this ratio increases, the degree of product differentiation increases and firm L will try to use a pooling price strategy because its separating profit would be very low. The possible range in which firm L can use a pooling price strategy is, however, limited by the price of firm H.

Regarding the effect of the fraction of uninformed consumers and the probability that firm L can successfully cheat uninformed consumers, if all consumers are informed or the power of cheating is equal to zero, firm L will use a separating price strategy . This is because at the equilibrium firm L's separating profit is greater than its pooling profit at all levels of product differentiation. In addition, if firm L chooses a pooling price strategy, it will lose some consumers to firm H because consumers have full information about both qualities and will not choose firm L's product. When the number of uniformed consumers increases, the pooling profit of firm H will decrease, but that of firm L increases. Increasing this fraction until the market has only uninformed consumers, results in both firms' pooling profits being the same. Furthermore, if the market has only informed consumers, the pooling profit of firm H will exist at all levels of the probability

that firm L will successfully to cheat uninformed. In contrast, assuming that there are only uninformed consumers and firm L has full deceitful power, firm H will not receive any profit from the competition.

Turning to consumer welfare, the consumer surplus will decrease when the degree of product differentiation increases. Moreover, the consumer surplus when firm L uses a separating price strategy is the same in all stages and its value is higher than the consumer surplus under the pooling price strategy. The lower welfare under the pooling price strategy is due to the harm caused to buyers that consume low-quality products purchased at a high price, given they have incomplete information. In the extreme case which all consumers are uninformed and firm L has full deceiving power; the consumer surplus will be negative with the high level of product differentiation.

Information knowledge of consumers is important. The problem that both agents (consumers and firms) have different perception on product quality is due to asymmetric information. This unbalanced information of quality will only affect uninformed consumers though. If these consumers purchase goods in period one and at the end, firm H will become worse off. If there are repeated purchases by consumers in the market, consumers will adjust their expectations based on the quality they purchased in the last period. This study uses the Monte Carlo simulation method with 1000 consumers and four firms to simulate the competition in the market. Competition will repeat until there is no consumers will be deceived by firms. There are 8 situations which are different regarding the numbers of deceiving firms and 5 cases which have different fractions of uninformed consumers and cheating power of firms.

When the market does not have quality uncertainty, the firm that produces the highest quality product will gain the largest profits, followed by the firms that produce lower quality product. However, when the competition begins and the market has characterized by quality uncertainty, informed and uninformed consumers face different levels of taste parameters because some firms will deceive uninformed consumers.

The results show that there are three situation of Nash equilibrium. First, if all consumers are informed, the best situation is all firms will set reasonable price with their quality. The utility is the highest. Second, if the market has fewer fractions of uninformed consumers and low deceiving power of firm, the Nash equilibrium is only the lowest quality producing firm will use pooling price strategy. The utility is decreasing. Last, in the market with more uninformed consumers or high power of deceiving, the Nash situation is firms that produce the highest quality and the lowest quality will use separating price strategy. However the firms that produce medium quality products will use a pooling price strategy. Uninformed consumers are easily deceived by firms when all producers know that some consumers do not have complete information about quality. The middle quality producing firms have incentives to create the unclear information on quality to consumers by using a pooling price strategy to increase profits. In contrast to the highest quality producing firm and the lowest quality producing firm, they cannot use a pooling price strategy because consumers are aware of the top and bottom quality, making the firms find difficulty to deceive them. The producers will use a separating price strategy. The utility of consumers in last both situations are not maximized because some consumers suffer more from consuming low-quality products but purchasing at a higher price. Consumers will adjust their taste to eliminate quality uncertainty. Welfare of buyers at criteria time that no ones will be deceived by firms is certainty higher although there are some losses from cheating. This utility is lower than the utility in the market that does not have quality uncertainty.

When the market has more firms deceive uninformed consumers, consumers use a long convergence periods to eliminate quality uncertainty. Because this agent-based model assumes that no communication between buyers, so consumers cannot learn from others. The order of convergence will be extended. This is the limitation of this study. In real world, consumers share the information about product quality with each others. Then the order of convergence will be faster than appear in this model. The behavior of sharing the information about product quality will decrease the welfare loss from competition. Moreover, the researchers that want to develop their works from this model will consider the leaning between consumers on their model.

Quality uncertainty will lead to market failure, which decreases welfare of consumers and distorts profits among firms. Especially in the market with more uninformed consumers or higher probability that firm successfully deceives consumers, consumers experience a decreasing value of utility. Policymakers can solve this problem by giving information about quality to buyers before they make a decision. Government would construct the producer's rule to show their products' quality compare with others opponents or provide the consumers guide book to explain the feature of products. These policies will help to eliminate the quality uncertainty for uninformed consumers and raises social welfare of the market.

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APPENDIX

APPENDIX A: THE PROCESS OF GENERATE FIRMS' RANDOM QUALITIES

The method that generates the quality of firms starts with creating the variance matrix of random quality. This variance matrix has 4 parameters and 4 random errors to be estimated. To define the number in these 3 matrices, the methods try to find matrix $\boldsymbol{\sigma}$ and find the value of each equation.

$$Var(rq_i)=\begin{bmatrix}\sigma_{11}&\sigma_{12}&\sigma_{13}&\sigma_{14}\\ \sigma_{21}&\sigma_{22}&\sigma_{23}&\sigma_{24}\\ \sigma_{31}&\sigma_{32}&\sigma_{33}&\sigma_{34}\\ \sigma_{41}&\sigma_{42}&\sigma_{43}&\sigma_{44}\end{bmatrix}=\boldsymbol{\sigma}\ =\begin{bmatrix}\sqrt{\sigma_{11}}&0&0&0\\ 0&\sqrt{\sigma_{11}}&0&0\\ 0&0&\sqrt{\sigma_{11}}&0\\ 0&0&0&\sqrt{\sigma_{11}}\end{bmatrix}\begin{bmatrix}1&\rho_{12}&\rho_{13}&\rho_{14}\\ \rho_{21}&1&\rho_{23}&\rho_{24}\\ \rho_{31}&\rho_{32}&1&\rho_{34}\\ \rho_{41}&\rho_{42}&\rho_{43}&1\end{bmatrix}\begin{bmatrix}\sqrt{\sigma_{11}}&0&0&0\\ 0&\sqrt{\sigma_{11}}&0&0\\ 0&0&\sqrt{\sigma_{11}}&0\\ 0&0&0&\sqrt{\sigma_{11}}\end{bmatrix}$$

In the next step, this method generates vector random number: $\boldsymbol{\varepsilon}$ that has a normal distribution: N (0, 1). There are matrix A that is matrix of coefficient in linear combination between quality and random number.

$$vector\ \varepsilon=\begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \varepsilon_4\end{bmatrix}\sim MVN\left(\begin{bmatrix}0\\ 0\\ 0\\ 0\end{bmatrix},\begin{bmatrix}1&0&0&0\\ 0&1&0&0\\ 0&0&1&0\\ 0&0&0&1\end{bmatrix}\right)\ \ and\ \ matrix\ A=\begin{bmatrix}a_{11}&a_{12}&a_{13}&a_{14}\\ a_{21}&a_{22}&a_{23}&a_{24}\\ a_{31}&a_{32}&a_{33}&a_{34}\\ a_{41}&a_{42}&a_{43}&a_{44}\end{bmatrix}$$

There are four firms in the market, rq1-4 are random quality of firm 1 to 4. The pattern of random quality vector is

$$r\mathbf{q_i}=\begin{bmatrix}rq_1\\ rq_2\\ rq_3\\ rq_4\end{bmatrix}=\begin{bmatrix}a_{11}\varepsilon_1+a_{12}\varepsilon_2+a_{13}\varepsilon_3+a_{14}\varepsilon_4\\ a_{21}\varepsilon_1+a_{22}\varepsilon_2+a_{23}\varepsilon_3+a_{24}\varepsilon_4\\ a_{31}\varepsilon_1+a_{32}\varepsilon_2+a_{33}\varepsilon_3+a_{34}\varepsilon_4\\ a_{41}\varepsilon_1+a_{42}\varepsilon_2+a_{43}\varepsilon_3+a_{44}\varepsilon_4\end{bmatrix}=\mathbf{A\varepsilon}.$$

Random quality variance depends on variance of random number and coefficient matrix: $Var(rq_i)=\mathbf{A}\,Var(\varepsilon)\,\mathbf{A}^T=\mathbf{A}I\mathbf{A}^T$ .And then this study transforms matrix A into a low triangular matrix. To simplify the results, this study define $\mathbf{AA}^T=\Sigma$ that

$$\Sigma=\begin{bmatrix}a_{11}&0&0&0\\ a_{21}&a_{22}&0&0\\ a_{31}&a_{32}&a_{33}&0\\ a_{41}&a_{42}&a_{43}&a_{44}\end{bmatrix}\begin{bmatrix}a_{11}&a_{21}&a_{31}&a_{41}\\ 0&a_{22}&a_{32}&a_{42}\\ 0&0&a_{33}&a_{43}\\ 0&0&0&a_{44}\end{bmatrix}$$

$$=\begin{bmatrix}a_{11}^2&a_{11}a_{21}&a_{11}a_{31}&a_{11}a_{41}\\ a_{11}a_{21}&a_{21}^2+a_{22}^2&a_{21}a_{31}+a_{22}a_{32}&a_{21}a_{41}+a_{22}a_{42}\\ a_{11}a_{31}&a_{21}a_{31}+a_{22}a_{32}&a_{31}^2+a_{32}^2+a_{33}^2&a_{31}a_{41}+a_{32}a_{42}+a_{33}a_{43}\\ a_{11}a_{41}&a_{21}a_{41}+a_{22}a_{42}&a_{31}a_{41}+a_{32}a_{42}+a_{33}a_{43}&a_{31}^2+a_{32}^2+a_{33}^2+a_{44}^2\end{bmatrix}=\begin{bmatrix}\sigma_{11}&\sigma_{12}&\sigma_{13}&\sigma_{14}\\ \sigma_{21}&\sigma_{22}&\sigma_{23}&\sigma_{24}\\ \sigma_{31}&\sigma_{32}&\sigma_{33}&\sigma_{34}\\ \sigma_{41}&\sigma_{42}&\sigma_{43}&\sigma_{44}\end{bmatrix}=\boldsymbol{\sigma}$$

Converting from variance matrix and given Σ, this study solves matrix A and random qualities vector (set 4) as

$$A=\begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}=$$

$$\begin{bmatrix} \sqrt{\sigma_{11}} & 0 & 0 & 0 \\ \dfrac{\sigma_{12}}{\sqrt{\sigma_{11}}} & \sqrt{\sigma_{22}-\dfrac{\sigma_{12}^2}{\sigma_{11}}} & 0 & 0 \\ \dfrac{\sigma_{13}}{\sqrt{\sigma_{11}}} & \dfrac{\sigma_{13}\sigma_{23}-\sigma_{12}\sigma_{13}}{\sigma_{11}^2(\sigma_{22}-\dfrac{\sigma_{12}^2}{\sigma_{11}})} & \sqrt{\sigma_{33}-\dfrac{\sigma_{13}^2}{\sigma_{11}}-\dfrac{(\sigma_{11}\sigma_{23}-\sigma_{12}\sigma_{13})^2}{\sigma_{11}^2(\sigma_{22}-\dfrac{\sigma_{12}^2}{\sigma_{11}})}} & 0 \\ \dfrac{\sigma_{14}}{\sqrt{\sigma_{11}}} & \dfrac{\sigma_{11}\sigma_{24}-\sigma_{12}\sigma_{14}}{\sigma_{11}^2(\sigma_{22}-\dfrac{\sigma_{12}^2}{\sigma_{11}})} & \dfrac{\sigma_{34}-\dfrac{\sigma_{13}\sigma_{14}}{\sigma_{11}}-\dfrac{(\sigma_{13}\sigma_{23}-\sigma_{12}\sigma_{13})(\sigma_{11}\sigma_{24}-\sigma_{12}\sigma_{14})}{\sigma_{11}^2(\sigma_{22}-\dfrac{\sigma_{12}^2}{\sigma_{11}})}}{\sqrt{\sigma_{33}-\dfrac{\sigma_{13}^2}{\sigma_{11}}-\dfrac{(\sigma_{11}\sigma_{23}-\sigma_{12}\sigma_{13})^2}{\sigma_{11}^2(\sigma_{22}-\dfrac{\sigma_{12}^2}{\sigma_{11}})}}} & \sqrt{\sigma_{44}-\sigma_{33}} \end{bmatrix},$$

$$r\mathbf{q_i}=\begin{bmatrix} rq_1 \\ rq_2 \\ rq_3 \\ rq_4 \end{bmatrix}=\begin{bmatrix} a_{11}\varepsilon_1 \\ a_{12}\varepsilon_1+a_{22}\varepsilon_2 \\ a_{13}\varepsilon_1+a_{23}\varepsilon_2+a_{33}\varepsilon_3 \\ a_{14}\varepsilon_1+a_{24}\varepsilon_2+a_{34}\varepsilon_3+a_{44}\varepsilon_4 \end{bmatrix}$$

To find the quality of both firms, this study assumes variances and covariance of each random quality as shown in the variance-covariance matrix.

Table A1 Variance-covariance matrix of firms' qualities

	V1	V2	V3	V4
V1	0.021482	0.016068	0.010747	0.005517
V2	0.016068	0.032231	0.021721	0.010840
V3	0.010747	0.021721	0.033403	0.016564
V4	0.005517	0.010840	0.016564	0.021925

The next step is to generate random number: ε, and find random qualities and qualities of both firms. This study uses a random process method to make the qualities of firms in each test of simulation of which detail is in table A2.

Table A2 Detail of firm's qualities in simulation procedure

	V1	V2	V3	V4
Mean	1.469814	1.292157	1.112312	0.931289
Median	1.506846	1.307867	1.095289	0.894864
Maximum	1.649985	1.642867	1.597445	1.566199
Minimum	0.855033	0.788134	0.754860	0.750077
Std. Dev.	0.146593	0.179561	0.182796	0.148095
Observations	3000	3000	3000	3000

In vertical differentiated product market, firms will have some positive relation in production technique. This causes the quality of all firms have positive correlation in qualities. However, this relation will be high or low positive correlation that depends on product adjustment technique of each firm. In simulation market, this study assumes that the qualities of all firms are quite similar. The correlation matrix is shown in table A3.

