공학석사학위논문

Predation Strategy Considering Capital Endowment Level in Multi-period Stackelberg Game

자본 규모가 다른 기업 간 다기간 스타켈버그 게임 모형을 이용한 약탈적 가격책정에 대한 연구

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Abstract

Predation Strategy Considering Capital Endowment Level in Multi-period Stackelberg Game

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Amount of capital that market participants have can provide predictive information about occurrence of predation in certain market. Predation or predatory pricing is a firm's strategy that a firm with great market power intentionally can utilize to make a situation which is disadvantageous to all market participants through overproduction to get better profit after other several firms getting out of the market, and the market power that enables intentional overproduction and sufficient amount of capital is essential factor for firms which want to implement predatory pricing or predation policy. In this way, presence of market power and sufficient amount of capital can provide some information in predicting the likelihood of occurrence of predation or predatory pricing in certain market. Based on these ideas, we proposed a predatory pricing model by applying the concept of capital variable to multi-period Stackelberg game which is a competitive game model between a firm with great market power and the other. Several characteristics of the proposed predation model were also derived as propositions. Because there were few predation models considering firms' capital, this proposed model can be a pragmatic tool for firms with great market power which is finding an alternative-profitable way in competing with its opponents in a certain market, for small companies which consider entering a new market and also for analysts who want to analyze competition structures of some markets between firms especially in terms of predicting the occurrence of predation.

Keywords: Predation, Predatory pricing, Capital endowment level, Capital based predatory pricing model, Multi-period Stackelberg game, Multi-period predation game
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Chapter 1

Introduction

1.1 Background

Predatory pricing is not a rare phenomenon and still occurring in a lot of markets. Shale oil industry was recent example which got through predatory pricing in crude oil market. At the end of 2014, exactly on November 27, 2014, OPEC(Organization of Petroleum Exporting Countries) members agreed on a plan to increase production of crude oil especially led by Saudi Arabia. The decision of OPEC's increase in crude oil production was far beyond the market expectations because the crude oil price such as WTI, Dubai index hiked up unprecedented high price and OPEC could improve profitability at that time by gradually reducing crude oil production. The intention of OPEC was clear. They just wanted to drive the shale oil firms out of crude oil market. At that time shale oil industry was boomed by high crude oil price. Even though firms which extracting shale oil had disadvantageous break-even cost structure than traditional oil companies, it seemed it didn't matter at that time because oil price was a lot higher than break-evens of shale oil firms. In this situation, numerous shale oil companies started business, competed with each other and develop technology lowering break-even point. In this regard, OPEC members decide to break shale oil industry which can threaten their future profitability by lowering crude oil price when they had advantageous break-even structure. By this OPEC's strategy, crude oil price plummet in 2015 and a lot of shale oil companies were expelled from the market by bankrupcy. Whether OPEC's decision at that time was sensible or not is obscure, but one exact fact was there was predatory pricing in the oil market. In this way, some firms utilized radical strategy to survive or get better profit such as mutually risky strategy; predation. This predation phenomenon can easily be found in many other industries other than crude oil industry. For example, in semiconductor industry there was kind of custom that a firm which developed certain technology first earned sufficient profits in early stage by supplying proper amount of product to market and over-produced products when other following firms succeeded in developing technology. Because of this continual 'tradition' all other companies went bankrupt or merged and there are only three semiconductor suppliers which producing DRAM; Samsung Electronics, SK Hynix and Micron. Also, shipping industry was good example for explaining predation. In mid-2010, Maersk aggressively increased shipping supplies to market even though the shipping industry was not that good situation in terms of market demand and profitability. This over-supplying was so-called 'shipping industry chicken game' at that time. Maersk's decision let it gotten through enormous of deficit at that time. However, because of over-supplying Maersk could enlarge their market share in the shipping market while other companies had reduced their business and Maersk is now earning better profit than that time.

Like this way, occurrence of predation, or predatory pricing, can be found in many small or big markets. However, there seems to be few economic model that can make analyze or quantify predatory pricing strategy. That's because most of competitive game theoretical models didn't consider the possibility of game agent's bankruptcy and they implicitly assumed the game agent's eternity in the game structure. The first step to understand the predation is to appreciate the mortality of game agent and this approach can help compose predatory pricing model.

1.2 Research Motivation and Objective

If taking a look at the existing model which consider predation strategy, there has not been papers which consider capital as a key parameter in analyzing predatory pricing strategy. But, capital plays the most crucial role in predicting whether the predatory pricing situation will take place in some markets or not. OPEC members could attack shale oil industry because they had enormous amount of capital which can protect them from some periods of deficit. Maersk also can over-supplied shipping because they already had enough capital and asset to short-term future risk. And semiconductor companies like Samsung Electronics can over-produced DRAM because they earned sufficient money which can be interpreted as accumulated capital by developing next-generation semiconductors and supplying them first in the market. Once again, it can be said that capital is most important parameter related with predatory pricing.

In this study, simple approach was suggested to construct predatory pricing model which was to adopt the capital variable concept and bankrupt condition to competitive economic-model. Through the introduction of these capital concept and mortality condition, many other existing competitive model seems to be able to embrace the equilibrium about predatory pricing. At first, this study aimed at Stackelberg game which is game theoretical competitive model composed of market powered leader and somewhat weak follower. Therefore, the objective of this paper was to construct predation model based on traditional multi-period Stackelberg game by applying capital level parameter to qualify the predation situation between 'leader' firm and 'follower' firm. The next objective was to show that predation can be an optimal strategy at certain conditions, to find conditions under which predation strategy can be an equilibrium, to derive an amount of capital endowment level of entrant that can protect follower from predation, and to allow potential entrant firms which looking for market entering to qualify or estimate the risk of predation on considering market. In the end, how this predation strategy concept influenced the competitive smodel like multi-period Stackelberg game was studied.

1.3 Problem Definition

Predatory pricing usually happens between firms which has different market power rather than firms with similar market power. Market power can come from variety of forms. It can be stemmed from brand recognition of consumers, market share and technological progress etc. Among those market power factors, amount of capital was only parameter paid attention in this thesis. Consider the situation where there are two firms as follows. One is already running business in the market with great market power and the other one is small company considering whether to enter the market or not. This kind of situation can be interpreted as Stackelberg game structure: incumbent with great market power is 'leader' and entrant with small capital is 'follower' in Stackelberg game. In this situation, if entrant decide to enter the market then the game structure of competition will be exactly equivalent with Stackelberg game. Then, the problem that each firm should consider is as follows. For leader, it has to decide whether to predate the follower or accommodate follower when follower enter the market. If follower decide not to enter the market, leader will be, of course, satisfactory about opponent's decision because it can earn monopoly profits after all. On the other hand, follower should ponder whether to enter the market or not considering the probability of predation of leader. Most of all, if follower enter the market and attacked by leader, it should tell the predation is ‘Non-credible threat’ of leader or ‘real threat’. This problem structure is what this thesis addressed and Figure 1.1 is presented as overview.

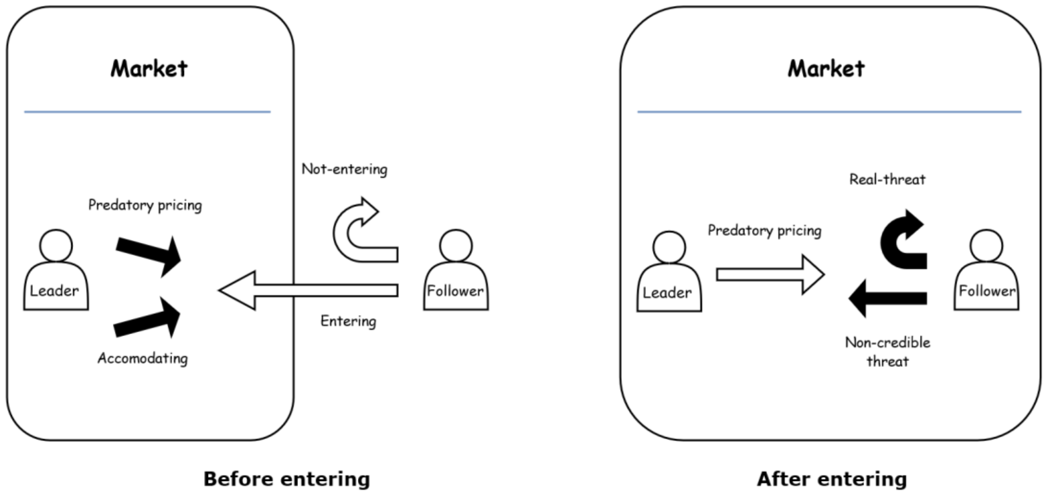

Figure 1.1 Overview of Predation game structure

1.4 Organization of the Thesis

The thesis is composed of 5 chapters. In chapter 2, Literature reviews are provided and some important classical predatory pricing models are introduced. In chapter 3, how multi-period Stackelberg can be transformed into predatory pricing model is presented. In addition to composing predatory pricing model, modified version of model which can be used to solve original composed model is defined. In chapter 4, these proposed model was solved by using an iterative method and this model’s properties are proposed as propositions. Finally, there is conclusion in chapter 5.

Chapter 2

Literature Review

2.1 Predatory Pricing Model

Predation or predatory pricing are academic areas that has long been discussed and studied in economics. For example, Sherman Act, one of preeminent antitrust law in United States, was enacted by federal government in 1890. It can show how old it has been a topic of debate in the market and academic field. Even though there was a law which banned anti-competitive trust and predation, it was often said that predatory pricing strategy occured in some markets by irrational behaviors of some managers. That is, possibility and rationality of predation strategy has been a controversial issue in academic area for so long. For example, Ordover et al. [1] pointed out that most papers which handled the topic of predatory pricing before the 1970s were against about possibility of predation strategy in a market full of rational market participants because predation inevitably incurs deficit. Then how the happening of certain firm's over-producing can be understood. Guiltinan et al. [2] introduced an example of The Marlboro's case. Philip Morris which was one of competitors of Marlboro, tried to bolster volume-oriented objectives and gave up short-term profit goals while emphasizing customer retention and customer lifetime value. According to Marlboro's case, over-producing or predatory pricing strategy is unreasonable strategy in terms of company's profit. But, as explained in Blattberg et al. [3] over-producing can be understood as 'kind of' rational behavior when a manager has an objective of increasing market sales rather than profits. And this phenomenon can happen if there are some firms which provide incentives to managers who make the firm's market share increase and there are managers who just seek to maximize their own career opportunities. From this point of view, papers such as Boulding et al. [4] see the predation as occasional event just happening when there are managers who just want to maximize sale-volume to show off one's marketing ability at the expense of profit.

On the other hand, there are also plenty of papers and scholars who emphasize the profitability of predatory pricing strategy. One of famous concept of profitable predation is 'long purse' which was proposed by Telser [5] it said that if certain firm has well developed financial condition, the firm can use this financial ability for getting out of its opponents and recouping the initial loss by earning monopoly profits. This long-purse concept exactly penetrates this thesis' model but the paper which proposed the concept of the long-purse didn't reach a construction of a fine economic model. And there are some more studies, or papers trying to construct mathematic and economic model which shows why predation strategy is possible, profitable and adaptable in real world. Because some basic form of predation model has been modified and used so far, some important early models and papers were introduced as below.