Table A3 Correlation matrix of each firms in simulation process

	V1	V2	V3	V4
V1	1.000000	0.610632	0.401176	0.254232
V2	0.610632	1.000000	0.661969	0.407762
V3	0.401176	0.661969	1.000000	0.612070
V4	0.254232	0.407762	0.612070	1.000000

From correlations of quality, this study constructs the variance matrix of quality and then creates random quality from generate random process method. The quality production behavior of each firm is set by random quality (rq_i). To create the qualities of both firm, this study set the behavior of both firm in the range (table A2) that firm 1 has maximum quality and minimum quality with a wider range than the others and followed by firm 2, 3 and 4, respectively. Figure A1 shows all qualities that generate from random process.

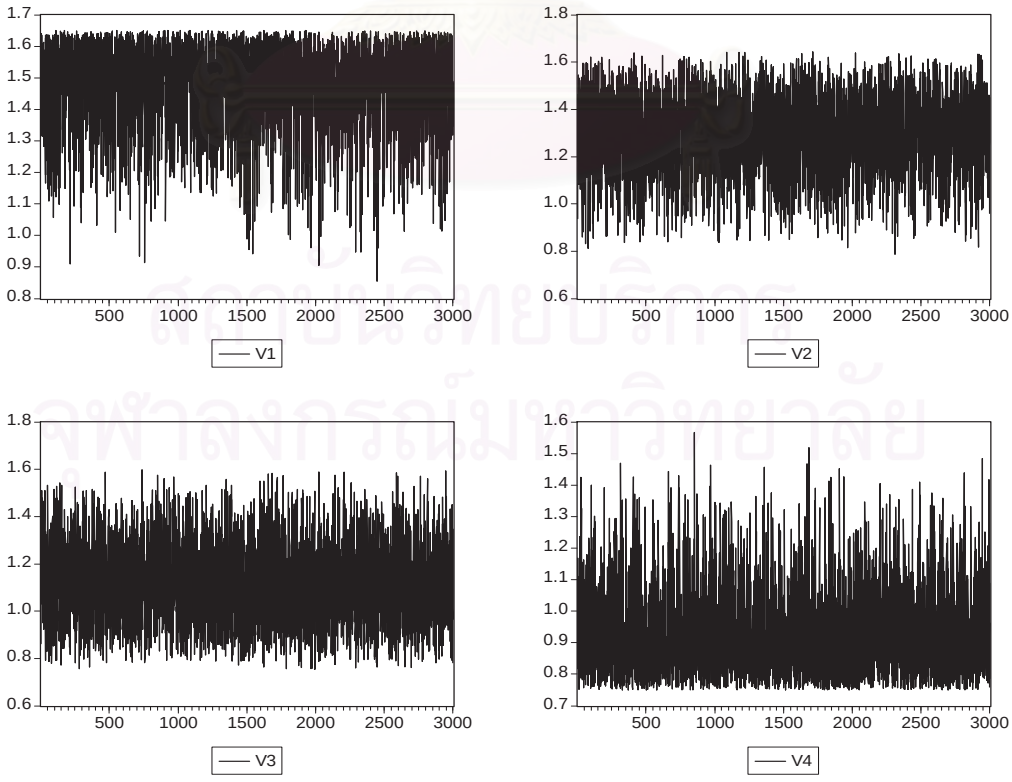

Figure A1 Generated qualities of firms with random process methods

APPENDIX B: THE PROCESS OF SIMULATION ON AGENT BASED MODEL

Table B1 An example of four firms' qualities used in Monte Carlo simulation

Quality 1	Quality 2	Quality 3	Quality 4	Quality 1	Quality 2	Quality 3	Quality 4	Quality 1	Quality 2	Quality 3	Quality 4	Quality 1	Quality 2	Quality 3	Quality 4
1.271714	1.263484	1.240966	0.800399	1.283538	1.165110	1.145618	0.895106	1.423246	1.343093	1.319260	0.897320	1.352860	1.146772	1.037384	0.928101
1.645716	1.183315	1.147655	0.841539	1.472359	1.428152	1.402543	0.961566	1.444200	1.178703	1.094817	0.939006	1.437738	1.036156	0.897530	0.821900
0.939437	0.895205	0.874902	0.753095	1.442413	1.360799	1.321006	0.901522	1.210738	1.080814	0.905810	0.812643	1.422363	0.972700	0.895263	0.852593
1.610817	1.292041	1.015013	0.883400	1.607502	1.240140	1.204501	0.951854	1.557482	1.394116	1.237384	1.039043	1.474674	1.245436	1.101715	0.894158
1.438848	1.301517	1.128941	0.765552	1.228029	1.172746	1.086843	0.794912	1.345448	1.279483	1.253280	0.908392	1.563696	1.403302	1.178179	1.055112
1.285932	1.165167	1.041742	0.954633	1.529236	1.355433	1.316703	0.857105	1.558153	1.515431	1.425638	1.170555	1.225482	1.174281	1.158282	1.058311
1.541152	1.420146	1.335507	1.296483	1.138135	1.059643	1.016736	0.788442	1.596501	1.403808	1.266470	0.833520	1.626296	1.394318	1.125734	1.094600
1.435635	1.183854	1.126391	0.964710	1.518586	1.302517	1.139193	0.967655	1.512044	1.327682	1.070209	0.905829	1.273623	1.078411	0.841348	0.805520
1.206343	1.165628	1.159344	1.122024	1.563119	1.336857	1.086020	0.930041	1.289228	1.183236	1.007735	0.897370	1.357973	1.243533	1.196597	1.022932
1.201067	1.169886	1.125192	1.020188	1.230463	1.108926	0.986982	0.903858	1.480729	1.227232	0.918825	0.752486	1.321717	1.151150	1.069732	1.041786
1.508680	1.255650	1.223678	0.787422	1.181891	1.140187	1.081256	1.067238	1.253614	1.218084	1.138447	1.041134	1.483886	1.429433	1.384580	1.201410
1.394926	1.148971	1.017836	0.938418	1.628014	1.602393	1.537152	1.360970	1.450864	1.115747	1.024586	0.782862	1.551631	1.463256	1.333244	0.762744
1.106584	0.934031	0.949337	0.814237	1.462136	1.100039	0.995472	0.950952	1.046042	0.906001	0.846530	0.784511	1.054019	1.033104	1.014409	0.833800
1.601290	1.278016	1.100788	0.986396	1.091538	1.012142	1.000294	0.912964	1.038157	0.977251	0.946283	0.831225	1.542372	0.940729	0.861413	0.833071
1.648580	1.572286	1.444800	1.154029	1.630309	1.588275	1.568765	1.068934	1.605879	1.117523	1.047585	0.832560	1.162254	0.938397	0.785783	0.752936
1.573910	1.174695	1.063665	0.974420	1.158761	0.863599	0.805338	0.775700	1.646080	1.337241	1.009763	0.818092	1.528908	1.211627	1.095137	1.008899
1.644743	1.480038	1.363906	0.938618	1.630229	1.366279	1.222665	0.767679	1.516328	1.206165	1.124027	0.810648	1.558668	1.227018	1.139346	1.059994
1.484234	1.388293	1.304349	0.955524	1.004975	0.945892	0.920164	0.892378	1.648478	0.936384	0.853396	0.752225	1.123580	0.986906	0.917863	0.851266
1.615134	1.454361	1.351458	1.125332	1.467688	1.032596	0.991482	0.759324	1.271850	1.194281	1.126240	0.938880	1.273385	0.924439	0.871958	0.794443
1.638299	1.460885	1.373610	0.794639	1.496587	1.104577	0.903968	0.753004	1.555577	1.260758	1.211172	0.831870	1.431116	1.421176	1.322877	1.279606
1.458751	1.296610	1.145688	0.957119	1.436284	1.322714	1.278680	0.907209	1.601823	1.513366	1.465500	1.014243	1.278373	1.195760	1.057870	0.958355
1.617513	0.961589	0.923852	0.817087	1.520617	1.381660	1.254495	0.850912	1.435645	1.232369	0.963231	0.920188	1.340002	1.271092	1.159452	0.793202
1.641523	1.256963	1.045891	0.870307	1.494166	1.440953	1.429262	1.206235	1.327080	1.089827	0.901302	0.875874	1.322723	1.219608	1.135016	0.971689
1.450714	1.375321	1.325416	0.909381	1.194182	1.149313	1.055179	0.964749	1.422438	1.294748	1.106258	0.896301	1.614935	1.069257	0.860565	0.794845
1.138937	1.128020	1.112010	1.025156	1.642934	1.402490	1.226323	0.947444	1.538504	1.390397	1.267245	0.996475	1.443414	1.411277	1.378671	0.791844
1.556357	1.282306	0.940471	0.760855	1.497091	1.440043	1.432055	0.916632	1.463357	0.988888	0.785088	0.775763	1.432255	1.336220	1.174126	0.999169
1.414645	1.014103	0.953055	0.809874	1.458801	1.327171	1.215562	1.039583	1.630627	1.341267	1.133615	0.973495	1.293927	1.182454	1.091967	0.969296
1.435254	1.273071	1.094404	0.948189	1.552195	1.157963	1.118379	1.026114	1.443252	1.408504	1.337454	1.284180	1.573805	1.146835	1.106205	1.051778
1.539291	1.524446	1.504389	0.768082	1.336702	1.176713	1.045538	0.803202	1.010027	0.941734	0.912281	0.782249	1.346472	1.117661	1.055583	0.883539
1.441377	1.047779	0.942400	0.869318	1.514015	1.014635	0.943330	0.883331	1.626262	1.070726	0.956999	0.954639	1.576631	1.119136	0.963147	0.773163
1.058891	0.944895	0.938164	0.864486	1.614271	1.568301	1.487607	0.889589	1.628386	1.533854	1.388870	1.040539	1.555116	1.169532	0.968066	0.926377
1.581236	1.497463	1.456792	1.237784	1.638830	1.459681	1.222611	0.815990	1.526655	1.404806	1.245670	1.108881	1.503117	1.241648	1.216532	1.086871
1.483016	1.099076	0.917481	0.841516	1.321061	1.194262	1.065673	0.867410	1.626992	1.499407	1.410719	1.037988	1.587880	1.336032	1.046644	0.923419
1.230385	1.004683	0.968177	0.954551	1.627851	0.998902	0.871742	0.831548	1.620783	1.461443	1.321896	0.937273	1.307750	1.093565	0.926498	0.916374
1.502882	1.123563	0.967765	0.808003	1.444711	1.113217	1.013588	0.963847	1.444612	1.412607	1.365663	1.253313	1.617628	1.364463	1.299906	0.897907
1.624176	1.193836	1.011219	0.857297	1.608883	1.391595	1.368932	1.198113	1.329591	1.317379	1.304261	1.212385	1.480091	1.161054	1.124879	0.905156
1.291263	1.193013	1.065667	0.800163	1.573659	1.402151	1.228350	1.121125	1.534325	1.221670	0.996161	0.792654	1.588001	1.090141	1.013157	0.907260
1.628052	1.099247	1.065212	1.057782	1.573639	1.383751	1.163836	1.080052	1.589725	1.503120	1.416724	1.357756	1.279133	1.075345	1.004086	0.755146
1.625805	0.984710	0.937557	0.934664	1.305528	1.188025	1.039446	1.002202	1.297791	1.229878	1.114969	1.092025	1.601432	1.302900	1.133975	0.786237
1.431251	1.300643	1.272745	0.894515	1.563017	1.222687	1.013012	0.800871	1.639733	1.181201	1.002625	0.830777	1.434356	1.144135	0.886559	0.832137
1.222892	1.104177	1.027094	0.757015	1.306055	1.013759	0.843684	0.758858	1.503251	1.318307	1.262871	1.006181	1.632533	1.461209	1.469432	1.391631
1.512927	1.450867	1.416827	0.959462	1.258432	0.808473	0.765291	0.761604	1.422442	1.269804	1.260896	0.754436	1.619597	1.402824	1.336901	1.257104
1.377336	1.229233	1.143381	0.891440	1.525130	1.049140	0.992335	0.982659	1.511392	1.237660	1.126267	0.998050	1.188682	1.137771	1.036990	0.995297
1.466191	1.272821	1.156368	1.154622	1.588232	1.247272	1.120320	0.851845	1.331437	0.978392	0.908861	0.855908	1.559788	1.344346	1.086663	0.842972
1.484245	0.964330	0.871370	0.854089	1.614322	1.425722	1.332913	1.119697	1.423295	1.024486	0.838577	0.875307	1.164019	1.129335	1.122004	0.969309
1.268485	1.085453	1.057718	0.800816	1.325384	1.142967	1.032398	0.756679	1.359979	1.231895	1.147035	1.094799	1.562842	1.223345	1.160683	0.983621
1.480036	1.389512	1.291099	1.262987	1.487298	1.035605	0.988317	0.751412	1.127550	1.048768	0.985304	0.905291	1.557710	1.538211	1.520957	1.250262
1.048660	0.984183	0.961038	0.956480	1.632365	1.154527	0.976607	0.893126	1.564043	1.219325	1.128379	0.886309	1.426056	1.238631	1.047730	0.932019
1.326753	1.256371	1.150903	0.938687	1.580821	1.283695	1.178271	1.144483	1.568527	1.092350	0.928545	0.894893	1.263194	1.228298	1.181873	1.103287
1.525262	1.188042	0.902661	0.839484	1.378506	1.047018	1.023052	0.937965	1.246221	1.083350	0.972324	0.764789	1.536596	1.268444	1.173543	0.814530
1.478358	1.248435	1.086937	0.920812	1.532253	1.473789	1.454386	1.021891	1.351980	1.231184	1.041183	1.027982	1.521755	1.433195	1.385082	0.954893
1.426042	1.177879	1.076344	0.942688	1.447752	1.145038	1.090160	1.055713	1.481070	1.244384	1.166967	0.923272	1.258639	0.995629	0.971828	0.839563
1.066890	0.925509	0.810599	0.794814	1.245045	1.167919	1.157400	0.996078	1.098990	1.023307	1.010718	0.817858	1.639275	1.214953	1.173548	0.793614
1.355690	1.343759	1.298226	0.899042	1.241500	1.025726	0.835018	0.834889	1.125599	0.910815	0.878932	0.842796	1.586181	1.157618	1.012343	0.794789
1.605960	1.386319	1.247413	1.029382	1.529463	1.150286	1.067214	0.847074	1.578216	1.285663	0.940305	0.937745	1.503073	1.417245	1.272909	0.770359
1.281434	1.114980	0.894353	0.835294	1.513318	1.192778	0.928833	0.853669	1.635101	1.565414	1.462437	1.074585	1.473106	1.167451	0.863852	0.751761
1.295940	1.076304	0.852490	0.816863	1.619526	1.289027	1.221893	0.932685	1.456224	1.259168	1.214187	0.804272	1.635463	1.366688	1.173231	0.882322
1.511704	1.374014	1.270379	1.123427	1.136776	1.079546	0.970091	0.951449	1.443139	1.020133	0.952148	0.933638	1.079715	1.017097	0.975982	0.845939
1.264198	0.984132	0.948220	0.762327	1.540367	1.403291	1.338994	0.765181	1.366755	1.311506	1.222584	1.058163	1.493736	1.128515	1.085144	0.924977
1.442470	1.411707	1.395386	1.312455	1.293263	1.122427	0.899468	0.832983	1.581104	1.243305	0.987025	0.776396	1.564843	1.416603	1.303307	1.219489
1.366593	1.026559	0.969747	0.955285	1.584501	1.324125	1.232540	0.827685	1.608490	1.548401	1.491917	1.030401	1.522683	1.257939	1.067718	0.790328
1.412621	1.402031	1.348262	0.901304	1.579584	1.300295	1.009053	0.974362	1.490235	1.318420	1.073826	0.867248	1.641771	1.361308	1.286401	0.979344
1.568270	1.304253	1.219777	1.064564	1.433437	1.088432	0.922654	0.914138	1.447929	1.127786	0.826618	0.766258	1.453745	1.332051	1.208052	1.163331
1.468495	1.443750	1.364294	1.061552	1.435779	1.356472	1.243822	1.131584	1.439613	1.022216	0.977179	0.807776	1.470924	1.446413	1.384381	0.763018
1.002576	0.939480	0.875870	0.837976	1.511972	1.315625	1.239976	0.762283	1.435210	1.305868	1.215734	0.808301	1.648681	1.537636	1.473744	1.264272
1.365028	0.952271	0.913303	0.880177	1.292797	1.234574	1.178203	0.895251	1.257654	1.135087	1.091736	0.930408	1.613738	1.202446	0.881533	0.775899
1.462588	1.097013	0.912805	0.855039	1.387472	1.282159	1.238341	0.903912	1.437272	1.221614	1.133476	0.983431	1.319679	1.165246	1.025388	0.869516