2.1.1 Predation for Reputation

Non-credible threat is one of famous game theoretical concept which has been played a key role in criticizing the possibility and reasonability of predation strategy. As explained Ordover et al. [1], consider the situation where there are two game player in the market; incumbent and entrant. The payoff structure which incumbent and entrant can get is as below.

Table 2.1: Payoff matrix

		Payoffs	
		Incumbent	Entrant
Incumbent's actions	Predatory pricing(P)	P^I	P^E
	Accommodating(A)	A^I	A^E

Without loss of generality, $M > A^I > 0 > P^I$ and $A^E > 0 > P^E$ conditions also can be assumed where M is monopoly profit. Then, even though $P^I + \delta M > (1+\delta)A^I$ condition holds, the incumbent's strategy of (P, M) where incumbent predate entrant at first game stage and monopolize the whole market at next turn cannot be Sub-game Perfect Nash Equilibrium(SPNE) in three-stages game like Figure 2.1 below. In the game tree, delta(δ) means discount rate or present preference factor.

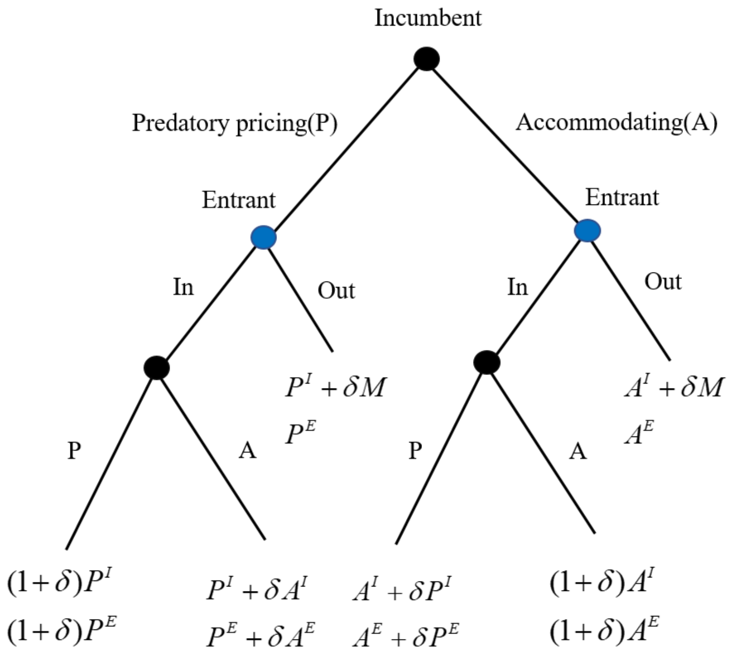

Figure 2.1: Game tree of Predation for Reputation

By back-ward induction approach, it can be easily found that incumbent's strategy of (A, A) and entrant's strategy of (In) is SPNE in this game. In short, no matter how attractive the predation strategy is, rational incumbent will eventually accommodate entrant and this compose SPNE. Thus, predation strategy in this game structure would be 'Non-credible threat' to entrant.

To refute this non-credible threat concept and show predation-possible model can be constructed as economic, mathematical model, Milgrom et al. [6] proposed the same game structure like above except the game stage is infinite. If the game has structure of infinite stages, then incumbent's 'predate whenever entrant gets into the market' and entrant's 'stay out of market' would be Nash equilibrium. Therefore, once incumbent have a success on getting reputation of aggressiveness, any other potential entrants never enter the market in that infinite-stages model.

2.1.2 Predation under Incomplete Information

Kreps et al. [7] approached the predation topic by using incomplete information game model. According to the paper, incumbent can have one of two types; tough or weak. When incumbent's type is tough, $M > P^{I,t} > A^{I,t} > 0$ condition holds. When incumbent's type is weak, $M > A^{I,w} > 0 > P^{I,w}$ condition holds. Entrant's payoff structure is fixed as $A^E > 0 > P^E$. And the whole game structure can be depicted as Figure 2.2.

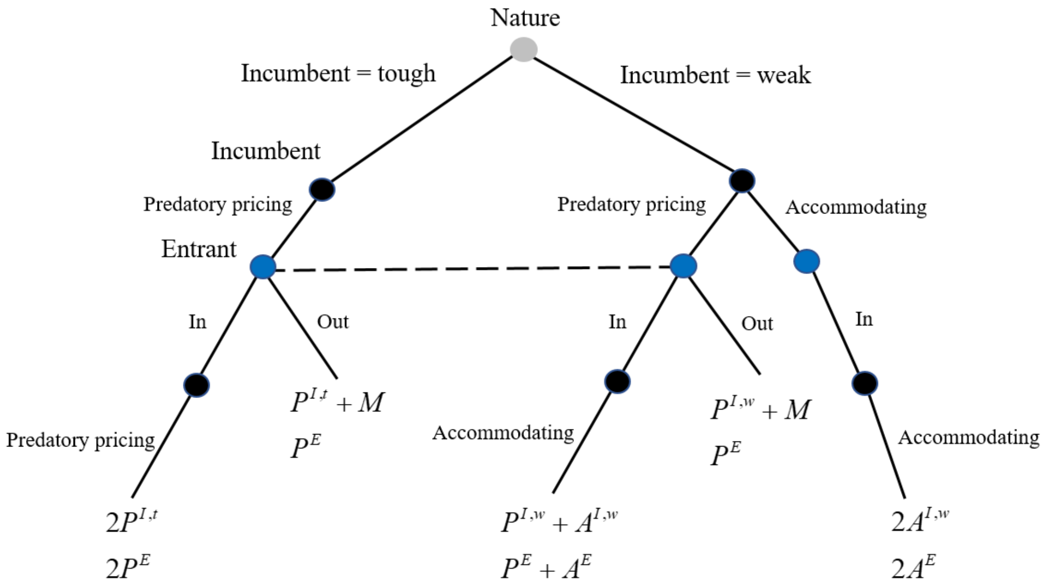

Figure 2.2: Game tree of Predation under Incomplete Information

Then, predation strategy can be 'real' threat to entrant. Especially weak incumbent can camouflage his type as if he is tough by attacking entrant at first stage. In this model entrant decide how to react based on its belief system. Thus this game can have Perfect Bayesian equilibrium(PBE). However, this model has fatal flaw in terms of assumption; that is, predatory pricing is more profitable than accommodation when incumbent's type is tough($M > P^{I,t} > A^{I,t} > 0$). No matter how tough the incumbent is, the condition that over-producing can raise profitability seems like immoderate.

2.1.3 Reverse chain-store Paradox

Benoit [8] proposed infinite-game which was quite similar with Milgrom et al. [6] in 2.1.1 above. The only different thing is that incumbent can drive entrant out of market by attacking entrant N times. This paper showed by back-ward induction approach that incumbent's continual predation if there is entrant in the market and entrant's leaving the market as soon as possible is sole equilibrium in this model.

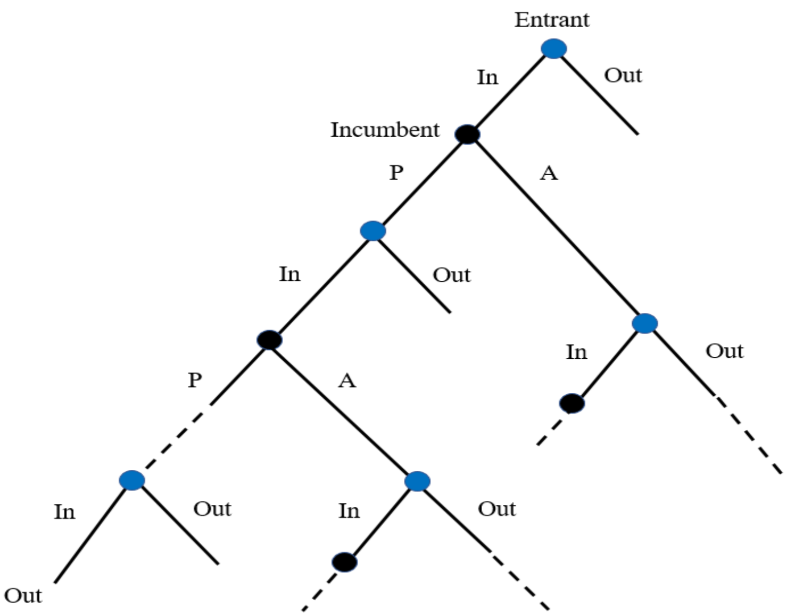

Figure 2.3: Game tree of Reverse chain-store Paradox

2.2 Capital Accumulation and Differential Game

From the standpoint of incumbent, predatory pricing strategy means finding more profitable equilibrium even though it incurs deficit in the beginning. The key idea on predation is whether incumbent or firm with great market power has ability to prospect long-term future periods by balancing early deficits and later monopoly profits. Thus, problem of whether to implement predatory pricing or not is kind of optimal path-finding problem. Especially it is a problem of finding an optimal path which seems poor in early stages but later gives great benefits. When the predation strategy is looked at from the perspective of this kind of optimal path finding problem, the following papers which are in the areas of capital accumulation and differential game can provide insights as well as mathematical methods.

Sinha et al. [9] analyzed the several sequential game scenarios especially in terms of cumulative profits of each game players during whole game periods changing the number of leader and the number of follower. Hasnas et al. [10] made the model which was basically following Cournot model but each player had to reinvest its own profit to prepare next game period. One of interesting point of in this model was concept of spillover; that is, game player can enjoy some benefits by the investment of his opponent. In this situation, the paper studied how much each player would invest focusing on whether total re-investment amount go increase or decrease. Xin et al. [11] adapted this capital accumulation concept on the field of water pollution in business area. When there were water usage allocation and additional cost of using water to a company, this paper found optimal path to maximize long-term profits by using Pontryagin maximum principle. Cellini et al. [12] studied how much a firm have to invest in product differentiation which makes the market demand increase and in cumulative capital which makes the firm's asset grow in terms of long-term cumulative asset. Cellini et al. [13] can be said as one of the earliest papers which consider optimal investment path to make maximum cumulative asset in the game theoretical model. Lambertini et al. [14] pointed out that a lot of papers studying differential oligopoly game implicitly utilize linear demand function. This paper analyzed characteristics of optimal paths and equilibriums in the structure of the differential oligopoly game models which have different kinds of non-linear demand curves. Raoufinia et al. [15] added the variable of advertising effectiveness and advertising cost to the differential oligopoly game model and analyzed the optimal investment-path which maximize each firms' profit. Actually Cellini et al. [16] originally used this kind of advertising effectiveness and advertising cost framework and this paper focused on finding optimal advertisement and producing quantity which let the game agent get maximum asset at final game period comparing open-loop equilibrium and closed-loop equilibrium. Colombo et al. [17] analyzed difference of optimal path's characteristics between Stackelberg setting and Cournot setting in the infinite horizon differential game. Like this ways, there were lots of theses and papers studying optimal path which maximizes game agent's cumulative profits or capital.

The objective or focus are almost same with these studies and this thesis, but usually they don't consider the core assumption which is handled in this thesis; mortality of game agent. If the assumption of agent's impermanence is considered, other paper's model can embrace the situation of predation or predatory pricing and it give more practical solutions to firms in harsh, competitive market.

2.3 Antitrust Law

The problems of predation or merger between firms in the market have long been discussed since late-1800s. Especially to ban firms' predation strategy in the market, Sherman Act has been utilized as anti-predatory pricing law. In this regard, two papers were eminent, which are still influential in antitrust, or anti-predatory pricing law area. Areeda et al. [18] proposed the necessity of analyzing cost structure of a firm especially when the firm is under investigation for suspicious act of predatory pricing such as variable cost, fixed cost, marginal cost and average cost etc. Williamson [19] asserted that it was hard to tell whether a certain firm committed intentional predatory pricing or not if there are overproducing or drastic price-cut in certain market. This paper also suggested the criterion in presuming a firm doing illegal predatory pricing. The criterion is P<AVC: certain firm's suspicious predation act should be presumed illegal when a firm sold products under its average variable cost(P<AVC). This paper points out that the criterion of P<AVC cannot be a perfect touchstone in presuming illegal predation, and argues that the background of certain predation related events should be examined in detail. In relation to the existence of this Sherman act, Sherman Act's general presuming criterion P<AVC was applied to check whether this criterion prevented illegal predation effectively and the results were presented in the latter part of this thesis.

Chapter 3

Model

3.1 Problem Setting

Table 3.1: Nomenclature

T	Study period	TD_1	Expected period of Leader's bankrupcy
K_1	Leader's endowment capital level	TD_2	Expected period of Follower's bankrupcy
K_2	Follower's endowment capital level	δ	Discount rate
$q_{1,t}$	Leader's production quantity at t period	r	Interest rate
$q_{2,t}$	Follower's production quantity at t period	π^M	General expression of monopoly profit
$\pi_{1,t}$	Leader's profit at t period	π^S	General expression of Stackelberg equilibrium profit
$\pi_{2,t}$	Follower's profit at t period	π^P	General expression of predatory pricing strategy profit

In this study, basic form of multi-period duopoly Stackelberg model was used to construct multi-period predation model. All firms produce homogeneous goods in the market and price discrimination is impossible. In Stackelberg game, there are two stages at each game period. The first stage is for leader's production quantity decision, and the second stage is for follower's. That is, follower can react to leader's decision after observing leader's production quantity but follower has to wait until leader set its production level. On the other hand, leader has to produce without observing follower's output level but it has priority of preemptive output determining. When all of two players have finished setting the output level, the market price is determined by the sum of total product quantities of two game players and the period ends with each player earning profit based on their own output level. These Stackelberg game's sequence is described as figure below. From now on, 'subscript 1' stands for leader and 'subscript 2' stands for follower.

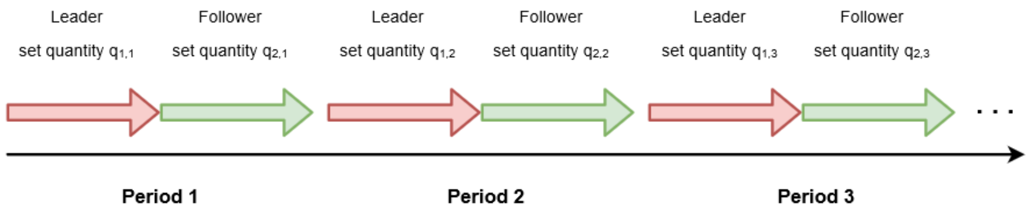

Figure 3.1: Sequence of Multi-period Stackelberg Game

In this Stackelberg game structure, follower's problem can be written as partial differential equation as below.

$$\frac{\delta\pi_{follower}(q_{leader}, q_{follower})}{\delta q_{follower}} = 0 \tag{3.1}$$

Then follower can get best response function against leader's output, $q^{BR}_{follower}(q_{leader})$. After considering follower's best reponse function, leader can use this follower's best response function to maximize its own profit and it solve total differential equation.

$$\frac{d\pi_{leader}(q_{leader}, q^{BR}_{follower}(q_{leader}))}{dq_{leader}} = 0 \tag{3.2}$$

If the equations like above are solved, the solution of leader's output and follower's output are called Stackelberg equilibrium and it provide 'maximum' profit to leader. However, the main point of this thesis is that this Stackelberg equilibrium's maximum profit may not actually be the exact 'maximum' profit but rather short-term maximum profit if considering predatory pricing in long-term perspective.

To consider the predatory pricing, Stackelberg game can be transformed by applying some additional assumptions to it. At first, concept of capital endowment level was added to the existing Stackelberg model; that is, each firm has its own capital endowment level at period 0(before the game starts) and profits of each period are accumulated to the previous capital level. If a firm earns profit at a certain period, the profit earned is added to the previous capital level and the total capital level is increased by that earning. But if firm records a deficit, the amount of deficit is deducted from previous capital level as capital loss. And each firm's capital level is common knowledge for all game players in every period as real market.

$$K_{i,t} = K_i + \sum_{t=1}^{T} \pi_{i,t} \tag{3.3}$$

One of important setting related with the concept of capital level is that a firm can go bankrupt or default. That is, if a firm's capital level falls below zero at the end of certain period, then the firm will be expelled from the market at that moment and never be able to enter the market again. It means a firm which has success on predation becomes monopoly supplier of the market. By using these capital level concepts, multi-period Stackelberg game can embrace the concept of predatory pricing or predation strategy.

Based on these settings, consider the problem situation that this thesis want to solve. There is a leader in certain market and it is now monopoly supplier at that market. So leader can also be said as incumbent in the market. And there is follower, or entrant, who is considering entering to the market. Because leader has market power, the game between leader and follower is going to be Stackelberg game structure when follower decides to enter the market. And follower has option to leave out the market at the beginning of each period. If the market doesn't seem to be profitable to follower, it can leave the market at any period. If the competition between leader and follower goes on in complete imformation gmae and perfect game structure, what would be the equilibrium? At first, the objective function of each player can be written as follows. Especailly in the follower's objective function, $\pi_{2,t}$ would be zero after follower decides to leave the market.

Leader's objective function

$$\underset{q_1}{Max} \quad K_1 + \sum_{t=1}^{T} \delta^t \pi_{1,t}(q_{1,t}, q_{2,t}) \tag{3.4}$$

Follower's objective function

$$\underset{q_2}{Max} \quad K_2 + \sum_{t=1}^{T} \delta^t \pi_{2,t}(q_{1,t}, q_{2,t}) \tag{3.5}$$

Game tree of the problem can also be presented as below.

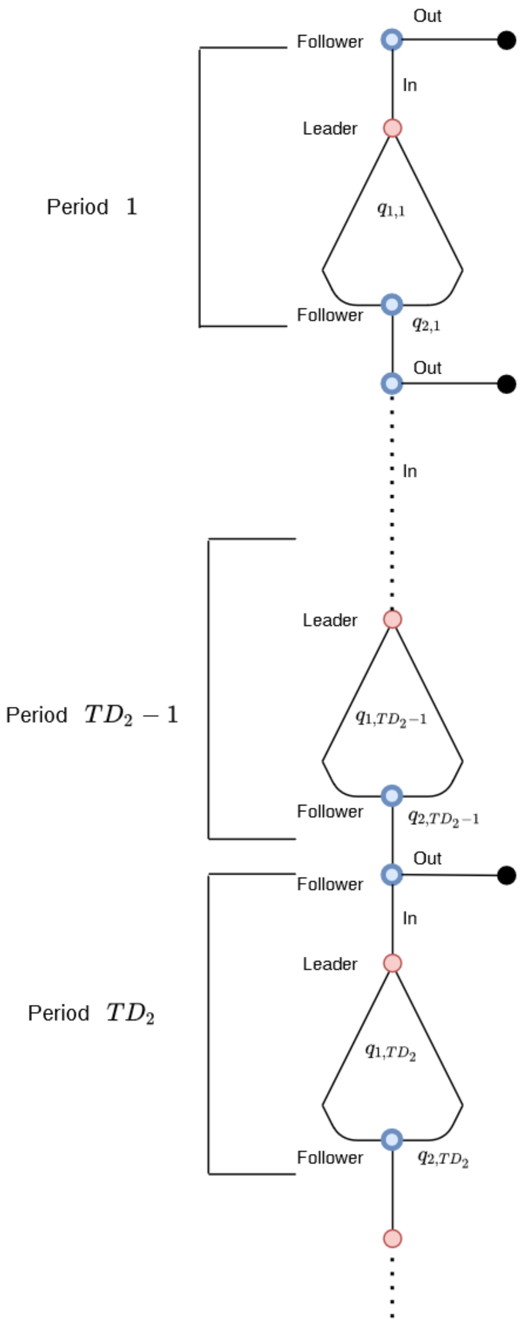

Figure 3.2: Game tree of predation problem(Original game)

Even though leader has preemptive priority on setting output in this problem structure, follower also has corresponding option in this game. Follower can decide whether to stay in the market or not at the beginning of each period. But, if follower choose ‘leaving out of market’ as option, it will never comes back to the market again. This rule is applied from the very first game period and if follower decides not to enter the market at period 1, it can be translated as follower decide not to enter the market at all. On the other hand, if follower chooses leaving option after period 2, it can be traslated as follower decided to enter the market at first but it gives up the competition after some duopoly games.

In this game structure, each player must strategically determine its reaction. For leader, it would be good if follower gives up entering the market. But if follower decides to enter the market, there is three options that leader can make. One of options is to predate follower thoroughly to take back the position of monoploy supplier. This strategy would be incurring damage to financial state at early periods but if recouping is possible, it would also be effective strategy. Another one is just frighten follower by some periods’ predatory pricing. This strategy will be used when leader want to take back monopoly position but don’t have sufficient finantial stockpile. And the last one is to accommodate follower. If leader thinks that expelling follower from market by predation is impossible, it will accommodate follower and choose continual Stackelberg equilibriums which provide maximum short-term profits.

When it comes to follower, it should predict the possibility of leader’s predation before entering the market. Follower can choose entering when it is guaranteed that leader would not predate follower in the market or when it can assure itself that leader’s possible predatory pricing would be non-credible theat.

3.2 Modified Model

Game setting explained above has some complex characteristics. Especially follower's option to quit out from market at any periods makes the problem difficult to solve. But this problem can be solved by backward induction approach. Most of all, to apply backward induction approach, 'Modified model(or Modified game)' is need to be defined. In modified model follwer should enter the market at the beginning of game(period 1) and follower doesn't have any option to leave out the market by its will. Then the modified model's game tree can be plotted as below.