Table B2 Consumers' preferences used in Monte Carlo simulation (1000 consumers)

0.557097	0.556162	0.400578	0.008126	0.401450	0.898865	0.927026	0.539799	0.124134	0.229323	0.887078	0.586041	0.537160	0.127764	0.458620	0.377324	0.518314	0.887556	0.888697	0.159418
0.128208	0.786826	0.657860	0.387556	0.510001	0.845772	0.581611	0.019364	0.012627	0.050632	0.178203	0.551490	0.095551	0.555393	0.690483	0.424431	0.384218	0.784628	0.699962	0.894136
0.389257	0.862655	0.494299	0.743918	0.627448	0.773830	0.236430	0.175385	0.739421	0.450023	0.760330	0.889720	0.024555	0.654532	0.035602	0.422846	0.697664	0.161730	0.999182	0.174888
0.212779	0.554052	0.990743	0.910247	0.131754	0.583973	0.833823	0.156888	0.464891	0.863510	0.514925	0.114790	0.223097	0.269236	0.894688	0.588089	0.506967	0.430417	0.807631	0.309713
0.372950	0.628714	0.659719	0.839998	0.542268	0.364286	0.742371	0.195607	0.788077	0.560734	0.536111	0.759080	0.989981	0.237028	0.159990	0.211279	0.472729	0.095571	0.796688	0.530289
0.553338	0.132552	0.221282	0.782696	0.693427	0.513261	0.139600	0.732579	0.022824	0.435864	0.134345	0.697591	0.158273	0.669815	0.058624	0.079279	0.058648	0.837351	0.973949	0.006521
0.062840	0.834510	0.668807	0.029599	0.755329	0.646367	0.399368	0.359050	0.527273	0.039126	0.045440	0.642623	0.219895	0.479767	0.244255	0.636316	0.762648	0.606972	0.537940	0.995607
0.090344	0.896534	0.145992	0.071268	0.263759	0.589943	0.636763	0.760880	0.849200	0.489875	0.150856	0.116352	0.355351	0.228748	0.677723	0.538105	0.975697	0.376228	0.497315	0.668416
0.129889	0.904049	0.753695	0.425993	0.253974	0.560486	0.685183	0.532518	0.324350	0.350456	0.012264	0.512384	0.195738	0.902463	0.694957	0.107644	0.527303	0.141639	0.984143	0.045568
0.811912	0.307338	0.301320	0.229293	0.583809	0.641440	0.539189	0.644636	0.298382	0.992303	0.825490	0.489747	0.321558	0.760944	0.454961	0.011524	0.161814	0.534866	0.107057	0.201960
0.563365	0.217409	0.383378	0.582161	0.578677	0.046370	0.407098	0.151316	0.719062	0.992869	0.732396	0.344946	0.020903	0.516223	0.504844	0.152700	0.059011	0.026512	0.196303	0.697664
0.960818	0.091117	0.981540	0.669647	0.923041	0.416958	0.428050	0.394262	0.647711	0.794653	0.453629	0.067608	0.898735	0.482394	0.274867	0.389760	0.957592	0.083050	0.532845	0.303117
0.526114	0.102612	0.492775	0.396335	0.953968	0.195743	0.713577	0.924929	0.679805	0.273551	0.315486	0.944239	0.098617	0.289405	0.365792	0.001263	0.051653	0.867954	0.548332	0.927931
0.711552	0.709407	0.666766	0.716274	0.704609	0.771825	0.843656	0.676301	0.450351	0.998064	0.204103	0.720976	0.801390	0.789144	0.100466	0.382957	0.795283	0.833802	0.262988	0.277366
0.767804	0.528508	0.455649	0.469108	0.408113	0.757988	0.588507	0.395866	0.999884	0.580470	0.789332	0.720641	0.159355	0.305987	0.336281	0.365200	0.646233	0.383781	0.144260	0.744519
0.078416	0.780974	0.893405	0.190223	0.028236	0.702530	0.654936	0.615289	0.256579	0.289486	0.610651	0.861124	0.269843	0.721592	0.305767	0.411722	0.974981	0.264088	0.387900	0.405363
0.896959	0.580512	0.173255	0.253386	0.901496	0.011776	0.258227	0.504060	0.952553	0.303365	0.595762	0.353371	0.966507	0.523888	0.657136	0.982045	0.608424	0.651598	0.314230	0.310695
0.306163	0.576266	0.950813	0.917084	0.732013	0.093532	0.026948	0.622474	0.350673	0.264796	0.426806	0.201275	0.791780	0.221848	0.335792	0.354726	0.993901	0.172017	0.137621	0.485006
0.384327	0.348471	0.464626	0.615068	0.261551	0.501781	0.086155	0.288318	0.684760	0.803719	0.067967	0.520900	0.881407	0.700969	0.490756	0.851887	0.649613	0.170210	0.653898	0.596738
0.289572	0.627034	0.932510	0.679561	0.575767	0.793290	0.850702	0.497696	0.736826	0.473761	0.500573	0.496238	0.341551	0.991956	0.589861	0.870747	0.463377	0.595519	0.606884	0.828693
0.449804	0.656540	0.051390	0.967614	0.862161	0.268655	0.464082	0.510708	0.229053	0.082459	0.880684	0.761152	0.488621	0.321608	0.129906	0.614947	0.047324	0.212754	0.697153	0.985188
0.204301	0.586000	0.260635	0.804682	0.672403	0.875909	0.830678	0.380256	0.719890	0.861099	0.423895	0.678168	0.128406	0.833431	0.090683	0.617738	0.557362	0.949278	0.793048	0.035308
0.267807	0.898592	0.577778	0.656372	0.793336	0.683959	0.471968	0.601285	0.966762	0.547149	0.478101	0.828950	0.728164	0.333204	0.988448	0.091085	0.290401	0.279455	0.275612	0.311814
0.277777	0.282875	0.282461	0.017582	0.105184	0.932324	0.027045	0.498153	0.352361	0.493869	0.066368	0.517733	0.253490	0.810482	0.474376	0.765790	0.601127	0.469300	0.430529	0.022149
0.451604	0.720186	0.934981	0.969032	0.302532	0.147321	0.949061	0.933760	0.340430	0.688154	0.581275	0.417706	0.565455	0.603253	0.606686	0.673838	0.089693	0.136340	0.793418	0.052704
0.532802	0.127272	0.457955	0.740438	0.637014	0.836466	0.537816	0.119145	0.771255	0.172250	0.716526	0.428244	0.800227	0.421967	0.011030	0.871219	0.512565	0.746156	0.805107	0.123465
0.110053	0.655442	0.544432	0.579202	0.310266	0.951449	0.370710	0.033665	0.344732	0.119519	0.364991	0.953638	0.007394	0.029552	0.849200	0.528590	0.318212	0.712746	0.806869	0.577435
0.488235	0.392380	0.831547	0.642056	0.510119	0.226187	0.073134	0.797423	0.528034	0.949668	0.131671	0.470680	0.131028	0.650421	0.651285	0.456813	0.655012	0.246946	0.840622	0.008764
0.416989	0.444961	0.605721	0.962561	0.774744	0.800589	0.536829	0.486988	0.994013	0.223206	0.690395	0.246233	0.886698	0.645943	0.367450	0.197725	0.621957	0.034127	0.125602	0.630658
0.539239	0.375244	0.384893	0.803701	0.153035	0.206836	0.004834	0.863103	0.648447	0.679358	0.986868	0.932086	0.786345	0.908987	0.230063	0.982362	0.833803	0.320900	0.902152	0.486082
0.193730	0.083592	0.891791	0.763996	0.698896	0.572972	0.544969	0.764771	0.426577	0.119683	0.101696	0.819981	0.033837	0.579908	0.680186	0.181737	0.282267	0.838139	0.728470	0.218346
0.643978	0.186315	0.513600	0.185372	0.345005	0.087809	0.998600	0.192745	0.031784	0.498075	0.815807	0.540220	0.211127	0.467176	0.176724	0.061317	0.856241	0.903223	0.718787	0.055873
0.799745	0.360410	0.950644	0.128045	0.177031	0.687660	0.303905	0.346739	0.994366	0.585748	0.773149	0.381525	0.646757	0.504075	0.310703	0.538497	0.687329	0.762102	0.113442	0.136458
0.284734	0.512190	0.182754	0.742371	0.084839	0.598288	0.165339	0.050135	0.293631	0.355218	0.514235	0.309806	0.146857	0.071929	0.295117	0.236560	0.601178	0.662928	0.567648	0.072763
0.603012	0.774692	0.307994	0.641116	0.535555	0.175330	0.362874	0.902458	0.304188	0.515522	0.084327	0.673173	0.917077	0.818699	0.350832	0.090019	0.687586	0.063941	0.674490	0.444839
0.866236	0.189638	0.297047	0.820212	0.302663	0.265673	0.014000	0.543887	0.281887	0.801645	0.056134	0.780973	0.681280	0.916320	0.759366	0.740748	0.713017	0.090537	0.823569	0.546723
0.287557	0.008004	0.738242	0.541873	0.019028	0.048474	0.156019	0.273880	0.484069	0.891415	0.015642	0.672374	0.157828	0.636413	0.382787	0.751366	0.850307	0.874121	0.625672	0.052957
0.700622	0.800871	0.127538	0.343729	0.042196	0.899657	0.137695	0.393453	0.516965	0.308758	0.340152	0.661867	0.665846	0.447785	0.794763	0.518817	0.006715	0.678454	0.480648	0.349685
0.026876	0.586695	0.067950	0.411794	0.189519	0.387036	0.318434	0.297426	0.020845	0.985716	0.244276	0.418768	0.180252	0.516969	0.382319	0.386022	0.661661	0.620891	0.233865	0.332193
0.132696	0.403990	0.092999	0.894687	0.439997	0.912306	0.655344	0.915341	0.946656	0.205375	0.172547	0.693437	0.996048	0.764502	0.581361	0.777104	0.299945	0.056437	0.888787	0.776912
0.625270	0.374236	0.234046	0.189493	0.668301	0.102605	0.558740	0.979486	0.340749	0.042314	0.438785	0.340479	0.830297	0.098691	0.724834	0.785179	0.147008	0.639661	0.221786	0.561308
0.465720	0.676272	0.143310	0.031216	0.373606	0.870914	0.755503	0.932627	0.003934	0.669282	0.360490	0.400758	0.756042	0.595293	0.413223	0.494226	0.261475	0.574421	0.030428	0.544108
0.691037	0.276200	0.016806	0.657338	0.440327	0.601603	0.768256	0.391001	0.556128	0.044006	0.257086	0.969267	0.069718	0.833158	0.304650	0.839938	0.315476	0.847967	0.334968	0.488414
0.314055	0.918467	0.154430	0.878097	0.710366	0.236216	0.480747	0.246895	0.166810	0.672563	0.426941	0.928927	0.367472	0.855552	0.313830	0.118406	0.165622	0.714414	0.285035	0.035862
0.064607	0.801121	0.928730	0.974129	0.799932	0.200640	0.270245	0.465347	0.536322	0.389169	0.805377	0.346818	0.274871	0.135593	0.351656	0.434307	0.927675	0.694847	0.810505	0.360642
0.882601	0.185657	0.451324	0.095544	0.363998	0.474775	0.054302	0.973812	0.993413	0.601213	0.535142	0.544761	0.010223	0.772433	0.599603	0.452608	0.659857	0.240735	0.644998	0.887480
0.179485	0.122868	0.381167	0.881084	0.406981	0.313865	0.416461	0.435708	0.110222	0.819570	0.276176	0.761071	0.576847	0.047572	0.735737	0.358253	0.094376	0.496801	0.400725	0.755436
0.957775	0.170782	0.495935	0.092326	0.710348	0.362327	0.549183	0.112549	0.847017	0.808463	0.871405	0.161342	0.035760	0.329217	0.243084	0.255130	0.194256	0.435501	0.320179	0.070165
0.065387	0.074327	0.118806	0.767039	0.819899	0.818975	0.967282	0.986596	0.688631	0.185731	0.413590	0.136202	0.689351	0.959153	0.021717	0.760982	0.596350	0.102606	0.534175	0.345081
0.685933	0.199833	0.498391	0.973386	0.991710	0.462203	0.113162	0.006733	0.374701	0.190943	0.790668	0.560297	0.688515	0.358429	0.331991	0.146645	0.973206	0.336745	0.128454	0.096495

Table B3 Example of Monte Carlo simulation result at t0 and next times (Case 2, situation B)

Simulation Consumers behaviors

ze13	0.6338
z04	0.1386
z34	0.1770
z13	0.4723
zetabar	1.0000

Set 4	quality	price
Not buy	0.0000	0.0000
Goods 4	0.9760	0.3922
Goods 3	1.0920	0.4517
Goods 2	1.3624	1.2070
Goods 1	1.6435	1.2070

Lamda	0.5	alpha	0.5
Informed	504	Noncheated	763
Uninformed	496	Cheated	237

	Random Number					t0				t1			t13		
obs	Set 1	Set 2	Set 3	Lamda	Alpha	Type 0	Quality	price	Utility	Set 5	Type 1	Utility	Set 5	Type 13	Utility
1	0.5571	0.9825	0.9824	Informed	Noncheated	Goods 1	1.6435	1.2070	0.2914	0.7105	Goods 1	0.2914	0.2678	Goods 1	0.2914
2	0.1282	0.7109	0.5177	Informed	Noncheated	Not buy	0.0000	0.0000	0.0000	0.6360	Not buy	0.0000	0.7581	Not buy	0.0000
3	0.3893	0.0685	0.7567	Uninformed	Noncheated	Goods 3	1.0920	0.4517	0.0267	0.5547	Goods 3	0.0267	0.7266	Goods 3	0.0267
4	0.2128	0.5310	0.7053	Informed	Noncheated	Goods 3	1.0920	0.4517	0.2194	0.4459	Goods 3	0.2194	0.5132	Goods 3	0.2194
5	0.3729	0.3245	0.5052	Uninformed	Noncheated	Goods 3	1.0920	0.4517	0.0445	0.5137	Goods 3	0.0445	0.5060	Goods 3	0.0445
6	0.5533	0.2746	0.7382	Uninformed	Noncheated	Goods 3	1.0920	0.4517	0.1525	0.4517	Goods 3	0.1525	0.4315	Goods 3	0.1525
7	0.0628	0.4664	0.5563	Uninformed	Noncheated	Not buy	0.0000	0.0000	0.0000	0.0642	Not buy	0.0000	0.6371	Not buy	0.0000
34	0.9040	0.4616	0.3602	Uninformed	Cheated	Goods 2	1.3624	1.2070	-0.0246	0.9599	Goods 2	-0.0246	0.7680	Goods 3	0.5355
35	0.3073	0.7138	0.7517	Informed	Noncheated	Goods 3	1.0920	0.4517	0.1161	0.4486	Goods 3	0.1161	0.4439	Goods 3	0.1161
36	0.2174	0.8766	0.1000	Informed	Noncheated	Goods 3	1.0920	0.4517	0.2143	0.0091	Goods 3	0.2143	0.7338	Goods 3	0.2143
37	0.0911	0.9530	0.7367	Informed	Noncheated	Not buy	0.0000	0.0000	0.0000	0.4353	Not buy	0.0000	0.1293	Not buy	0.0000
38	0.1026	0.9301	0.6912	Informed	Noncheated	Not buy	0.0000	0.0000	0.0000	0.7573	Not buy	0.0000	0.8534	Not buy	0.0000
39	0.7094	0.2749	0.2035	Uninformed	Cheated	Goods 2	1.3624	1.2070	-0.2406	0.0544	Goods 2	-0.2406	0.6022	Goods 3	0.3229
58	0.1460	0.4240	0.7677	Uninformed	Noncheated	Goods 4	0.9760	0.3922	0.2497	0.1466	Goods 4	0.2497	0.5293	Goods 4	0.2497
59	0.7537	0.4123	0.3706	Uninformed	Cheated	Goods 2	1.3624	1.2070	-0.1802	0.6975	Goods 2	-0.1802	0.1320	Goods 3	0.3713
995	0.6859	0.8406	0.2480	Informed	Noncheated	Goods 1	1.6435	1.2070	0.0797	0.6200	Goods 1	0.0797	0.7376	Goods 1	0.0797
996	0.1857	0.1317	0.5259	Uninformed	Noncheated	Goods 3	1.0920	0.4517	0.2490	0.1550	Goods 3	0.2490	0.2483	Goods 3	0.2490
997	0.1229	0.2562	0.7210	Uninformed	Noncheated	Not buy	0.0000	0.0000	0.0000	0.2825	Not buy	0.0000	0.6855	Not buy	0.0000
998	0.1708	0.5609	0.5578	Informed	Noncheated	Goods 4	0.9760	0.3922	0.2255	0.2726	Goods 4	0.2255	0.2270	Goods 4	0.2255
999	0.0743	0.4401	0.6794	Uninformed	Noncheated	Not buy	0.0000	0.0000	0.0000	0.0989	Not buy	0.0000	0.3685	Not buy	0.0000
1000	0.1998	0.6773	0.9652	Informed	Noncheated	Goods 3	1.0920	0.4517	0.2335	0.2386	Goods 3	0.2335	0.0512	Goods 3	0.2335
Sum	485.23	501.17	509.94				1141.42	713.66	-29.35	495.75		-20.73	504.33		9.55
Mean	0.4854	0.5019	0.5109				1.1425	0.7141	-0.0296	0.4960		-0.0210	0.5044		0.0093
Max	0.9992	0.9990	0.9998				1.6435	1.2070	0.4351	0.9998		0.4351	0.9995		0.6355
Min	0.0013	0.0002	0.0006				0.0000	0.0000	-0.4301	0.0009		-0.4401	0.0022		0.0000

Table B4 Example of Monte Carlo simulation result at t0 and next times (Case 2, situation B)

													Goods (t0)					Profit (t0)					Order	Goods (t_criteria)					Profit				
	Quality 1	Quality 2	Quality 3	Quality 4	Price 1	Price 2	Price 3	Price 4	z13	z34	z04	ze13	1	2	3	4	Not	1	2	3	4	Utility	to convert	1	2	3	4	Not	1	2	3	4	Utility
1	1.2668	1.1509	1.1149	0.9046	0.7131	0.7131	0.4485	0.3584	0.6007	0.1478	0.1366	0.9714	206	6	624	11	153	120.80	3.59	210.31	2.95	119.26	3	206	0	630	11	153	120.80	0.00	212.33	2.95	120.63
2	1.5496	1.4083	1.2584	0.9357	0.8930	0.8930	0.5203	0.3759	0.4413	0.1543	0.1385	0.5827	391	86	355	13	155	288.57	64.68	140.05	3.67	73.70	14	391	0	441	13	155	288.57	0.00	173.97	3.67	95.90
3	1.6485	1.6323	1.6022	0.9744	0.6776	0.6776	0.6308	0.3818	0.3487	0.1367	0.1351	0.4229	469	136	242	4	149	240.46	69.95	113.87	1.14	214.56	17	469	0	378	4	149	240.46	0.00	177.87	1.14	218.19
4	1.2969	1.2254	1.0967	1.0445	0.6563	0.6563	0.4364	0.4115	0.3786	0.1645	0.1358	0.4609	445	126	250	29	150	234.32	67.25	81.67	8.90	98.25	15	445	0	376	29	150	234.32	0.00	122.84	8.90	114.81
5	1.4902	1.4226	1.3587	1.0972	0.7187	0.7187	0.5455	0.4342	0.4538	0.1468	0.1365	0.6109	378	76	385	8	153	215.33	43.81	157.72	2.60	145.35	13	378	0	461	8	153	215.33	0.00	188.85	2.60	154.69
6	1.4838	1.4346	1.3988	1.3784	0.6758	0.6758	0.5502	0.5399	0.5096	0.1748	0.1351	0.7169	320	45	447	39	149	168.77	23.95	183.43	15.68	173.23	12	320	0	492	39	149	168.77	0.00	201.89	15.68	177.48
7	1.5974	1.4494	1.3589	0.8165	0.9147	0.9147	0.5580	0.3269	0.5157	0.1470	0.1380	0.7476	309	45	484	7	155	233.29	34.64	204.31	1.72	108.26	12	309	0	529	7	155	233.29	0.00	223.31	1.72	120.78
8	1.6456	1.5656	1.3307	1.1745	0.8156	0.8156	0.5343	0.4648	0.3080	0.1534	0.1365	0.3528	511	148	173	15	153	332.67	97.53	69.42	5.21	122.16	17	511	0	321	15	153	332.67	0.00	128.81	5.21	141.32
9	1.4715	1.2734	1.1985	0.8740	0.9523	0.9523	0.4932	0.3502	0.5799	0.1519	0.1382	0.9103	233	15	586	11	155	187.60	12.37	218.77	2.89	90.85	6	233	0	601	11	155	187.60	0.00	224.37	2.89	96.66
10	1.5713	1.3502	1.1684	1.0151	1.0545	1.0545	0.4835	0.4080	0.4886	0.1699	0.1386	0.6733	351	57	410	27	155	314.97	52.41	150.32	8.27	28.88	13	351	0	467	27	155	314.97	0.00	171.22	8.27	52.80
11	1.6219	1.5371	1.1530	0.7991	0.8208	0.8208	0.4705	0.3189	0.2576	0.1477	0.1376	0.2832	556	168	112	11	153	366.18	112.07	39.78	2.63	98.55	19	556	0	280	11	153	366.18	0.00	99.45	2.63	118.22
12	1.5539	1.3906	1.1361	1.0315	0.9463	0.9463	0.4617	0.4107	0.3999	0.1680	0.1373	0.4971	432	113	273	29	153	341.67	91.22	95.03	8.92	32.83	15	432	0	386	29	153	341.67	0.00	134.36	8.92	67.14
13	1.5682	1.4646	1.1851	0.7677	0.8363	0.8363	0.4896	0.3083	0.3120	0.1498	0.1385	0.3608	506	145	185	9	155	343.80	100.02	68.66	2.08	77.76	17	506	0	330	9	155	343.80	0.00	122.47	2.08	101.58
14	1.4838	1.3623	1.2326	0.8804	0.8272	0.8272	0.5079	0.3531	0.4384	0.1516	0.1383	0.5782	393	89	352	11	155	266.78	61.50	135.38	2.92	83.50	14	393	0	441	11	155	266.78	0.00	169.61	2.92	103.17
15	1.2424	1.1353	0.9048	0.7957	0.7126	0.7126	0.3680	0.3170	0.3520	0.1613	0.1374	0.4183	466	137	221	23	153	274.17	82.07	61.34	5.46	39.21	17	466	0	358	23	153	274.17	0.00	99.36	5.46	65.33
16	1.4560	1.2779	1.1827	1.0030	0.9146	0.9146	0.4853	0.4014	0.5416	0.1611	0.1380	0.8034	276	33	515	21	155	212.26	25.97	189.02	6.32	81.54	9	276	0	548	21	155	212.26	0.00	201.14	6.32	92.87
312	1.2443	1.2072	0.9994	0.9777	0.5680	0.5680	0.3919	0.3824	0.2479	0.1519	0.1349	0.2682	563	173	98	17	149	249.71	77.37	28.61	4.84	119.11	20	563	0	271	17	149	249.71	0.00	79.12	4.84	128.08
313	1.5200	1.3741	1.2103	0.7614	0.8925	0.8925	0.5053	0.3074	0.4311	0.1520	0.1392	0.5639	394	93	347	11	155	291.74	70.22	133.35	2.54	60.34	14	394	0	440	11	155	291.74	0.00	169.09	2.54	84.91
314	1.2394	1.1720	1.0276	0.8906	0.6273	0.6273	0.4148	0.3534	0.3459	0.1545	0.1368	0.4114	472	137	222	16	153	237.57	69.88	69.28	4.23	88.76	17	472	0	359	16	153	237.57	0.00	112.03	4.23	104.66
315	1.4044	1.3829	1.1300	0.8364	0.5969	0.5969	0.4474	0.3287	0.1878	0.1395	0.1355	0.1955	610	186	49	6	149	278.43	85.30	16.39	1.47	163.49	21	610	0	196	6	183	278.43	0.00	65.55	1.47	156.05
316	1.2494	1.2373	1.1272	0.8113	0.5149	0.5149	0.4445	0.3182	0.1986	0.1379	0.1352	0.2090	598	182	65	6	149	233.22	71.20	21.57	1.42	158.35	21	598	0	231	6	163	233.22	0.00	76.65	1.42	156.13
317	1.2110	1.1739	0.7528	0.7527	0.5568	0.5568	0.2936	0.2935	0.1981	0.1451	0.1345	0.2065	598	183	60	10	149	260.56	80.42	13.10	2.18	110.77	21	598	0	213	10	168	260.56	0.00	46.50	2.18	110.99
318	1.4263	1.2688	1.2196	1.1610	0.8527	0.8527	0.4878	0.4586	0.6086	0.1720	0.1362	0.9832	200	3	613	33	151	142.01	2.18	224.27	11.30	125.07	2	200	0	616	33	151	142.01	0.00	225.37	11.30	126.01
319	1.6414	1.4947	1.2164	1.0915	0.9499	0.9499	0.4936	0.4343	0.3703	0.1637	0.1372	0.4475	452	132	237	26	153	355.17	105.66	88.16	8.45	51.49	15	452	0	369	26	153	355.17	0.00	137.26	8.45	86.87
320	1.2031	1.0107	0.9498	0.8548	0.8317	0.8317	0.3871	0.3409	0.6053	0.1678	0.1375	0.9759	204	4	610	29	153	145.13	2.92	178.19	7.41	73.13	2	204	0	614	29	153	145.13	0.00	179.36	7.41	74.67
321	1.5050	1.3817	1.1176	0.7665	0.8505	0.8505	0.4650	0.3089	0.3432	0.1533	0.1390	0.4082	475	137	220	13	155	332.50	97.59	77.71	3.02	51.29	17	475	0	357	13	155	332.50	0.00	126.10	3.02	79.96
322	1.4211	1.3055	1.1985	0.8541	0.7884	0.7884	0.4924	0.3420	0.4587	0.1506	0.1381	0.6196	377	74	385	9	155	243.67	48.68	143.45	2.31	88.02	13	377	0	459	9	155	243.67	0.00	171.02	2.31	103.66
323	1.3994	1.2519	1.0232	0.8289	0.8539	0.8539	0.4245	0.3336	0.3936	0.1614	0.1388	0.4896	434	114	275	22	155	309.86	83.07	88.59	5.52	26.11	15	434	0	389	22	155	309.86	0.00	125.32	5.52	56.57
417	1.3984	1.3858	1.3561	1.1664	0.5728	0.5728	0.5335	0.4569	0.3204	0.1392	0.1351	0.3768	495	144	206	6	149	214.31	62.53	81.96	2.04	182.43	17	495	0	350	6	149	214.31	0.00	139.25	2.04	185.30
418	1.3672	1.2052	1.0686	1.0220	0.8561	0.8561	0.4287	0.4043	0.4936	0.1806	0.1364	0.6773	343	57	404	44	152	246.74	41.93	130.01	13.29	57.36	12	343	0	461	44	152	246.74	0.00	148.36	13.29	75.24
419	1.2725	1.2041	1.0676	0.9505	0.6417	0.6417	0.4297	0.3766	0.3569	0.1562	0.1366	0.4284	463	135	232	17	153	238.20	70.38	74.91	4.79	93.94	17	463	0	367	17	153	238.20	0.00	118.50	4.79	110.20
420	1.6377	1.4106	1.1683	1.1475	1.0973	1.0973	0.4617	0.4505	0.4668	0.1861	0.1354	0.6159	372	74	353	52	149	347.26	70.76	121.75	17.46	22.74	13	372	0	427	52	149	347.26	0.00	147.28	17.46	55.59
492	1.5205	1.3293	1.1261	1.0442	0.9807	0.9807	0.4571	0.4156	0.4578	0.1750	0.1372	0.6043	379	77	355	36	153	314.05	65.28	122.30	11.20	31.99	13	379	0	432	36	153	314.05	0.00	148.83	11.20	60.04
493	1.5365	1.4992	1.0960	1.0938	0.6843	0.6843	0.4276	0.4267	0.2009	0.1455	0.1345	0.2098	596	182	63	10	149	316.25	97.25	20.03	3.17	157.27	20	596	0	222	10	161	316.25	0.00	70.59	3.17	158.49
494	1.5429	1.3680	1.0955	1.0192	0.9657	0.9657	0.4425	0.4046	0.4033	0.1713	0.1369	0.5013	426	112	278	31	153	345.68	92.84	92.55	9.38	21.35	15	426	0	390	31	153	345.68	0.00	129.83	9.38	58.20
495	1.6238	1.3522	1.2686	1.1922	1.1435	1.1435	0.5130	0.4735	0.6121	0.1781	0.1370	0.9912	197	2	608	40	153	193.28	2.02	234.78	14.17	99.58	2	197	0	610	40	153	193.28	0.00	235.55	14.17	100.67
496	1.4616	1.4373	1.0838	0.8278	0.6258	0.6258	0.4289	0.3252	0.1797	0.1397	0.1355	0.1857	616	186	42	7	149	295.45	89.66	13.46	1.70	166.71	21	616	0	169	7	198	295.45	0.00	54.17	1.70	154.72
497	1.5985	1.4244	1.2570	0.9234	0.9766	0.9766	0.5240	0.3725	0.4570	0.1566	0.1391	0.6133	377	76	377	15	155	307.91	63.40	150.15	4.20	54.97	13	377	0	453	15	155	307.91	0.00	180.42	4.20	79.37
498	1.3471	1.1533	1.0270	0.8981	0.9067	0.9067	0.4238	0.3604	0.5202	0.1696	0.1384	0.7461	306	45	467	27	155	236.22	35.61	149.97	7.31	41.40	12	306	0	512	27	155	236.22	0.00	164.42	7.31	58.19
499	1.4669	1.4635	1.1702	1.0704	0.5800	0.5800	0.4570	0.4177	0.1430	0.1356	0.1346	0.1438	648	194	8	1	149	280.76	84.12	2.72	0.31	204.03	21	648	0	40	1	306	280.76	0.00	13.60	0.31	161.57
500	1.3240	1.2562	1.0964	0.9010	0.6622	0.6622	0.4438	0.3581	0.3307	0.1514	0.1370	0.3886	489	140	205	13	153	259.06	75.12	68.51	3.48	97.09	17	489	0	345	13	153	259.06	0.00	115.30	3.48	112.85
AVG	1.4643	1.3675	1.1575	0.9554	0.7696	0.7696	0.4648	0.3779	0.3609	0.1534	0.1365	0.4692	456	119	258	17	152	271.49	69.33	93.15	4.82	108.85	15	456	0	364	17	162	271.49	0.00	129.71	4.82	119.52
MAX	1.6499	1.6380	1.6022	1.5210	1.3447	1.3447	0.6308	0.5952	0.6152	0.2040	0.1404	0.9950	648	194	644	70	156	426.43	127.60	278.94	23.55	221.40	21	648	0	646	70	306	426.43	0.00	280.24	23.55	218.19
Min	0.8575	0.8205	0.7528	0.7503	0.3853	0.3853	0.2936	0.2933	0.1428	0.1356	0.1345	0.1436	195	1	8	1	149	90.61	0.72	1.90	0.23	-3.96	1	195	0	39	1	149	90.61	0.00	10.91	0.23	41.25