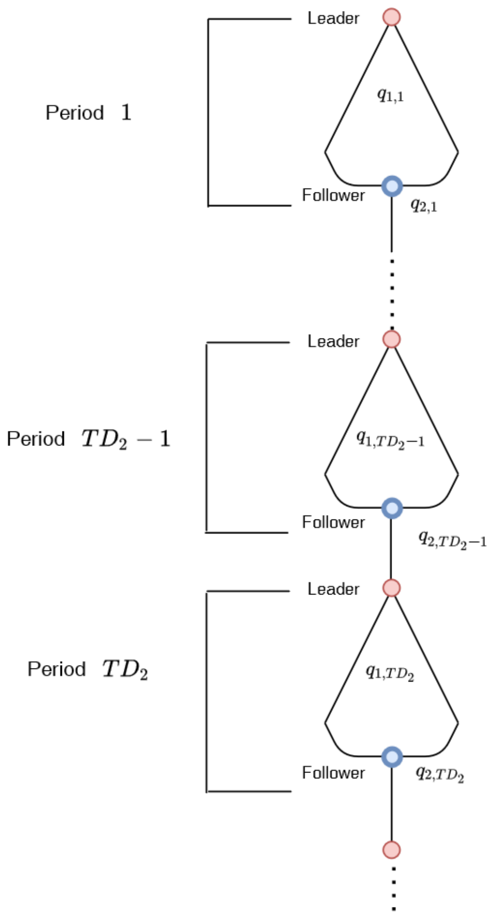

Figure 3.3: Game tree of Modified model

This modified game can be seemed too disadvantageous to follower because it doesn't have option to leave out in this game structure. But this modified game gives the information about which strategy would be 'dominant strategy' for leader in the original game. Therefore, each player should consider a special situation in which follower never retreat and fight in a row. Then leader's option of frightening follower would be impossible because follower will never retreat in this modified version. Thus, leader should choose one strategy which is thought to be more profitable option : predatory pricing or accomodating(Stackelberg equilibrium). The overview of each strategy's cash flows can be plotted as below.

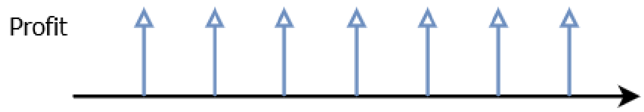

Figure 3.4: Overview of continual Stackelberg equilibrium's cash flows

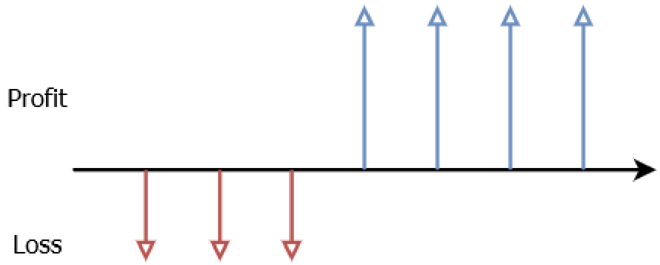

Figure 3.5: Overview of Predatory pricing strategy's cash flows

Choosing Stackelberg strategy means firm wants to earn maximized profits in terms of each short-term period and accumulate it. On the other hand, choosing predation strategy means firm gives up immediate-maximized profits at the beginning periods of the game but earns monopoly profits after getting the opponent out of the market. However, the important point is that predation strategy is not always possible. When follower has a quite large endowment capital, it is impossible for leader to expel follower. Also, when leader's financial study period is too short to recoup the early periods' profit loss, the predation strategy is not implementable. Therefore, leader should ponder the possibility and profitability of implementation of predation strategy at the beginning of the game and choose Stackelberg equilibrium when predatory pricing strategy is turned out to be impossible in this modified game.

After considering every factors such as study period, variable costs, capital endowment levels of each player etc, leader can find optimal strategy in modified game. Then the leader's dominant strategy in this modified game is to be also dominant strategy in original game to leader. Because this game structure based on Stackelberg game, it cannot make asny big variation about game outcome that follower has option to leave out the market. Therefore, if predation is dominant strategy in a certain modified game then predation is also being a dominant strategy of the original game and vice versa.

So, if leader realizes that predation is dominant strategy in modified game then it will predate follower whenever follower enter the market in original game. On the other hand, if follower realizes that leader's dominant strategy is predation in modified game, it will never try to enter the market to save its capital as much as possible in original game. In short, (leader's predation, follower's quit to enter the market) will be original game's equilibrium if leader's dominant strategy in modified game is predation. If leadr's dominant strategy in modified game is accomodating, (leader's accomodating, follower's entering) will be equilibrium of original game. In this regard, modified game's outcome gives solution for orinigal game. Thus, from now on, the objective of this section is to solve modified game.

Each player's objective function in modified game can be written as below. The only different feature of modified game's objective function is that follower maximizes its own profit at each game period just by reacting to each period's residual market demand. Additionally, in the leader's objective function the discount factor is replaced by inverse of interest rate $(\delta = (1+r)^{-1})$.

Leader's objective function

$$\underset{q_1}{Max} \quad K_1 + \sum_{t=1}^{T} \left(\frac{1}{1+r}\right)^t \pi_{1,t}(q_{1,t}, q_{2,t}) \tag{3.6}$$

Follower's objective function

$$\underset{q_{2,t}}{Max} \quad \pi_{2,t}(q_{1,t}, q_{2,t}) \ \ at\ each\ t \tag{3.7}$$

At next step, to check whether 'predatory pricing' is dominant strategy for leader in modified game the objective functions and constraints can be re-written as below. That is, leader have to search whether there is optimal production output set that can make it possible to expel follower from the market on proper time and bring better net present value of profits.

Leader's problem

$$\underset{q_1, TD_2}{Max} \quad K_1 + \sum_{t=1}^{TD_2} \pi_1(q_{1,t}, q_{2,t}{}^{BR}(q_{1,t})) \times (1+r)^{-t} + \sum_{t=TD_2+1}^{T} \pi_1^M \times (1+r)^{-t} \tag{3.8}$$

$$\textit{subject to} \quad \sum_{t=1}^{TD_2} \pi_2(q_{1,t}, q_{2,t}{}^{BR}(q_{1,t})) \le -K_2 \tag{3.9}$$

$$\pi_2(q_{1,TD_2}, q_{2,TD_2}{}^{BR}(q_{1,TD_2})) < 0 \tag{3.10}$$

$$\sum_{t=1}^{n} \pi_1(q_{1,t}, q_{2,t}^{BR}(q_{1,t})) > -K_1 \quad (n = 1, 2, ...TD_2) \tag{3.11}$$

$$\sum_{t=1}^{TD_2} \pi_1(q_{1,t}, q_{2,t}{}^{BR}(q_{1,t})) \times (1+r)^{-t} + \sum_{t=TD_2+1}^{T} \pi_1^M \times (1+r)^{-t} > \sum_{t=1}^{T} \pi_1^S \times (1+r)^{-t} \tag{3.12}$$

$$TD_2 < T \tag{3.13}$$

$$TD_2 < TD_1 \quad (TD_1, TD_2 \in N) \tag{3.14}$$

Follower's problem

$$\underset{q_{2,t}}{Max} \quad \pi_{2,t}(q_{1,t}, q_{2,t}) \qquad \textit{at each } t \tag{3.15}$$

If there is an optimal solution in this problem, then implementing predation strategy will be strict dominant strategy for leader. To reiterate, the problem above is for checking whether predation strategy is dominant for leader or not. If there is no optimal solution in above problem, accommodation strategy, or Stackelberg equilibrium, would be dominant strategy for leader.

Next, the meanings of each objective function and constraint were explained one by one. At first, objective function (3.8) can be analyzed as follow. In order to successfully implement predatory pricing, leader has to maximize sum of net present value of predation period's profits and monopoly peiod's profits. Because this basic form of the game is Stackelberg game, follower's output function can be re-written as follower's best response function $(q_{2,t}{}^{BR}(q_{1,t}))$. Then, what the leader must ultimately decide is: how aggressively it attacks its opponent by product output (q_1) and how quickly it gets the opponent out of market (TD_2). Actually these decision variables are correlated; aggressive predation over production usually leads to quick exit of the follower.

Constraint (3.9) is related with follower's endowment capital exhaustion. In this study, going bankrupt means a firm exhausts all capital by accumulation of deficits. Because follower firm has endowment capital of (K_2), the bankruptcy condition can be written as (3.9).

The next constraint of (3.10) is for qualifying the meaning of TD_2 variable. This constraint (3.10) may seem to be redundant but it is necessary. Think about the situation where conditions of $\sum_{t=1}^{TD_2} \pi_2(q_{1,t}, q_{2,t}{}^{BR}(q_{1,t})) \leq -K_2$ and $\pi_2(q_{1,TD_2}, q_{2,TD_2}{}^{BR}(q_{1,TD_2})) \geq 0$ are met. It means follower already went bankrupt right before the period of TD_2 but it is contradictory because TD_2 has the meaning of follower's default period. Thus, the constraint (3.10) has to hold to solve the problem.

During implementing predation strategy, leader should not go bankrupt. If leader is gotten out of market by its own over-producing strategy, it is useless to implement predation strategy. Because bankruptcy occurs when a player's capital falls below zero in this model, leader who pondering predation has to manage its capital level not to be going below zero especially for any game periods until its opponent is expelled from market. That is, these leader's non-bankruptcy condition of (3.11) should hold for all game periods.

Whether implementing predation strategy would be economically beneficial or not must be considered for leader. If the net present sum-value of deficits in initial predation periods and monopoly profits in latter periods is not big enough than that of continual short-term maximized profits, or Stackelberg profits, there is no reason to implement predation strategy for game player. Thus, constraint (3.12) has to be satisfied especially for the play who is leading predation.

Timing of follower's default should be shorter than study period. Solely in this condition, leader can enjoy monopoly profits during the periods in which it remains alone in the market and constraint (3.13) implies it.

Lastly, from the idea that player who taking a lead in carrying out predation strategy must not go bankrupt, constraint (3.14) can be brought: If there is risk or any possibilities for leader being able to go bankrupt, its bankruptcy timing must be later than the follower's default timing. At here, once follower goes bankrupt, leader's risk of goint bankrupt could fade away.

Chapter 4

Analysis

4.1 Algorithm

The problem of modified game is basically MINLP(Mixed Integer Non Linear Problem). Production quantity q_1 is real-value decision variable and TD_1, TD_2 are integer decision variables. In this problem structure, there is a singular factor which makes solving this problem quite difficult. According to constraint (3.11), the number of constraints depends on decision variable TD_2. Therefore, in order to solve this variable-constraints correlated problem every possible solutions q_1^* has to be listed for all possible TD_2 values and then the global optimal set of (q_1^*, TD_2) which give the biggest value of objective function has to be found. This process of problem solving method can be expressed by pseudo-code and algorithm diagram as below.