APPENDIX C: MONTE CARLO SIMULATIONS RESULTS

Table C1 The simulation results of situation A with all cases

Case		Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	z12	z23	z34	z04	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4578	1.3543	1.1633	0.9589	1.1632	1.0793	1.2637	1.5532	1.1735	1.4428	1.2368	0.7753	0.5733	0.4690	0.3791	0.6259	0.2389	0.1522	0.1364	216.07	177.67	29.39	4.57	123.16
	Max		1.6432	1.6312	1.5900	1.5006	1.3487	1.3078	2.0953	2.1876	2.0189	2.0727	1.9671	1.2472	0.7152	0.6233	0.5864	0.7391	0.4021	0.2235	0.1399	322.28	221.18	77.52	32.76	225.77
	Min		0.8872	0.8189	0.7740	0.7501	1.0133	1.0011	1.0103	1.0403	1.0008	1.0114	1.0001	0.3914	0.3435	0.3020	0.2943	0.5411	0.1389	0.1356	0.1345	93.68	100.44	0.90	0.22	45.77
2	Average	500	1.4579	1.3527	1.1645	0.9654	1.1591	1.0806	1.2690	1.5388	1.1767	1.4277	1.2200	0.7794	0.5797	0.4666	0.3815	0.6257	0.2393	0.1527	0.1363	217.40	177.72	29.05	4.78	121.67
	Max		1.6498	1.6290	1.5963	1.5215	1.3439	1.3437	2.0506	2.1802	1.8869	2.1384	1.9807	1.3332	0.7162	0.6261	0.5941	0.7379	0.3764	0.2119	0.1402	321.85	222.43	79.41	27.38	224.12
	Min		0.8666	0.8086	0.7538	0.7501	1.0133	1.0015	1.0040	1.0404	1.0014	1.0127	1.0003	0.3508	0.3306	0.2940	0.2939	0.5414	0.1394	0.1357	0.1345	84.27	90.92	0.71	0.22	40.11
3	Average	500	1.4568	1.3466	1.1636	0.9611	1.1617	1.0854	1.2615	1.5469	1.1654	1.4295	1.2342	0.7862	0.5745	0.4684	0.3797	0.6293	0.2433	0.1525	0.1363	215.62	176.17	30.70	4.75	121.62
	Max		1.6499	1.6371	1.5878	1.5747	1.3562	1.3583	2.0328	2.1461	1.9594	2.0804	2.0452	1.3783	0.7050	0.6233	0.6155	0.7379	0.4024	0.2214	0.1403	320.87	217.97	81.04	26.10	226.25
	Min		0.9633	0.7918	0.7565	0.7501	1.0038	1.0013	1.0188	1.0296	1.0033	1.0086	1.0005	0.4062	0.3196	0.2952	0.2931	0.5409	0.1384	0.1356	0.1345	98.23	94.99	0.99	0.22	35.02
4	Average	500	1.4634	1.3603	1.1743	0.9677	1.1622	1.0839	1.2691	1.5496	1.1738	1.4330	1.2288	0.7902	0.5819	0.4706	0.3824	0.6280	0.2408	0.1519	0.1363	218.45	178.83	30.13	4.54	122.25
	Max		1.6489	1.6377	1.6142	1.4848	1.3396	1.3364	1.9974	2.1568	1.9054	2.1086	1.9232	1.3207	0.7107	0.6337	0.5805	0.7390	0.4047	0.2193	0.1402	315.74	220.21	80.99	28.34	223.42
	Min		0.9013	0.8369	0.7767	0.7524	1.0170	1.0017	1.0135	1.0515	1.0009	1.0134	1.0005	0.3797	0.3304	0.3065	0.2958	0.5411	0.1388	0.1356	0.1345	92.06	103.33	0.91	0.22	35.22
5	Average	500	1.4536	1.3464	1.1634	0.9579	1.1615	1.0827	1.2657	1.5468	1.1719	1.4327	1.2300	0.7807	0.5766	0.4664	0.3786	0.6284	0.2419	0.1527	0.1364	216.09	176.82	30.06	4.71	120.77
	Max		1.6500	1.6343	1.5822	1.5254	1.3547	1.3052	1.9887	2.1410	1.9165	2.0886	1.9301	1.2633	0.7159	0.6230	0.5965	0.7388	0.3974	0.2143	0.1399	322.80	220.42	77.28	29.75	224.80
	Min		0.9828	0.8154	0.7634	0.7506	1.0058	1.0009	1.0115	1.0175	1.0007	1.0041	1.0004	0.4029	0.3192	0.3024	0.2932	0.5410	0.1391	0.1356	0.1345	99.70	97.63	0.99	0.23	40.32
All	Average	500	1.4591	1.3520	1.1682	0.9622	1.1615	1.0824	1.2658	1.5471	1.1723	1.4331	1.2300	0.7825	0.5784	0.4682	0.3803	0.6276	0.2408	0.1524	0.1363	216.73	177.44	29.87	4.67	121.89
	Max		1.6495	1.6339	1.5941	1.5214	1.3486	1.3303	2.0450	2.1623	1.9374	2.0978	1.9813	1.3087	0.7126	0.6259	0.5946	0.7385	0.3966	0.2181	0.1401	320.71	220.44	79.25	28.86	226.07
	Min		0.9203	0.8143	0.7661	0.7507	1.0118	1.0013	1.0116	1.0359	1.0014	1.0100	1.0004	0.3862	0.3287	0.3000	0.2941	0.5411	0.1389	0.1356	0.1345	93.59	97.46	0.90	0.22	39.29

Table C2 Informed and uninforemd buyers in situation A with all cases

Case	T0					Goods 1			Goods 2			Goods 3			Goods 4			Not buy		
	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Informed	Uninformed		Informed	Uninformed		Informed	Uninformed		Informed	Uninformed		Informed	Uninformed	
							Nonches	Cheated		Nonches	Cheated		Nonches	Cheated		Nonches	Cheated		Nonches	Cheated
1	351	401	81	15	151	351	0	0	401	0	0	81	0	0	15	0	0	151	0	0
2	351	400	81	16	151	190	88	73	202	35	103	44	20	17	9	5	2	59	50	42
3	347	401	85	16	151	187	0	159	203	0	138	46	0	39	9	0	7	59	0	92
4	349	402	83	15	151	0	182	166	0	197	205	0	48	35	0	10	5	0	75	76
5	348	401	84	16	151	0	0	348	0	0	401	0	0	84	0	0	16	0	0	151