Pseudo-code : Predation model based on multi-period Stackelberg game

Get the best response function of firm 2 ($q_2^{BR}(q_1)$)
Set the study period T
for TD_2 in *1:T* do
    Find the decision variables(q_1) *which maximize 'Maxobj' funtion*
    (*Maxobj :* $\sum_{t=1}^{TD_2} \pi_1(q_{1,t}, q_{2,t}^{BR}(q_{1,t})) \times (1+r)^{-t} + \sum_{t=TD_2+1}^{T} \pi_1^M \times (1+r)^{-t}$)
    If q_1^* *can be found which satisty all the constraints* then
        Save the values TD_2, $q_1^*, Maxobj_{TD_2}^*$
    Else
        Discard the values TD_2, $q_1^*, Maxobj_{TD_2}^*$
    End-if
End-for
If *there are* $Maxobj_{TD_2}^*$ *values which were saved before* then
    List them in order from large value to small value
    Implementing predatory pricing strategy(TD_2, $q_{1,t}^*$) *which maximize* $Maxobj_{TD_2}^*$ *as optimal strategy*
Else
    Choose Stackelberg Equilibrium(q_1^S) *as optimal strategy*
End-if

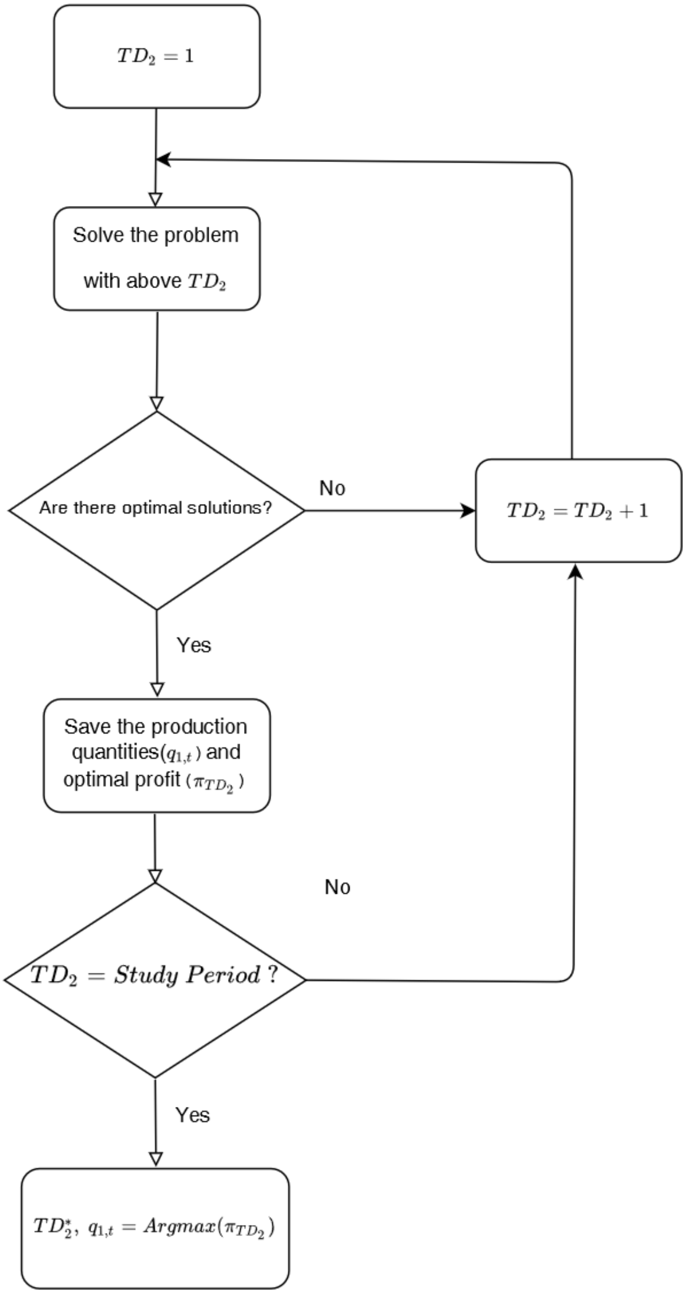

Figure 4.1: Algorithm diagram for searching optimal predation strategy

4.2 Solution of Modified Model

Some properties of modified model were studied and presented as propositions in this section. Most of propositions in this chapter are about characteristics of modified model but it can give intuitions about original game. The question such as how much capital endowment level of leader can make it possible for leader to implement predation strategy, how much capital endowment level of follower can prevent predation against leader, under what conditions predations strategy can be profitable for leader, and what characteristics consumer surplus will show when predation occurs in market were studied. And as in all chapters, subscript 1(player 1) stands for leader and subscript 2(player 2) stands for follower in this chapter.

Proposition 4.1. If Firm 1's profit is negative for all range of $q_{1,t}$ which satisfy $\pi_2 < 0$, firm 2's endowment capital is large enough to hold $\frac{K_2}{K_1} > \max_{q_{1,t}}(\frac{\pi_2(q_{1,t})}{\pi_1(q_{1,t})})$, then implementing predatory pricing strategy is impossible for Firm 1.

Proof

Let's think about the leader's output level of $\underline{q_1}$ which makes follower's profit zero ($\pi_2\left(\underline{q_1}, q_{2,t}^{BR}\left(\underline{q_1}\right)\right) = 0$) and define $q_{1,t}$ which is in range of ($\underline{q_1}$, $\overline{q_1}$). $\overline{q_1}$ is maximum output leader can make based on potential demand. Then it can be re-written as,

$$q_{1,t} \subset (\underline{q_1}, \overline{q_1}) \tag{4.1}$$

From the proposition's condition,

$$\pi_1 < 0,\ \pi_2 < 0 \quad for\ all\ q_{1,t}\,(t \le TD_2) \tag{4.2}$$

Each period's profits can be ordered as below.

$$\underset{q_{1,t}}{Max}\left[\frac{\pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}{\pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}\right] \ge \frac{\pi_2(q_{1,i},\ q_{2,i}^{BR}(q_{1,i}))}{\pi_1(q_{1,i},\ q_{2,i}^{BR}(q_{1,i}))} \ge \frac{\pi_2(q_{1,j},\ q_{2,j}^{BR}(q_{1,j}))}{\pi_1(q_{1,j},\ q_{2,j}^{BR}(q_{1,j}))} \ldots \ge \frac{\pi_2(q_{1,k},\ q_{2,k}^{BR}(q_{1,k}))}{\pi_1(q_{1,k},\ q_{2,k}^{BR}(q_{1,k}))} \tag{4.3}$$

By formula 4.2 and 4.3, it can be shown that following inequality 4.4 holds.

$$\underset{q_{1,t}}{Max}\left[\frac{\pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}{\pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}\right] \ge \frac{\sum_{t=1}^{T}\pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}{\sum_{t=1}^{T}\pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))} \tag{4.4}$$

i) When the summation above the inequality is calculated until $T = TD_2(TD_2 < TD_1)$

$$\frac{K_2}{K_1} > \frac{\sum_{t=1}^{TD_2}\pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}{\sum_{t=1}^{TD_2}\pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))} \tag{4.5}$$

By the meaning of TD_2,

$$\sum_{t=1}^{TD_2}\pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t})) + K_2 = 0 \tag{4.6}$$

And inequality above can be transformed as inequality 4.7.

$$\frac{K_2}{K_1} - \frac{\sum_{t=1}^{TD_2} \pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}{\sum_{t=1}^{TD_2} \pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))} = K_2\left(\frac{1}{K_1} + \frac{1}{\sum_{t=1}^{TD_2} \pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}\right) > 0 \tag{4.7}$$

Because inequalities $K_2 > 0$ and $\sum_{t=1}^{TD_2} \pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t})) < 0$ holds,

$$\therefore\ K_1 + \sum_{t=1}^{TD_2} \pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t})) < 0 \tag{4.8}$$

However, this inequality means Firm 1(Leader) already went bankrupt before follower being default. It is impossible to calculate the summation of firms' profits in formula 4.4 until TD_2 period; that is, in this condition there is contradiction.

ii) When the summation above the inequality is calculated until $T = TD_1(TD_1 < TD_2)$

Without loss of generality following condition can be got.

$$\frac{K_2}{K_1} > \frac{\sum_{t=1}^{TD_1} \pi_2(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))}{\sum_{t=1}^{TD_1} \pi_1(q_{1,t},\ q_{2,t}^{BR}(q_{1,t}))} \tag{4.9}$$

By the meaning of TD_1,

$$\sum_{t=1}^{TD_1} \pi_1(q_{1,t},\, q_{2,t}^{BR}(q_{1,t})) + K_1 = 0 \tag{4.10}$$

And inequality above can be transformed as below.

$$\frac{K_2}{K_1} - \frac{\sum_{t=1}^{TD_1} \pi_2(q_{1,t},\, q_{2,t}^{BR}(q_{1,t}))}{\sum_{t=1}^{TD_1} \pi_1(q_{1,t},\, q_{2,t}^{BR}(q_{1,t}))} = \frac{K_2 + \sum_{t=1}^{TD_1} \pi_2(q_{1,t},\, q_{2,t}^{BR}(q_{1,t}))}{K_1} > 0 \tag{4.11}$$

Because inequlity $K_1 > 0$ holds,

$$\therefore\ K_2 + \sum_{t=1}^{TD_1} \pi_2(q_{1,t},\, q_{2,t}^{BR}(q_{1,t})) > 0 \tag{4.12}$$

■

According to formula 4.1 – 4.12, if follower's endowment capital is large enough to satisfy $\frac{K_2}{K_1} > \max_{q_{1,t}}(\frac{\pi_2(q_{1,t})}{\pi_1(q_{1,t})}$, there is no possibility of follower's bankruptcy when leader has to confront deficit to make follower's profit negative.

At any $q_{1,t}(t = 1,2,\dots,TD_2)$ defined in this proposition which make firm 1 and firm 2's profit negative, a ratio of firm 1's profit over firm 2's profit$(\frac{\pi_2(q_{1,t},q_{2,t}^{BR}(q_{1,t}))}{\pi_1(q_{1,t},q_{2,t}^{BR}(q_{1,t}))})$ can be regarded as capital loss of firm 2 per unit capital loss of firm 1; that is, the effectiveness predation strategy for firm 1. And the largest value of this ratio means the ratio at which Firm 1 can minimize its own capital loss while maximizing the opponent's capital loss. Therefore, if the inequality $\frac{K_2}{K_1} > \max_{q_{1,t}}(\frac{\pi_2(q_{1,t})}{\pi_1(q_{1,t})})$ holds for all $q_{1,t}$, there is no way for firm 1 to get firm 2 out of market because it would be bankrupt before the opponent being expelled from market if firm 1 implements continual predation policy. On the other hand, if there is any output level q_1 that satisfy $\pi_1\left(q_1, q_{2,t}^{BR}(q_1)\right) > 0$ and $\pi_2\left(q_1, q_{2,t}^{BR}(q_1)\right) < 0$, the ratio $\frac{\pi_2(q_{1,t})}{\pi_1(q_{1,t})}$ becomes negative and firm 1 can implement predatory pricing strategy without having risk of capital loss. But no risk of predation strategy doesn't mean it is dominant strategy because predatory pricing sometimes provides inferior net present value of profits than continual Stackelberg profits. Thus, economic feasibility should be checked before implementing predation and related contents are covered in Proposition 4.4.

Proposition 4.2. If study period and firm 1's capital endowment level are sufficiently large ($T = \infty$, $K_1 \gg 1$) and there is any production output level which satisfy the inequalities, $\delta > (\frac{\pi_1^S - \pi_1^P}{\pi_1^M - \pi_1^P})^{\frac{1}{TD_2}}$ and $\pi_2^P < 0$, getting firm 2 out of market by predation strategy is possible for firm 1 and implementing predation strategy is always profitable for firm 1 on long-term perspective.