Table C3 The simulation results of situation B with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	ε13	ε34	ε04	εc12_3	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4546	1.3783	1.1664	0.9570	1.1628	1.0562	1.2643	1.5498	1.1985	1.4693	1.2338	0.7261	0.7261	0.4673	0.3781	0.3426	0.1508	0.1363	0.4363	367.26	0.00	69.07	4.25	120.18
	Max		1.6499	1.6249	1.5901	1.4941	1.3443	1.1836	1.9018	2.1034	1.8641	2.0512	1.9828	1.0642	1.0642	0.6259	0.5865	0.6113	0.2080	0.1394	0.9947	542.53	0.00	202.71	27.30	226.90
	Min		0.8427	0.8414	0.7943	0.7522	1.0123	1.0016	1.0162	1.0372	1.0036	1.0123	1.0006	0.3318	0.3318	0.3106	0.2936	0.1437	0.1358	0.1345	0.1445	160.79	0.00	1.87	0.22	40.69
2	Average	500	1.4643	1.3675	1.1575	0.9554	1.1652	1.0733	1.2842	1.5616	1.1977	1.4577	1.2247	0.7636	0.7636	0.4648	0.3779	0.3609	0.1534	0.1365	0.4632	271.49	69.33	93.15	4.82	108.85
	Max		1.6499	1.6380	1.6022	1.5210	1.3448	1.3082	1.9383	2.1299	1.9038	2.0387	1.9448	1.3447	1.3447	0.6308	0.5952	0.6152	0.2040	0.1404	0.9950	426.43	127.60	278.94	23.55	221.40
	Min		0.8575	0.8205	0.7528	0.7503	1.0130	1.0017	1.0164	1.0395	1.0057	1.0270	1.0001	0.3853	0.3853	0.2936	0.2933	0.1428	0.1356	0.1345	0.1436	90.61	0.72	1.90	0.23	-3.96
3	Average	500	1.4635	1.3561	1.1456	0.9327	1.1745	1.0819	1.2963	1.5986	1.1989	1.4801	1.2426	0.7907	0.7907	0.4617	0.3636	0.3734	0.1546	0.1367	0.4880	202.78	142.55	96.96	4.96	91.10
	Max		1.6495	1.6393	1.5529	1.4246	1.3511	1.3124	1.9861	2.1763	1.8886	2.1258	1.9903	1.3395	1.3395	0.6127	0.5569	0.6147	0.2060	0.1411	0.9936	310.20	261.50	281.43	24.81	220.88
	Min		0.8610	0.8225	0.7678	0.7502	1.0153	1.0014	1.0165	1.0465	1.0042	1.0278	1.0016	0.3930	0.3930	0.2999	0.2946	0.1440	0.1356	0.1345	0.1449	69.14	1.38	2.19	0.23	-55.81
4	Average	500	1.4775	1.3406	1.1161	0.9310	1.1784	1.1086	1.3496	1.6181	1.2170	1.4627	1.2095	0.8528	0.8528	0.4505	0.3692	0.3806	0.1583	0.1369	0.5018	153.58	151.20	117.58	5.80	90.82
	Max		1.6499	1.6376	1.6137	1.4664	1.3336	1.4809	2.0551	2.1891	1.9307	2.0728	1.9025	1.6135	1.6135	0.6333	0.5720	0.6118	0.2053	0.1418	0.9933	285.72	299.39	354.39	22.58	225.03
	Min		0.9193	0.8967	0.7586	0.7502	1.0118	1.0023	1.0098	1.0358	1.0024	1.0282	1.0002	0.4068	0.4068	0.2960	0.2950	0.1422	0.1356	0.1345	0.1429	2.00	3.40	2.18	0.22	-124.02
5	Average	500	1.4686	1.3237	1.1060	0.9277	1.1758	1.1157	1.3499	1.6106	1.2101	1.4469	1.2015	0.8648	0.8648	0.4475	0.3684	0.3963	0.1597	0.1370	0.5295	0.00	294.40	126.78	6.07	70.75
	Max		1.6498	1.6385	1.5853	1.4352	1.3545	1.5392	2.0827	2.1640	1.9826	2.1183	1.9630	1.6076	1.6076	0.6251	0.5638	0.6140	0.2130	0.1413	0.9914	0.00	566.06	365.77	26.30	218.85
	Min		0.9376	0.8607	0.7745	0.7500	1.0203	1.0025	1.0182	1.0618	1.0052	1.0208	1.0002	0.3904	0.3904	0.3033	0.2952	0.1440	0.1358	0.1345	0.1449	0.00	4.29	2.41	0.22	-143.97
All	Average	500	1.4657	1.3532	1.1383	0.9407	1.1713	1.0871	1.3089	1.5878	1.2045	1.4633	1.2224	0.8008	0.8008	0.4584	0.3726	0.3707	0.1554	0.1367	0.4850	193.02	131.50	100.71	5.18	96.34
	Max		1.6498	1.6357	1.5868	1.4683	1.3457	1.3643	1.9928	2.1525	1.9140	2.0813	1.9567	1.3939	1.3939	0.6255	0.5749	0.6134	0.2073	0.1408	0.9936	312.98	250.91	296.65	24.91	222.61
	Min		0.8836	0.8484	0.7696	0.7506	1.0145	1.0019	1.0154	1.0441	1.0042	1.0232	1.0005	0.3814	0.3814	0.3007	0.2944	0.1433	0.1357	0.1345	0.1442	64.51	1.96	2.11	0.22	-58.61

Table C4 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation B)

	T0									Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	647	0	188	14	151	367.26	0.00	69.07	4.25	120.18	**0**	647	0	188	14	151	367.26	0.00	69.07	4.25	120.18
2	456	119	258	17	152	271.49	69.33	93.15	4.82	108.85	**15**	456	0	364	17	162	271.49	0.00	129.71	4.82	119.52
3	324	234	272	17	152	202.78	142.55	96.96	4.96	91.10	**17**	324	0	489	17	167	202.78	0.00	171.19	4.96	118.22
4	245	239	344	21	152	153.58	151.20	117.58	5.80	90.82	**15**	245	0	563	21	169	153.58	0.00	191.74	5.80	118.79
5	0	455	371	22	152	0.00	294.40	126.78	6.07	70.75	**16**	0	0	793	22	181	0.00	0.00	267.84	6.07	118.77

Table C5 The simulation results of situation C with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	z12	z24	z04	zc23_4	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4543	1.3500	1.1694	0.9658	1.1591	1.0808	1.2612	1.5362	1.1635	1.4256	1.2268	0.7765	0.5765	0.5765	0.3815	0.6276	0.1843	0.1363	0.2553	215.18	198.39	0.00	13.72	122.25
	Max		1.6482	1.6285	1.6134	1.4957	1.3834	1.3360	1.9864	2.1699	1.9475	2.1493	2.1328	1.2772	0.7078	0.7078	0.5850	0.7380	0.4076	0.1401	0.8084	313.01	275.40	0.00	79.57	225.20
	Min		0.9348	0.8442	0.7715	0.7507	1.0142	1.0012	1.0087	1.0432	1.0015	1.0043	1.0002	0.4046	0.3549	0.3549	0.2934	0.5391	0.1359	0.1345	0.1363	94.15	105.61	0.00	0.22	40.35
2	Average	500	1.4573	1.3391	1.1611	0.9625	1.1607	1.0932	1.2739	1.5455	1.1679	1.4183	1.2209	0.8021	0.5750	0.5750	0.3804	0.6309	0.1876	0.1364	0.2604	220.51	139.88	44.47	24.06	111.80
	Max		1.6496	1.6363	1.6104	1.4626	1.3452	1.3831	1.9428	2.1847	1.8706	2.1600	1.9389	1.4140	0.7199	0.7199	0.5724	0.7393	0.3535	0.1411	0.6861	353.75	209.13	69.15	119.41	228.73
	Min		0.8852	0.7983	0.7760	0.7503	1.0185	1.0003	1.0067	1.0563	1.0005	1.0034	1.0002	0.4253	0.3144	0.3144	0.2947	0.5384	0.1347	0.1345	0.1367	95.95	63.80	0.82	0.48	-0.74
3	Average	500	1.4626	1.3389	1.1487	0.9581	1.1632	1.0969	1.2924	1.5556	1.1809	1.4230	1.2119	0.8162	0.5794	0.5794	0.3790	0.6294	0.1913	0.1365	0.2690	226.07	100.57	83.79	25.72	100.75
	Max		1.6499	1.6387	1.6259	1.4804	1.3558	1.3519	2.1280	2.1814	1.9581	2.1503	1.9835	1.4023	0.7138	0.7138	0.5809	0.7393	0.3570	0.1410	0.6562	347.27	137.75	132.89	124.99	223.97
	Min		0.9003	0.8242	0.7682	0.7508	1.0181	1.0001	1.0107	1.0549	1.0004	1.0076	1.0007	0.3640	0.3463	0.3463	0.2939	0.5380	0.1346	0.1345	0.1359	111.79	53.30	7.15	0.26	-16.40
4	Average	500	1.4567	1.3278	1.1416	0.9467	1.1659	1.1020	1.2943	1.5663	1.1771	1.4263	1.2185	0.8235	0.5764	0.5764	0.3747	0.6333	0.1934	0.1366	0.2712	226.38	79.41	87.60	36.94	100.09
	Max		1.6498	1.6443	1.5922	1.4383	1.3530	1.3216	2.0546	2.1857	1.9031	2.1444	1.9861	1.2962	0.7134	0.7134	0.5863	0.7383	0.3524	0.1412	0.6513	354.50	139.66	138.47	135.53	230.33
	Min		0.9436	0.8135	0.7566	0.7504	1.0171	1.0002	1.0125	1.0523	1.0006	1.0035	1.0004	0.3961	0.3460	0.3460	0.2935	0.5381	0.1346	0.1345	0.1366	87.80	8.66	8.98	1.06	-15.94
5	Average	500	1.4543	1.3195	1.1354	0.9443	1.1666	1.1083	1.3018	1.5685	1.1773	1.4209	1.2141	0.8344	0.5732	0.5732	0.3737	0.6355	0.1946	0.1365	0.2741	227.30	0.00	168.58	37.36	85.38
	Max		1.6494	1.6352	1.6024	1.4856	1.3583	1.4266	1.9926	2.1576	1.8027	2.0566	2.0099	1.4331	0.7154	0.7154	0.5804	0.7390	0.3686	0.1412	0.6917	375.91	0.00	276.55	169.44	228.14
	Min		0.9195	0.8129	0.7610	0.7505	1.0114	1.0002	1.0051	1.0345	1.0007	1.0054	1.0006	0.4108	0.3497	0.3497	0.2946	0.5384	0.1349	0.1345	0.1357	84.62	0.00	4.57	0.26	-64.41
All	Average	500	1.4573	1.3350	1.1512	0.9555	1.1631	1.0962	1.2847	1.5544	1.1746	1.4228	1.2184	0.8106	0.5761	0.5761	0.3779	0.6313	0.1903	0.1364	0.2660	223.21	103.65	76.89	27.56	104.05
	Max		1.6494	1.6367	1.6088	1.4845	1.3591	1.3638	2.0209	2.1759	1.8964	2.1321	2.0102	1.3646	0.7141	0.7141	0.5811	0.7388	0.3678	0.1409	0.6988	348.89	152.39	123.41	137.80	227.27
	Min		0.9167	0.8198	0.7667	0.7505	1.0159	1.0004	1.0087	1.0482	1.0007	1.0048	1.0004	0.4002	0.3423	0.3423	0.2940	0.5384	0.1349	0.1345	0.1362	94.86	46.27	4.31	0.45	-11.43

Table C6 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation C)

	T0										Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	350	453	0	46	151	215.18	198.39	0.00	13.72	122.25	**0**	350	453	0	46	151	215.18	198.39	0.00	13.72	122.25
2	346	320	99	83	151	220.51	139.88	44.47	24.06	111.80	**11**	346	320	0	161	172	220.51	139.88	0.00	46.23	119.76
3	348	227	184	89	152	226.07	100.57	83.79	25.72	100.75	**11**	348	227	0	239	186	226.07	100.57	0.00	68.07	118.45
4	343	182	193	130	152	226.38	79.41	87.60	36.94	100.09	**11**	343	182	0	287	188	226.38	79.41	0.00	81.07	117.23
5	341	0	374	133	152	227.30	0.00	168.58	37.36	85.38	**11**	341	0	0	430	229	227.30	0.00	0.00	120.78	119.53

Table C7 The simulation results of situation D with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	z14	zc12_23	z04	zc24_4	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4668	1.3405	1.1179	0.9376	1.1724	1.0936	1.3382	1.5942	1.2158	1.4519	1.2018	0.8288	0.8288	0.5933	0.3714	0.2972	0.4678	0.1367	0.2952	453.42	0.00	0.00	43.14	96.86
	Max		1.6500	1.6484	1.5320	1.4301	1.3463	1.5206	2.0391	2.1811	1.9565	2.1340	1.9213	1.7110	1.7110	0.7167	0.5832	0.5384	0.9396	0.1415	0.6362	676.65	0.00	0.00	162.35	234.51
	Min		0.8784	0.8343	0.7622	0.7502	1.0124	1.0005	1.0148	1.0376	1.0067	1.0293	1.0001	0.4074	0.4074	0.3496	0.2932	0.1356	0.0023	0.1345	0.1388	201.36	0.00	0.00	0.26	0.06
2	Average	500	1.4566	1.3109	1.1584	0.9396	1.1676	1.1152	1.2718	1.5786	1.1383	1.4184	1.2492	0.8609	0.8609	0.5853	0.3739	0.3328	0.6260	0.1373	0.2905	298.17	53.26	38.54	71.19	60.72
	Max		1.6497	1.6181	1.6021	1.3844	1.3574	1.4087	1.6877	2.1760	1.4133	2.1107	2.0161	1.5147	1.5147	0.6966	0.5443	0.5950	0.9943	0.1413	0.7086	438.41	126.19	88.66	194.64	220.13
	Min		0.9558	0.8716	0.7817	0.7501	1.0295	1.0009	1.0046	1.0908	1.0021	1.0599	1.0008	0.4011	0.4011	0.3754	0.2949	0.1358	0.1826	0.1345	0.1355	139.92	0.71	0.30	4.93	-79.24
3	Average	500	1.4354	1.3116	1.1577	0.9471	1.1579	1.0973	1.2522	1.5405	1.1394	1.4064	1.2369	0.8116	0.8116	0.5803	0.3763	0.3195	0.5826	0.1371	0.2838	231.03	121.82	67.06	45.47	56.70
	Max		1.6432	1.6084	1.5934	1.4329	1.3659	1.2808	1.6567	2.1663	1.4471	2.1382	2.0320	1.2565	1.2565	0.7041	0.5600	0.5632	0.9353	0.1405	0.6809	325.43	269.07	178.26	173.12	216.97
	Min		0.9334	0.8841	0.7755	0.7505	1.0280	1.0075	1.0121	1.0862	1.0047	1.0539	1.0016	0.4375	0.4375	0.3757	0.2951	0.1524	0.1817	0.1346	0.1407	111.48	0.41	0.53	3.52	-74.75
4	Average	500	1.4609	1.2882	1.1158	0.9090	1.1736	1.1391	1.3303	1.6291	1.1637	1.4322	1.2360	0.9155	0.9155	0.5879	0.3625	0.3452	0.6359	0.1376	0.3065	123.14	120.64	78.81	90.09	63.43
	Max		1.6439	1.5799	1.5021	1.2383	1.3082	1.5575	2.0231	2.1846	1.4642	1.9384	1.8394	1.6908	1.6908	0.6985	0.4903	0.5855	0.9933	0.1415	0.6789	258.12	262.34	187.88	215.04	172.38
	Min		0.9165	0.8952	0.7802	0.7506	1.0257	1.0044	1.0185	1.0790	1.0119	1.0532	1.0043	0.3745	0.3745	0.3605	0.2950	0.1613	0.1833	0.1348	0.1442	1.05	2.15	0.34	10.95	-90.01
5	Average	500	1.4743	1.2983	1.1227	0.9030	1.1861	1.1414	1.3368	1.6538	1.1666	1.4519	1.2502	0.9274	0.9274	0.5935	0.3604	0.3407	0.6348	0.1377	0.2988	0.00	251.87	160.54	41.44	24.55
	Max		1.6500	1.6245	1.6030	1.3795	1.3358	1.4579	2.0023	2.1878	1.5799	2.0697	1.8552	1.6367	1.6367	0.7055	0.5394	0.5977	0.9383	0.1414	0.7212	0.00	563.19	381.12	143.32	216.93
	Min		0.9324	0.8455	0.7535	0.7501	1.0351	1.0038	1.0125	1.1089	1.0037	1.0707	1.0009	0.4522	0.4522	0.3640	0.2937	0.1473	0.1673	0.1345	0.1419	0.00	0.40	0.40	2.35	-184.13
All	Average	500	1.4588	1.3099	1.1345	0.9272	1.1727	1.1185	1.3059	1.5993	1.1648	1.4322	1.2348	0.8688	0.8688	0.5881	0.3689	0.3271	0.5894	0.1373	0.2950	221.15	109.52	68.99	58.27	60.45
	Max		1.6497	1.6158	1.5785	1.3850	1.3428	1.4451	1.8938	2.1793	1.5722	2.0782	1.9328	1.5619	1.5619	0.7043	0.5434	0.5880	0.9362	0.1412	0.6975	339.72	245.36	167.19	177.69	212.18
	Min		0.9233	0.8661	0.7706	0.7503	1.0261	1.0034	1.0125	1.0805	1.0058	1.0534	1.0015	0.4145	0.4145	0.3650	0.2944	0.1465	0.1434	0.1346	0.1402	90.76	0.73	0.31	4.40	-85.61

Table C8 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation D)

	T0										Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	693	0	0	155	152	453.42	0.00	0.00	43.14	96.86	**0**	693	0	0	155	152	453.42	0.00	0.00	43.14	96.86
2	432	80	84	252	153	298.17	53.26	38.54	71.19	60.72	**19**	432	0	0	334	174	298.17	0.00	0.00	111.22	79.23
3	352	187	148	158	153	231.03	121.82	67.06	45.47	56.70	**22**	352	0	0	453	195	231.03	0.00	0.00	128.53	75.75
4	176	170	168	332	153	123.14	120.64	78.81	90.09	63.43	**19**	176	0	0	635	189	123.14	0.00	0.00	172.67	75.20
5	0	349	342	156	153	0.00	251.87	160.54	41.44	24.55	**22**	0	0	0	764	236	0.00	0.00	0.00	205.76	77.30

Table C9 The simulation results of situation E with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	z12	z23	z03	zc34_0	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4560	1.3460	1.1600	0.9615	1.1607	1.0857	1.2734	1.5433	1.1762	1.4259	1.2202	0.7857	0.5747	0.4642	0.4642	0.6263	0.2394	0.1380	0.1509	217.32	176.28	33.74	0.00	121.31
	Max		1.6439	1.6352	1.5839	1.4312	1.3628	1.3619	1.9556	2.1520	1.9235	2.0990	2.0554	1.3538	0.7098	0.6236	0.6236	0.7390	0.3817	0.1460	0.1829	328.06	218.35	94.14	0.00	230.84
	Min		0.9197	0.8594	0.7566	0.7511	1.0130	1.0004	1.0066	1.0575	1.0007	1.0270	1.0000	0.3752	0.3573	0.2954	0.2954	0.5389	0.1357	0.1345	0.1345	89.80	103.27	0.28	0.00	30.10
2	Average	500	1.4561	1.3331	1.1633	0.9665	1.1576	1.0961	1.2667	1.5349	1.1584	1.4039	1.2182	0.8112	0.5751	0.4674	0.4674	0.6366	0.2521	0.1385	0.1514	221.12	176.16	28.94	7.22	112.18
	Max		1.6438	1.6341	1.6248	1.4688	1.3673	1.3702	1.9719	2.1551	1.9317	2.1073	2.0549	1.4136	0.7172	0.6359	0.6359	0.7396	0.4086	0.1463	0.1840	326.12	225.21	80.62	22.41	232.57
	Min		0.8628	0.8493	0.7748	0.7521	1.0203	1.0017	1.0101	1.0619	1.0001	1.0038	1.0003	0.3666	0.3440	0.3050	0.3050	0.5407	0.1385	0.1345	0.1345	70.44	94.10	1.40	0.24	32.56
3	Average	500	1.4548	1.3166	1.1427	0.9520	1.1636	1.1108	1.2907	1.5563	1.1653	1.4067	1.2143	0.8382	0.5700	0.4592	0.4592	0.6401	0.2566	0.1386	0.1512	225.77	174.76	20.89	16.50	103.41
	Max		1.6439	1.6376	1.5964	1.4270	1.3763	1.4407	1.9396	2.1902	1.8878	2.1350	2.0818	1.4841	0.7203	0.6274	0.6274	0.7389	0.4224	0.1474	0.1843	340.97	223.92	48.87	47.81	228.76
	Min		0.8213	0.8139	0.7593	0.7501	1.0095	1.0010	1.0058	1.0286	1.0002	1.0066	1.0003	0.3222	0.3209	0.2970	0.2970	0.5404	0.1381	0.1345	0.1345	99.11	97.46	0.90	0.26	-0.14
4	Average	500	1.4648	1.3247	1.1439	0.9486	1.1680	1.1111	1.3000	1.5747	1.1736	1.4215	1.2193	0.8464	0.5755	0.4602	0.4602	0.6385	0.2542	0.1387	0.1517	229.23	176.78	19.31	14.90	104.42
	Max		1.6439	1.6247	1.6092	1.5082	1.3391	1.4760	2.1023	2.1419	1.9503	2.0519	1.9752	1.4787	0.7228	0.6305	0.6305	0.7396	0.4035	0.1479	0.1814	346.21	225.30	53.08	38.95	231.65
	Min		0.8801	0.8339	0.7526	0.7502	1.0104	1.0004	1.0017	1.0314	1.0001	1.0040	1.0001	0.3789	0.3457	0.2935	0.2935	0.5425	0.1412	0.1345	0.1345	86.29	98.57	0.27	0.24	-5.49
5	Average	500	1.4527	1.3031	1.1234	0.9503	1.1627	1.1216	1.3047	1.5557	1.1666	1.3930	1.1938	0.8595	0.5631	0.4545	0.4545	0.6419	0.2604	0.1388	0.1508	231.55	174.07	0.00	36.63	94.83
	Max		1.6436	1.6392	1.5987	1.5243	1.3361	1.5198	1.9575	2.1736	1.8525	2.1114	1.7945	1.5436	0.7101	0.6284	0.6284	0.7394	0.4153	0.1471	0.1831	357.17	220.07	0.00	107.31	230.93
	Min		0.8047	0.7823	0.7683	0.7505	1.0098	1.0007	1.0082	1.0297	1.0002	1.0079	1.0000	0.3543	0.3105	0.3003	0.3003	0.5331	0.1362	0.1345	0.1345	73.26	84.66	0.00	0.23	-25.38
All	Average	500	1.4569	1.3247	1.1479	0.9558	1.1625	1.1051	1.2871	1.5530	1.1681	1.4102	1.2144	0.8282	0.5729	0.4611	0.4611	0.6367	0.2526	0.1385	0.1512	225.00	175.61	20.58	15.05	107.23
	Max		1.6438	1.6342	1.6026	1.4719	1.3565	1.4338	1.9374	2.1625	1.9092	2.1009	1.9323	1.4548	0.7160	0.6292	0.6292	0.7393	0.4063	0.1469	0.1833	339.71	222.57	55.34	43.41	230.95
	Min		0.8577	0.8279	0.7624	0.7508	1.0138	1.0008	1.0065	1.0418	1.0002	1.0099	1.0001	0.3596	0.3357	0.2984	0.2984	0.5403	0.1379	0.1345	0.1345	83.78	95.61	0.57	0.19	6.33

Table C10 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation E)

	T0										Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	351	401	95	0	153	217.32	176.28	33.74	0.00	121.31	**0**	351	401	95	0	153	217.32	176.28	33.74	0.00	121.31
2	340	399	82	20	159	221.12	176.16	28.94	7.22	112.18	**4**	340	399	82	0	179	221.12	176.16	28.94	0.00	116.85
3	336	399	60	46	159	225.77	174.76	20.89	16.50	103.41	**4**	336	399	60	0	205	225.77	174.76	20.89	0.00	114.13
4	338	400	55	41	166	229.23	176.78	19.31	14.90	104.42	**5**	338	400	55	0	207	229.23	176.78	19.31	0.00	114.24
5	334	397	0	103	165	231.55	174.07	0.00	36.63	94.83	**5**	334	397	0	0	268	231.55	174.07	0.00	0.00	115.89

Table C11 The simulation results of situation F with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	z13	ze13	z03	ze34	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4700	1.3307	1.1029	0.9236	1.1793	1.1119	1.3590	1.6210	1.2223	1.4624	1.2038	0.8546	0.8546	0.4450	0.4450	0.3839	0.5080	0.1392	0.1514	405.27	0.00	81.45	0.00	96.67
	Max		1.6500	1.6470	1.5911	1.5352	1.3719	1.5401	2.1032	2.1778	2.1011	2.1239	2.0263	1.6139	1.6139	0.6255	0.6255	0.6148	0.9987	0.1494	0.1825	666.54	0.00	209.33	0.00	233.32
	Min		0.8603	0.8120	0.7556	0.7502	1.0150	1.0004	1.0166	1.0456	1.0046	1.0327	1.0002	0.3536	0.3536	0.2950	0.2950	0.1360	0.1362	0.1345	0.1345	145.25	0.00	0.23	0.00	1.24
2	Average	500	1.4692	1.3291	1.1133	0.9343	1.1740	1.1113	1.3445	1.6015	1.2090	1.4440	1.2016	0.8562	0.8562	0.4496	0.4496	0.3913	0.5178	0.1393	0.1514	285.71	68.32	74.63	30.84	72.25
	Max		1.6500	1.6167	1.5825	1.4569	1.3492	1.5947	2.0012	2.1611	1.8823	2.0887	1.9900	1.7947	1.7947	0.6209	0.6209	0.6154	0.9941	0.1493	0.1819	455.67	132.97	194.08	84.56	217.63
	Min		0.9205	0.9035	0.7593	0.7504	1.0136	1.0016	1.0046	1.0413	1.0014	1.0297	1.0007	0.3698	0.3698	0.2972	0.2972	0.1475	0.1487	0.1345	0.1346	81.86	0.53	3.45	0.25	-125.83
3	Average	500	1.4670	1.3233	1.1012	0.9217	1.1784	1.1155	1.3583	1.6183	1.2171	1.4541	1.2025	0.8617	0.8617	0.4448	0.4448	0.3874	0.5145	0.1393	0.1516	214.61	140.44	42.62	62.27	57.15
	Max		1.6499	1.6126	1.5517	1.4417	1.3661	1.5630	2.0980	2.1797	1.8102	2.1152	2.0219	1.7257	1.7257	0.6155	0.6155	0.6153	0.9974	0.1495	0.1848	355.13	274.87	107.66	179.66	202.28
	Min		0.8930	0.8579	0.7524	0.7501	1.0231	1.0003	1.0083	1.0885	1.0031	1.0414	1.0001	0.3792	0.3792	0.2936	0.2936	0.1353	0.1354	0.1345	0.1345	86.74	0.00	0.00	0.00	-171.88
4	Average	500	1.4629	1.3179	1.0997	0.9240	1.1769	1.1154	1.3565	1.6124	1.2153	1.4483	1.2000	0.8635	0.8635	0.4443	0.4443	0.3957	0.5236	0.1393	0.1513	150.34	148.36	65.74	63.48	58.52
	Max		1.6500	1.6175	1.5787	1.4102	1.3386	1.5172	2.0966	2.1817	1.9186	2.0886	1.9253	1.6740	1.6740	0.6216	0.6216	0.6189	0.9933	0.1487	0.1822	286.66	237.00	179.72	184.16	176.82
	Min		0.8820	0.8759	0.7626	0.7503	1.0164	1.0015	1.0151	1.0439	1.0055	1.0322	1.0002	0.3574	0.3574	0.2980	0.2980	0.1468	0.1480	0.1345	0.1345	1.85	4.24	1.40	0.87	-195.97
5	Average	500	1.4713	1.3223	1.1027	0.9220	1.1798	1.1180	1.3589	1.6242	1.2148	1.4556	1.2067	0.8743	0.8743	0.4462	0.4462	0.3998	0.5334	0.1396	0.1519	0.00	298.94	0.00	136.51	-29.52
	Max		1.6500	1.6197	1.5754	1.4672	1.3427	1.5722	2.0543	2.1642	1.8416	2.0648	1.9336	1.7561	1.7561	0.6207	0.6207	0.6143	0.9954	0.1488	0.1827	0.00	563.74	0.00	403.11	95.11
	Min		0.9318	0.8615	0.7565	0.7501	1.0094	1.0031	1.0182	1.0283	1.0076	1.0181	1.0000	0.4252	0.4252	0.2961	0.2961	0.1408	0.1414	0.1345	0.1345	0.00	1.55	0.00	0.29	-194.02
All	Average	500	1.4681	1.3247	1.1040	0.9251	1.1777	1.1144	1.3555	1.6155	1.2157	1.4523	1.2029	0.8620	0.8620	0.4460	0.4460	0.3916	0.5195	0.1393	0.1515	211.18	131.21	52.89	58.62	51.01
	Max		1.6500	1.6227	1.5759	1.4622	1.3537	1.5574	2.0707	2.1729	1.9107	2.0975	1.9806	1.7129	1.7129	0.6208	0.6208	0.6157	0.9958	0.1491	0.1828	352.80	253.72	138.16	170.30	185.03
	Min		0.8975	0.8622	0.7573	0.7502	1.0167	1.0014	1.0126	1.0507	1.0044	1.0308	1.0003	0.3770	0.3770	0.2960	0.2960	0.1413	0.1419	0.1345	0.1345	63.14	1.27	1.02	0.28	-137.29

Table C12 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation F)