Proof Without loss of generality the inequality below always holds for any predation profits. The notation M stands for 'Monopoly', S for 'Stackelberg' and P for 'Predatory pricing' or 'predation strategy'.

$$\pi_1^{\,M} > \pi_1^{\,S} > \pi_1^{\,P} \tag{4.13}$$

Inequality 4.14, which means that predatory pricing is more profitable, can be reformulated as inequalities 4.15 and 4.16.

$$\sum_{t=1}^{TD_2} \pi_1^{\,P} \times (1+r)^{-t} + \sum_{t=TD_2+1}^{\infty} \pi_1^{\,M} \times (1+r)^{-t} > \sum_{t=1}^{\infty} \pi_1^{\,S} \times (1+r)^{-t} \tag{4.14}$$

$$\frac{(\pi_1^{\,M} - \pi_1^{\,S}) \times (1+r)^{-TD_2}}{r} > \frac{(\pi_1^{\,S} - \pi_1^{\,P}) \times (1-(1+r)^{-TD_2})}{r} \quad (\because r > 0) \tag{4.15}$$

$$\frac{1}{r}[\pi_1^{\,M}(1+r)^{-TD_2} - \pi_1^{\,S} + \pi_1^{\,P}(1-(1+r)^{-TD_2})] > 0 \tag{4.16}$$

Because r in inequalities 4.14 – 4.16 is market interest rate, it has positive value ($r > 0$). Thus inequality 4.16 holds if inequality 4.17 holds.

$$\pi_1^{\,M}(1+r)^{-TD_2} - \pi_1^{\,S} + \pi_1^{\,P}(1-(1+r)^{-TD_2}) > 0 \tag{4.17}$$

Inequality 4.17 also can be transformed into 4.18 by substituting $(1+r)^{-1}$ with δ

and using inequality 4.13.

$$\delta > \left(\frac{\pi_1^S - \pi_1^P}{\pi_1^M - \pi_1^P}\right)^{\frac{1}{TD_2}} \tag{4.18}$$

Therefore, if there is a certain output level which satisfies inequality $\delta > (\frac{\pi_1^S - \pi_1^P}{\pi_1^M - \pi_1^P})^{\frac{1}{TD_2}}$, that output level guarantees economically superior net present value(NPV) of predation strategy. In addition to economic condition of predation, if the output level which satisfies 4.18 also satisfies $\pi_2^P < 0$ then getting firm 2 out of market by predation is also possible by producing that amount of products until firm 2 go bankrupt because it is assumed that study period and endowment capital level are sufficiently large. In conclusion, it can be said that if $\delta > (\frac{\pi_1^S - \pi_1^P}{\pi_1^M - \pi_1^P})^{\frac{1}{TD_2}}$ and $\pi_2^P < 0$ hold at any production quantity level($q_{1,t}$), then leader always can get follower out of market by predatory pricing and it provide better net present value of profits than that of continual Stackelberg profits. ■

Proposition 4.3. If study period and firm 1's capital are sufficiently large ($T = \infty,\ K_1 \gg 1$) and firm 1 assesses profit in terms of accounting perspective rather than discount cash flow perspective, then predatory pricing strategies always be the dominant strategy for firm 1.

Proof

Since the left side has infinite values and the right side has finite values in the below inequality, the inequality below always holds.

$$\sum_{t=TD_2+1}^{\infty} (\pi_1{}^M - \pi_1{}^S) > \sum_{t=1}^{TD_2} (\pi_1{}^S - \pi_1{}^P) \qquad (\because \pi_1{}^M > \pi_1{}^S > \pi_1{}^P) \tag{4.19}$$

And the inequality can be transformed into the form as below.

$$\sum_{t=1}^{TD_2} \pi_1{}^P + \sum_{t=TD_2+1}^{\infty} \pi_1{}^M > \sum_{t=1}^{\infty} \pi_1{}^S \tag{4.20}$$

■

However, if follower cannot be got out of market by leader's predation strategy, this proposition would not be a meaningful one. Thus, this proposition has practical meaning only when predation, or expelling follower from market, is possible. And the condition that make predatory pricing possible under current proposition's conditions ($T = \infty,\ K_1 \gg 1$) is whether there is leader's output level which satisfies $\pi_2{}^P < 0$. In conclusion, for firm assessing profit in terms of accounting perspective, predation strategy is always providing better profits especially when there is output level which satisfies $\pi_2^{\ P} < 0$.

Proposition 4.4. If study period is sufficiently large($T = \infty$) and there is production quantity which makes leader's profit positive and follower's profit negative, the inequality $\delta > (\frac{\pi_1^S}{\pi_1^M})^{\frac{1}{TD_2}}$ plays determinant role in whether to implement predatory pricing strategy for leader.

Proof

Let's suppose that there is $q_{1,t}(t = 1,2, \dots, TD_2)$ which satisfies $\pi_1(q_{1,t}, q_{2,t}^{BR}(q_{1,t}) > 0$ and $\pi_2(q_{1,t}, q_{2,t}^{BR}(q_{1,t}) < 0$ for all t. In this assumption, it is always possible for leader to get follower out of market by utilizing output set of $q_{1,t}$ especially because study period is sufficiently large. However, the applicability of predatory pricing does not necessarily mean that predatory pricing is economically better strategy. Thus, it is necessary to check whether there is any $q_{1,t}$ set which satisfy inequality 4.21 to determine economic feasibility of predation strategy.

$$\sum_{t=1}^{TD_2} \pi_1^{\ P} \times (1+r)^{-t} + \sum_{t=TD_2+1}^{\infty} \pi_1^{\ M} \times (1+r)^{-t} > \sum_{t=1}^{\infty} \pi_1^{\ S} \times (1+r)^{-t} \qquad (4.21)$$

Inequality 4.21 can be transformed into 4.22.

$$\frac{1}{r}[\pi_1^{\ M}(1+r)^{-TD_2} - \pi_1^{\ S} + \pi_1^{\ P}(1-(1+r)^{-TD_2})] > 0 \tag{4.22}$$

Since market interest rate has always positive value($r > 0$) and also profits when implementing predatory pricing is positive($\pi_1^P > 0$) by assumption, inequality 4.22 always holds if inequality 4.23 below holds.

$$\pi_1^{\ M}(1+r)^{-TD_2} - \pi_1^{\ S} > 0 \tag{4.23}$$

This formula can be re-written by substituting market interest rate with market discount rate.

$$\delta > (\frac{\pi_1^S}{\pi_1^M})^{\frac{1}{TD_2}} \tag{4.24}$$

Therefore, if there is any output set of $q_{1,t}$ which make leader's profit positive and follower's profit negative and additionally satisfies inequality $\delta > (\frac{\pi_1^S}{\pi_1^M})^{\frac{1}{TD_2}}$, then predatory pricing is dominant strategy for leader in modified game. ■

Proposition 4.5. Sherman Antitrust Act, one of the most preeminent laws in the field of predatory pricing and antitrust law presumes a firm's production policy illegal when the firm sell its product under average variable cost($P < AVC$). In this multi-period Stackelberg game, Sherman Antitrust Act may not adequately prevent predatory pricing strategy from occurring in market.

Proof

Let's consider the Stackelberg game in which market demand function is $P(Q) = A - B(q_1 + q_2)$ where $Q = q_1 + q_2$ and each firm's profit function is $\pi_i = P(Q)q_i - c_i q_i - F_i$. If parameters of the model are set as $A = 30$, $\mathrm{B} = 1$, $c_1 = 1$, $c_2 = 1$, $K_1 = 100$, $K_2 = 45$, $F_1 = 10$, $F_2 = 10$, $r = 3$, then optimal strategy for firm 1 is implementing predatory pricing until 5-period and making the follower got out of market. The optimal production output set of leader are $q_{1,1}^* = 26.90, q_{1,2}^* = 26.95$, $q_{1,3}^* = 27.00$, $q_{1,4}^* = 27.05$, $q_{1,5}^* = 27.10$, $q_{1,6}^* = 14.5$, $q_{1,7}^* = 14.5$, $q_{1,8}^* = 14.5$, $q_{1,9}^* = 14.5$, $q_{1,10}^* = 14.5$ and output set of follower's response are $q_{2,1}^* = 1.05, q_{2,2}^* = 1.02$, $q_{2,3}^* = 1.00$, $q_{2,4}^* = 0.97$, $q_{2,5}^* = 0.95$. Therefore, the market price of each period is $P_1 = 2.06$, $P_2 = 2.03$, $P_3 = 2.00$, $P_4 = 1.98$, $P_5 = 1.95$, $P_6 = 15.5$, $P_7 = 15.5$, $P_8 = 15.5$, $P_9 = 15.5$, $P_{10} = 15.5$ and all of market prices are bigger than $c_1 = 1$ which is firm 1's average variable cost. Since the counterexample can be found in this way, the Sherman Antitrust Act may not function properly in this multi-period Stackelberg model. ■

Proposition 4.5 means Sherman act's criterion($P < AVC$) could be imperfect for certain situations. It implies that even though predatory pricing which hindering market competition in the long run are possible in some market, these firms' predation policy sometimes cannot be judged as illegal depending on the market conditions. This kind of Sherman act verification approach was also covered in interesting way in Naoum-Sawaya [20] and this thesis referenced it.

In addition, the numerical example above also shows that certain products' market price can be in very cheap state during leader's predation periods but after finishing predation periods those products' price drastically goes upward because firm which implemented predation wants to recoup its early periods' loss. This kind of price gap between predation periods and monopoly periods influences consumer surplus and Proposition 4.7 covers that topic.

Proposition 4.6. If follower has no fixed cost at all$(F_2 = 0)$, the leader cannot force the follower to suffer capital loss. Therefore, it is impossible for leader to implement predatory pricing strategy.

Proof

If follower firm's costs are incurred only by variable cost and there is no fixed cost, the follower may not suffer capital loss no matter how the leader overproduces. Because follower can stop its production by setting $q_2^{BR}(q_1) = 0$ and earn no profit $(\pi_2 = 0)$. In this non-fixed cost condition, the constraint $\sum_{t=1}^{TD_2} \pi_2 \left(q_{1,t}, q_{2,t}^{BR}(q_{1,t})\right) < -K_2$ never be satisfied and follower can preserve its own capital remaining in the market in any case. Therefore, if follower has cost structure of no fixed cost, predatory pricing cannot be a dominant strategy in modified game for leader. ■

Proposition 4.7. If predatory pricing is dominant strategy for leader, there must be monopoly periods in modified game structure. In this situation, even though there are monopoly periods in market, sum of consumer surpluses during study periods can be bigger than sum of consumer surpluses of continual Stackelberg equilibrium.

Proof

Let's consider the same numerical example which was presented in Proposition 4.5 where market demand function is $P(Q) = A - B_1 q_1 - B_2 q_2$ and each firm's profit function is $\pi_i = P(Q)\, q_i - c_i\, q_i - F_i$. If parameters are set as $A = 30,\ B_1 = 1,\ B_2 = 1,\ c_1 = 1,\ c_2 = 1,\ K_1 = 100,\ K_2 = 45,\ F_1 = 10,\ F_2 = 10,\ r = 3$, leader's dominant strategy is predatory pricing and total product output in market can be got as $Q_1 = 27.94,\ Q_2 = 27.97,\ Q_3 = 28.00,\ Q_4 = 28.02,\ Q_5 = 28.05,\ Q_6 = 14.5,\ Q_7 = 14.5,\ Q_8 = 14.5,\ Q_9 = 14.5,\ Q_{10} = 14.5$. On the other hand, if leader and follower chooses Stackelberg equilibrium then total output will be $Q_1 = 21.75,\ Q_2 = 21.75,\ Q_3 = 21.75,\ Q_4 = 21.75,\ Q_5 = 21.75,\ Q_6 = 21.75,\ Q_7 = 21.75,\ Q_8 = 21.75,\ Q_9 = 21.75,\ Q_{10} = 21.75$. Because consumer surplus is defined as $\int_0^Q P(Q)dQ - P(Q)\times Q$, total consumer surplus of study periods can be got by using summation, $\sum_{i=0}^{T}\int_0^{Q_i} P(Q_i)dQ - P(Q_i)\times Q_i$. Thus, total consumer surplus of predatory pricing case is 4970.1 and that of continual Stackelberg equilibrium is 4730.6. The former is bigger than the latter. ■

This proposition shows that predatory pricing can be seemed to contribute to consumer surplus during periods of leader firm's predation in modified game structure. During predation periods, consumer can enjoy better surplus by leader's overproducing and low product price. In this situation, since government's restriction on predatory pricing could be reduce consumer surplus in the short term, authority's efforts to prohibit firms from committing restricting competition policy could face great difficulties by consumers. However, these regulations always benefit consumer since production output of Stackelberg equilibrium is bigger than that of monopoly output when considering additional periods after study periods.

4.3 Numerical Analysis

Several scenarios were studied in this chapter to evaluate proposed multi-period Stackelberg-predation model. For constituting numerical examples, linear market demand function with homogeneous good condition($P(Q) = A - B_1 q_1 - B_2 q_2$) was assumed. The profit function of each firm was defined as $\pi_i = P(Q) q_i - c_i q_i - F_i$ where subscript i stands for player i, c_i stands for player i's variable cost and F_i stands for player i's fixed cost at each game period. To get optimal solutions of numerical examples, computer application XPRESS were used as solver. Most of all, all scenarios were solved based on modified game problem suggested in chapter 3.2. However, it is going to be shown that this modified game's solution eventually informs the equilibrium concept about original game which was suggested in chapter 3.1.

Table 4.1: Parameters of each scenarios

Case No.	Case name	Capital(K_1)	Capital(K_2)	Variable cost(c_1)	Variable cost(c_2)	Fixed cost(F_1)	Fixed cost(F_2)	Interest rate(r)	Study period(T)
1	Reference	200	45	1	1	10	10	3	10
2	Low-tech follower	200	45	1	3.5	10	10	3	10
3	Low-tech leader	200	45	3.5	1	10	10	3	10
4	Low-capital leader	100	45	1	1	10	10	3	10
5	High-capital follower	200	100	1	1	10	10	3	10

Scenarios were composed of five different cases like above as Reference case, Low-tech follower case, Low-tech leader case, Low-capital leader case, and High-capital follower case. As it is shown, all cases had same market interest rate of 3 percent, same study period of 10 years, and equivalent fixed costs of 10 for each player. Especially, all of scenarios were studied under same potential demand coefficient($A = 30$) and same product differentiation coefficient($B_1 = 1, B_2 = 1$). In scenarios, Low-tech means having high variable cost; that is, a player has to use a lot more resources in making product than reference case. High capital means player has high capital endowment level compared to reference case and low capital stands for low capital endowment in similar way.

4.3.1 Reference Case

Profit function of firm 1(leader) and firm 2(follower) can be shown as below. Because the problem is based on Stackelberg game, each player's profit function totally depends on leader's output that's because in the modified game structure, follower has no other way but to adjust its production quantity based on leader's output and its best response function at any periods. In ordinary multi-period Stackelberg game or one-shot game, leader would choose the quantity which maximize its own profit such as the highest point on the concave profit curve. For example, on the Figure 4.2, that point would be $q_1 = 14.5$. This production output gives quite good profit in terms of short-term profits to leader. However, when it comes to long-term profit, leader can speculate on the possibilities of implementing predation.

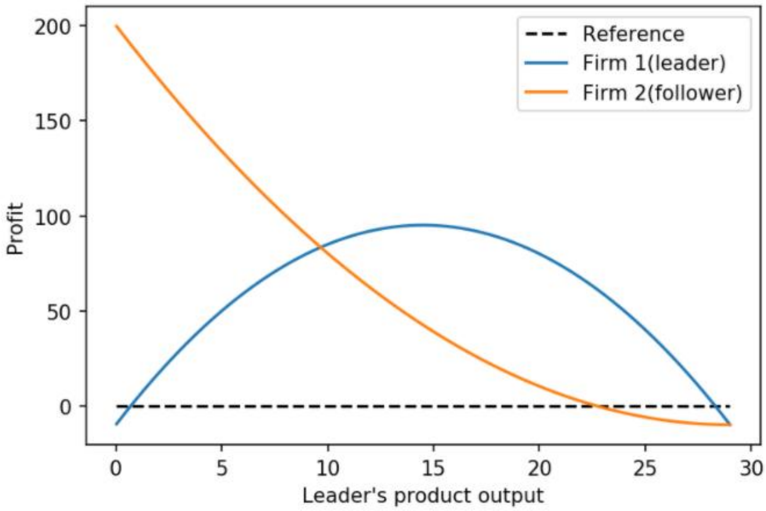

Figure 4.2: Profit functions of each player in reference case

To check whether predation strategy is dominant or not, leader should check the profit structure such as in which output region its opponent's profit become negative. According to the Figure 4.3, leader doesn't have big risk of capital loss in most of the production output range; that is, most parts of leader's profit function are in above zero-axis line. That is, leader can attack follower in large range of production output without big risk of going bankrupt by itself in getting the follower out of market in this parameter scenario.

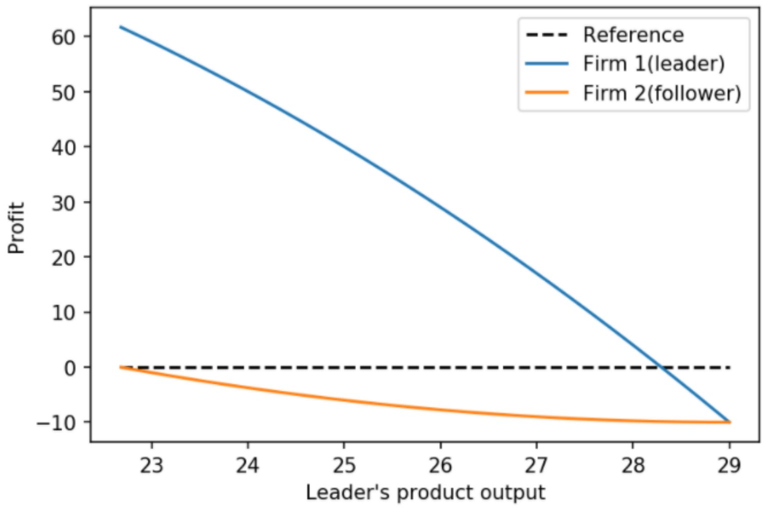

Figure 4.3: Magnified profit functions of each player in reference case

According to Figure 4.4, leader can successfully implement predation strategy. During early five periods leader earned inferior profits rather than Stackelberg equilibrium. However, after expelling the follower at game period 5, leader can take up all market as a monopoly supplier and recoup its profits by marking up. Ultimately when it becomes period 10, predatory pricing strategy turns out giving better total profit than continual Stackelberg case.

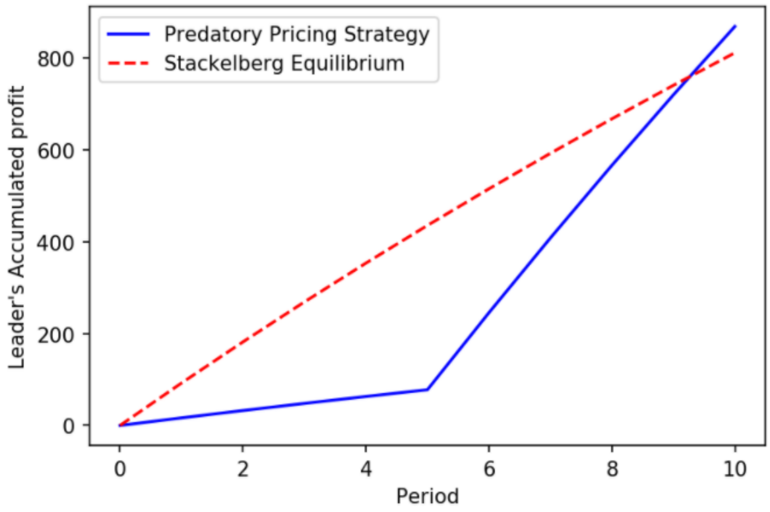

Figure 4.4: Accumulated profit function in reference case

At next, Net Present Value profile of Stackelberg-predation game was found. Figure 4.5 was got by slightly different approach with figure 4.4. Consider the situation where leader produce same amount of output during periods of predatory pricing. If leader can make follower out of market in this way, it earns monopoly profits after follower's liquidation. The Net Present Value(NPV) obtained through this approach is inferior than that of optimal output set of predation and surely has gap with optimal solution which can be obtained by optimization application such as XPRESS because leader doesn't adjust its output at each period but to produce same amount of output at predation periods. However, if solutions obtained by this method and optimal solution obtained by the optimization computer program are compared with this non-adjusted predation strategy's NPV, it shows that there is no significant difference in solution result. Thus, this method gives useful information about solution structure.

For example, optimal output set in this scenario is $q^*_{1,1} = 26.90, q^*_{1,2} = 26.95$, $q^*_{1,3} = 27.00$, $q^*_{1,4} = 27.05$, $q^*_{1,5} = 27.10$, $q^*_{1,6} = 14.50$, $q^*_{1,7} = 14.50$, $q^*_{1,8} = 14.50$, $q^*_{1,9} = 14.50$, $q^*_{1,10} = 14.50$ and NPV of optimal output set is 869.03. On the other hands, non-adjusted predatory pricing strategy's optimal output set is $q_{1,1} = 27.00$, $q_{1,2} = 27.00$, $q_{1,3} = 27.00$, $q_{1,4} = 27.00$, $q_{1,5} = 27.00$, $q_{1,6} = 14.50$ $q_{1,7} = 14.50$, $q_{1,8} = 14.50$, $q_{1,9} = 14.50$, $q_{1,10} = 14.50$ and NPV of this method is 868.86. The difference between optimal NPV and alternative method's NPV is less than 0.01%. Continual Stackelberg equilibrium's NPV is 811.44. Therefore, by this alternative approach it can be easily found whether predation strategy is dominant strategy for leader and Figure 4.5 below shows the plotted result of this alternative approach.