	T0										Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	604	0	242	0	154	405.27	0.00	81.45	0.00	96.67	**0**	604	0	242	0	154	405.27	0.00	81.45	0.00	96.67
2	428	107	220	86	159	285.71	68.32	74.63	30.84	72.25	**21**	428	0	220	0	352	285.71	0.00	74.63	0.00	73.46
3	317	222	126	175	160	214.61	140.44	42.62	62.27	57.15	**25**	317	0	126	0	557	214.61	0.00	42.62	0.00	58.84
4	233	228	195	178	166	150.34	148.36	65.74	63.48	58.52	**23**	233	0	195	0	572	150.34	0.00	65.74	0.00	59.14
5	0	452	0	382	167	0.00	298.94	0.00	136.51	-29.52	**25**	0	0	0	0	1000	0.00	0.00	0.00	0.00	0.00

Table C13 The simulation results of situation G with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	z12	ze23_34	z02	ze34	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4604	1.3523	1.1683	0.9527	1.1666	1.0842	1.2687	1.5639	1.1730	1.4471	1.2427	0.7847	0.5781	0.5781	0.4686	0.6293	0.4843	0.1475	0.1524	216.59	215.27	0.00	0.00	119.50
	Max		1.6437	1.6472	1.6217	1.4968	1.3453	1.3601	2.0134	2.1860	1.9241	2.0668	1.9779	1.4110	0.7199	0.7199	0.6345	0.7391	0.8208	0.1711	0.1842	330.18	273.11	0.00	0.00	234.92
	Min		0.9371	0.8575	0.7557	0.7512	1.0208	1.0001	1.0103	1.0634	1.0002	1.0052	1.0001	0.4205	0.3540	0.3540	0.2953	0.5380	0.2632	0.1345	0.1345	98.11	128.23	0.00	0.00	25.48
2	Average	500	1.4683	1.3112	1.1257	0.9330	1.1751	1.1291	1.3290	1.6031	1.1799	1.4257	1.2164	0.8800	0.5745	0.5745	0.4533	0.6390	0.5105	0.1515	0.1519	238.61	124.62	17.78	30.88	94.66
	Max		1.6436	1.6391	1.5732	1.4283	1.3387	1.7989	2.0519	2.1656	1.8904	2.0393	1.9553	1.3159	0.7245	0.7245	0.6151	0.7394	0.7076	0.1943	0.1825	426.87	153.26	37.85	64.49	239.44
	Min		0.9237	0.8901	0.7568	0.7506	1.0242	1.0001	1.0051	1.0743	1.0002	1.0346	1.0011	0.3978	0.3494	0.3494	0.2955	0.5383	0.2699	0.1345	0.1347	91.93	76.09	0.30	6.29	-107.03
3	Average	500	1.4639	1.3107	1.1248	0.9335	1.1739	1.1256	1.3255	1.5995	1.1800	1.4263	1.2159	0.8714	0.5744	0.5744	0.4533	0.6367	0.5063	0.1515	0.1519	237.50	111.14	31.74	62.33	81.15
	Max		1.6439	1.6308	1.6125	1.5140	1.3557	1.7752	2.1464	2.1915	1.8620	2.1274	1.9428	1.8624	0.7253	0.7253	0.6307	0.7384	0.7173	0.1924	0.1849	430.22	139.10	77.38	121.49	226.28
	Min		0.9260	0.8069	0.7640	0.7501	1.0168	1.0000	1.0036	1.0511	1.0007	1.0230	1.0001	0.4045	0.3368	0.3368	0.3003	0.5380	0.2692	0.1345	0.1345	103.21	63.41	0.59	12.67	-121.63
4	Average	500	1.4547	1.2739	1.0971	0.9031	1.1609	1.1523	1.3476	1.6260	1.1734	1.4194	1.2169	0.9185	0.5644	0.5644	0.4434	0.6455	0.5278	0.1529	0.1523	245.52	24.73	32.54	63.50	86.95
	Max		1.6439	1.5785	1.5270	1.4596	1.3412	1.8458	2.0429	2.1742	1.9469	2.0309	1.8764	1.8825	0.7248	0.7248	0.6019	0.7390	0.7316	0.1924	0.1817	432.02	66.70	70.25	120.91	205.41
	Min		0.9075	0.8182	0.7572	0.7504	1.0171	1.0010	1.0038	1.0519	1.0006	1.0175	1.0004	0.3579	0.3197	0.3197	0.2953	0.5392	0.2726	0.1347	0.1346	93.75	0.33	0.36	13.45	-108.10
5	Average	500	1.4574	1.3211	1.1289	0.9320	1.1721	1.1076	1.3127	1.5915	1.1865	1.4396	1.2224	0.8393	0.5787	0.5787	0.4547	0.6330	0.4971	0.1513	0.1521	232.06	0.00	68.20	125.30	77.22
	Max		1.6500	1.6359	1.5899	1.5224	1.3397	1.3606	2.1290	2.1526	1.8093	2.0986	1.9742	1.3955	0.7303	0.7303	0.6211	0.7396	0.7123	0.1847	0.1814	386.81	0.00	150.38	239.67	225.76
	Min		0.8274	0.8247	0.7627	0.7504	1.0024	1.0004	1.0045	1.0073	1.0001	1.0058	1.0002	0.3279	0.3225	0.3225	0.2986	0.5391	0.2721	0.1345	0.1345	70.11	0.00	0.34	30.58	-57.46
All	Average	500	1.4609	1.3138	1.1291	0.9321	1.1737	1.1198	1.3167	1.5968	1.1785	1.4316	1.2229	0.8588	0.5740	0.5740	0.4547	0.6367	0.5052	0.1509	0.1521	234.06	35.15	30.05	56.40	91.90
	Max		1.6439	1.6263	1.5849	1.4842	1.3441	1.6281	2.0779	2.1740	1.8869	2.0846	1.9453	1.6935	0.7250	0.7250	0.6207	0.7391	0.7379	0.1870	0.1829	401.22	126.43	67.17	109.31	226.36
	Min		0.9044	0.8395	0.7593	0.7505	1.0163	1.0003	1.0078	1.0496	1.0004	1.0172	1.0004	0.3817	0.3365	0.3365	0.2970	0.5385	0.2706	0.1346	0.1345	91.42	53.62	0.32	12.60	-73.76

Table C14 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation F)

	T0										Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	347	490	0	0	162	216.59	215.27	0.00	0.00	119.50	**0**	347	490	0	0	162	216.59	215.27	0.00	0.00	119.50
2	338	283	37	86	256	238.61	124.62	17.78	30.88	94.66	**14**	338	283	0	0	379	238.61	124.62	0.00	0.00	110.31
3	340	253	67	174	166	237.50	111.14	31.74	62.33	81.15	**15**	340	253	0	0	407	237.50	111.14	0.00	0.00	109.59
4	331	56	69	181	363	245.52	24.73	32.54	63.50	86.95	**14**	331	56	0	0	613	245.52	24.73	0.00	0.00	109.75
5	344	0	144	345	167	232.06	0.00	68.20	125.30	77.22	**15**	344	0	0	0	656	232.06	0.00	0.00	0.00	109.77

127

Table C15 The simulation results of situation H with all cases

	Case	Simulation Number	Quality 1	Quality 2	Quality 3	Quality 4	r average	v1/v2	v1/v3	v1/v4	v2/v3	v2/v4	v3/v4	Price 1	Price 2	Price 3	Price 4	zc04	zc12_23	z01	zc23_34	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	Average	500	1.4653	1.3789	1.1680	0.9396	1.1740	1.0641	1.2782	1.5917	1.2018	1.4945	1.2560	0.7491	0.7491	0.5901	0.4687	0.1533	0.4677	0.1759	0.1911	484.64	0.00	0.00	0.00	83.21
	Max		1.6493	1.6270	1.5900	1.5059	1.3522	1.2425	2.1691	2.1706	1.9362	2.1167	1.9191	1.2664	1.2664	0.7295	0.6231	0.1812	0.9371	0.2677	0.4587	806.50	0.00	0.00	0.00	224.66
	Min		0.9673	0.9193	0.7601	0.7507	1.0080	1.0003	1.0040	1.0241	1.0003	1.0202	1.0002	0.3785	0.3785	0.3777	0.2965	0.1345	0.0119	0.1348	0.0008	239.79	0.00	0.00	0.00	-189.03
2	Average	500	1.4603	1.3684	1.0709	0.9242	1.1751	1.0681	1.3793	1.6047	1.2923	1.5014	1.1648	0.7646	0.7646	0.6013	0.4311	0.1491	0.5429	0.1739	0.2656	318.38	57.26	34.58	7.29	75.59
	Max		1.6494	1.6325	1.4176	1.3866	1.3524	1.2176	2.0460	2.1617	1.9847	2.1413	1.4764	1.2131	1.2131	0.7255	0.5633	0.1737	0.9346	0.2547	0.4644	438.91	105.51	94.55	21.32	210.98
	Min		0.9522	0.9082	0.7768	0.7500	1.0199	1.0012	1.0285	1.0608	1.0238	1.0559	1.0001	0.4375	0.4375	0.3814	0.3043	0.1345	0.1836	0.1354	0.1577	161.96	0.78	0.40	0.33	-228.93
3	Average	500	1.4780	1.3887	1.1588	0.9208	1.1857	1.0658	1.2993	1.6352	1.2197	1.5335	1.2716	0.7606	0.7606	0.5964	0.4651	0.1542	0.4612	0.1769	0.1942	256.60	140.20	64.68	10.15	53.79
	Max		1.6498	1.6389	1.6185	1.6063	1.3694	1.2224	2.1416	2.1739	2.0144	2.1144	2.0453	1.1887	1.1887	0.7236	0.6325	0.1809	0.9351	0.2573	0.4491	394.19	253.35	187.67	54.45	188.82
	Min		0.9593	0.8940	0.7586	0.7500	1.0069	1.0004	1.0068	1.0207	1.0003	1.0171	1.0003	0.4057	0.4057	0.3721	0.2961	0.1345	0.0203	0.1348	0.0007	135.03	0.64	0.40	0.00	-235.82
4	Average	500	1.4680	1.3706	1.1540	0.9180	1.1838	1.0725	1.2962	1.6287	1.2090	1.5182	1.2697	0.7724	0.7724	0.5924	0.4640	0.1543	0.5031	0.1810	0.1964	140.40	137.20	72.07	9.74	56.10
	Max		1.6500	1.6454	1.5808	1.4363	1.3609	1.2431	1.8886	2.1821	1.8356	2.1776	2.0063	1.2177	1.2177	0.7096	0.6252	0.1841	0.9363	0.2586	0.4686	266.82	256.09	192.40	42.86	164.34
	Min		0.9146	0.8940	0.7732	0.7502	1.0173	1.0012	1.0067	1.0526	1.0006	1.0385	1.0000	0.3967	0.3967	0.3564	0.3040	0.1345	0.0132	0.1354	0.0011	0.00	0.53	0.46	0.00	-243.62
5	Average	500	1.4659	1.3900	1.1708	0.9279	1.1797	1.0553	1.2739	1.6105	1.2081	1.5246	1.2758	0.7558	0.7558	0.7414	0.5895	0.1936	0.5123	0.2146	0.2263	0.00	338.98	180.81	31.11	-36.73
	Max		1.6497	1.6436	1.6138	1.5001	1.3615	1.2132	2.0671	2.1567	2.0238	2.1039	1.9376	1.5043	1.5043	0.9011	0.7934	0.2310	0.9375	0.3152	0.5356	0.00	648.37	544.24	193.18	120.46
	Min		0.8854	0.8839	0.7738	0.7505	1.0201	1.0007	1.0091	1.0610	1.0007	1.0436	1.0006	0.4383	0.4383	0.4353	0.3826	0.1630	0.0341	0.1636	0.0025	0.00	0.89	0.53	0.00	-221.24
All	Average	500	1.4675	1.3793	1.1445	0.9261	1.1796	1.0652	1.3054	1.6142	1.2262	1.5144	1.2476	0.7925	0.7925	0.6243	0.4837	0.1603	0.4974	0.1856	0.2147	240.01	134.73	70.43	11.66	46.39
	Max		1.6497	1.6375	1.5641	1.4872	1.3593	1.2278	2.0625	2.1690	1.9589	2.1308	1.8771	1.2780	1.2780	0.7579	0.6475	0.1902	0.9361	0.2707	0.4753	381.28	252.66	203.77	62.36	181.85
	Min		0.9358	0.8939	0.7685	0.7503	1.0144	1.0007	1.0110	1.0438	1.0051	1.0351	1.0002	0.4113	0.4113	0.3846	0.3167	0.1414	0.0526	0.1420	0.0326	107.36	0.57	0.36	0.07	-223.73

Table C16 Number of buying consumers, firm's profit and consumers' utility at t0 and t_criteria (Situation H)

	T0									Convert	T_cirteria									
Case	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility	Order	Goods 1	Goods 2	Goods 3	Goods 4	Not buy	Profit 1	Profit 2	Profit 3	Profit 4	Utility
1	810	0	0	0	190	484.64	0.00	0.00	0.00	83.21	**0**	810	0	0	0	190	484.64	0.00	0.00	0.00	83.21
2	527	101	70	23	279	318.38	57.26	34.58	7.29	75.59	**21**	527	0	0	0	473	318.38	0.00	0.00	0.00	81.74
3	422	248	135	32	162	256.60	140.20	64.68	10.15	53.79	**25**	422	0	0	0	578	256.60	0.00	0.00	0.00	55.49
4	245	237	153	31	334	140.40	137.20	72.07	9.74	56.10	**23**	245	0	0	0	755	140.40	0.00	0.00	0.00	67.15
5	0	473	292	73	162	0.00	338.98	180.81	31.11	-36.73	**24**	0	0	0	0	1000	0.00	0.00	0.00	0.00	0.00

BIOGRAPHY

Ms. Papusson Chaiwat, the second child of Mr. Banharn and Mrs. Orasa Chaiwat, was born on September 6, 1977 in Samutsongkhram, Thailand. She attended Suksunari School in Bangkok and graduated 1994. In April 1999, she received her Bachelor Degree of Economics from the Faculty of Economics, Thammasat University. In April 2001, she received her Master Degree of of Economics from the Faculty of Economics, Chulalongkorn University. In June 2002, she gained admission to the Graduate School of Chulalongkorn University and awarded the Degree of Doctor of Philosophy Program in Economics (Economics) in September, 2007.