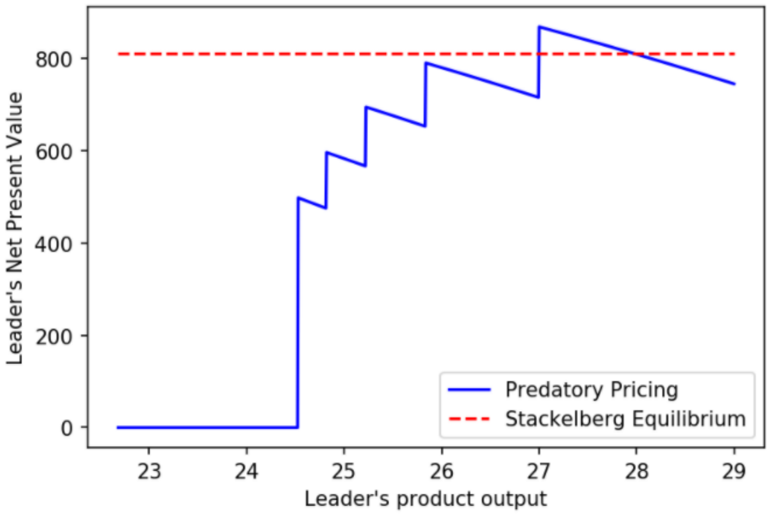

Figure 4.5: Net present value profile in reference case

In figure 4.5, dotted line is for showing NPV of continual Stackelberg equilibrium of total study period and solid line is for NPV of alternative or non-adjusted predation strategy. For example, the point where x-axis value is $q_1 = 27.00$

means total net present value of profits of predation periods and monopoly periods. That is, Figure 4.5 graph's y-axis value stands for sum of NPV of predation profits occurred during early periods by producing same output level of $q_1 = 27.00$ and sum of monopoly profits occurred during later periods by producing monopoly output level of $q_1^M = 14.5$.

In some range profits were plotted as zero because in that range of product output it is impossible to get the follower out of market within study period because follower's capital losses are too small in that output range. In that case, if leader wants to expel opponent within study period, it should implement aggressive predation strategy, or aggressive over-producing. If the solid line is taken look at from left to right direction, it can be found that there are vertical kinked points on the middle of the graph. These kinked points inform us that follower's bankruptcy period can be changed according to leader's output level during predation periods. That is, the more a leader overproduces in the market, the sooner his followers will be expelled from the market. This kinked point also informs that just aggressively overproducing a lot does not improve the leader's NPV especially as far as alternative predation strategy concerned. For example, after follower's bankruptcy period has just been changed, it doesn't help to slightly increase production outputs during predation periods in terms of economic point of view. This is because, while follower is prearranged to go bankrupt in a certain period, increasing production would only reduce leader's NPV.

Next, the important thing in this graph is that there is production range which is economically better than continual Stackelberg equilibrium. Therefore, by checking Figure 4.5 it can be easily found that there must be global optimal predation strategy output set in this parameter setting because even non-adjusted predation shows better NPV in some production output region.

In conclusion, by using Figure 4.4 or Figure 4.5, it is concluded that in this parameter setting predation strategy is dominant for leader especially in modified game. When it comes to original game where follower has option to leave out or give up entering the market at each game period, leader's optimal strategy is implementing predatory pricing whenever follower enters the market and follower's optimal strategy is not-entering the market at all and this strategy set of each player, (predation, not-entering) is equilibrium in this case.

4.3.2 Low-tech Follower Case

In low-tech follower case, numerical example when follower has relatively big variable cost, or inferior production technology, was studied. Figure 4.6 shows profit functions of leader and follower over every possible production output of leader. As suggested in chapter 4.3.1, leader will choose the output quantity point which maximize the concave-shaped profit function when there is no possibility of predation. But in this model predation can be technically possible, leader should take a closer look at the output range where its opponent's profit goes negative as in Figure 4.7. The singularity in low-tech follower case is that leader can implement predatory pricing strategy without having any risk of going bankrupt. This means leader is in advantageous position on implementing predation. Thus, if there are any predation output set which provide better NPV than Stackelberg equilibrium, predation strategy will be dominant strategy.

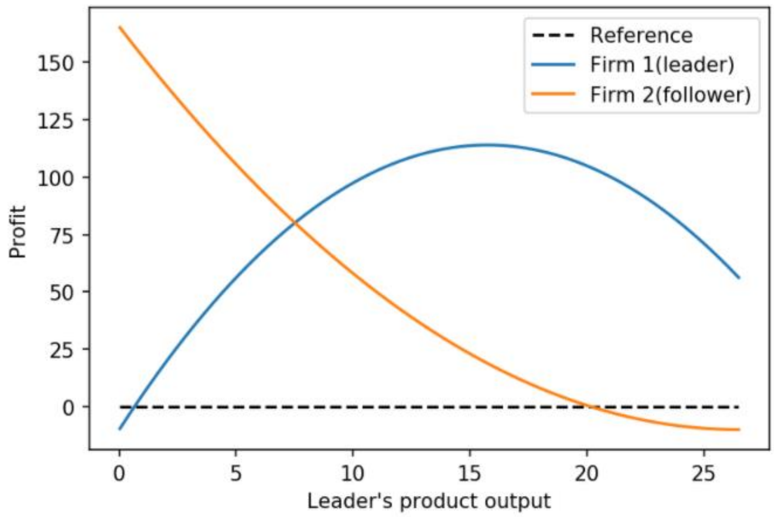

Figure 4.6: Profit functions of each player in low-tech follower case

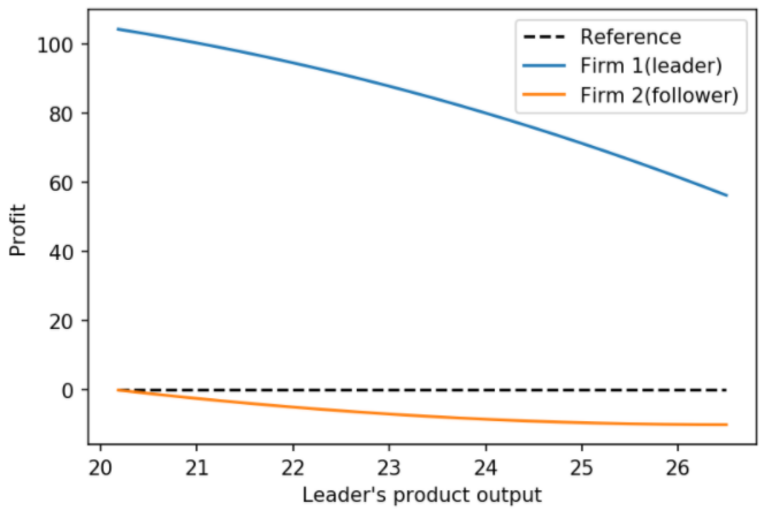

Figure 4.7: Magnified profit functions of each player in low-tech follower case

As it is shown in Figure 4.8, follower makes products until period 5 and goes bankrupt by leader after that period in this parameter setting. And carrying out predation is economically better than having continual Stackelberg profits during study period. Because leader can attack follower without any deficits, the gap between accumulated Stackelberg profits and accumulated predation profits are not very large until period 5 as Figure 4.8 below. And this difference is clear when the graph on Figure4.8 is compared with Figure 4.4 in reference case. Also, this scenario's payback period is shorter than reference case.

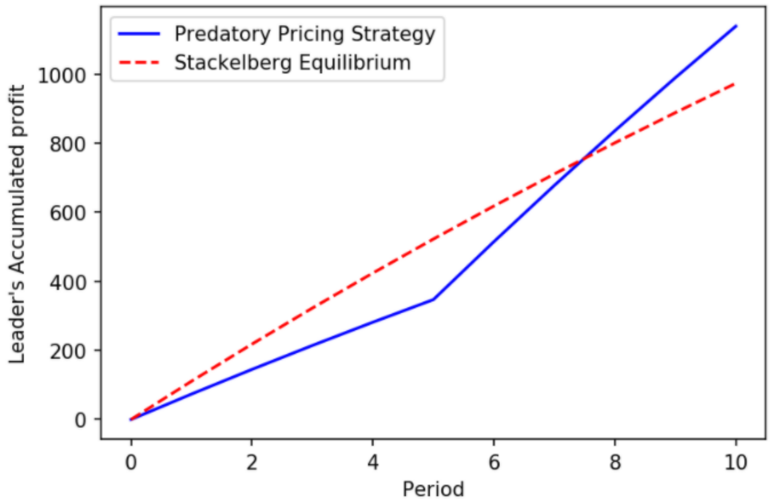

Figure 4.8: Accumulated profit function in low-tech follower case

Figure 4.9 shows that the leader is in a very advantageous position for predatory pricing. Compared to reference case, Figure 4.9 also shows that leader has a wider range of predation-possible product output which provide better profits than accommodate, or Stackelberg, profits. Thus, it can be inferred that the maximum NPV through optimal predation strategy would be also larger than reference case.

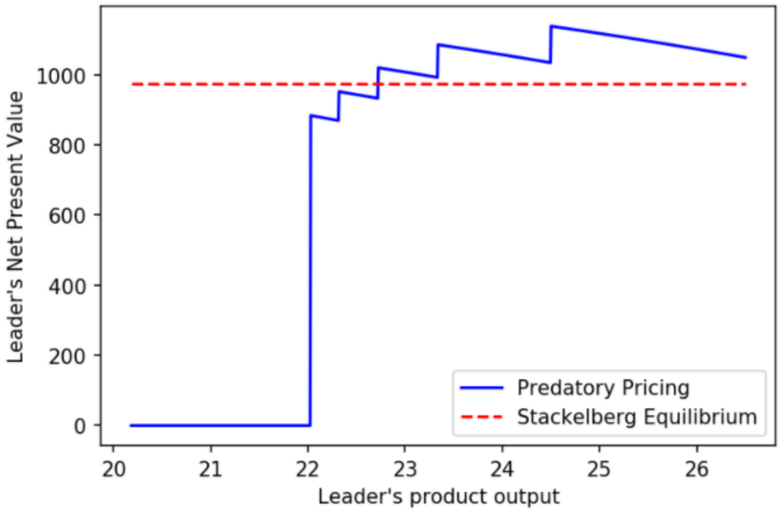

Figure 4.9: Net present value profile in low-tech follower case

Optimal output set in this scenario is $q^*_{1,1} = 24.40, q^*_{1,2} = 24.45,\ q^*_{1,3} = 24.50,$ $q^*_{1,4} = 24.55,\ q^*_{1,5} = 24.60,\ q^*_{1,6} = 14.50,\ q^*_{1,7} = 14.50,\ q^*_{1,8} = 14.50,\ q^*_{1,9} = 14.50,$ $q^*_{1,10} = 14.50$ and NPV of optimal output set is 1138.06. Non-adjusted predatory pricing strategy's optimal output set is $q_{1,1} = 24.50,\ q_{1,2} = 24.50,\ q_{1,3} = 24.50,$ $q_{1,4} = 24.50,\ q_{1,5} = 24.50,\ q_{1,6} = 14.50,\ q_{1,7} = 14.50,\ q_{1,8} = 14.50,\ q_{1,9} = 14.50,$ $q_{1,10} = 14.50$ and NPV of this method is 1137.94. Continual Stackelberg equilibrium's NPV is 972.71.

Therefore, in this scenario predatory pricing is dominant strategy for leader in modified game. As far as original game concerned, leader's predation whenever follower enter the market and follower's not-entering the market at all is optimal strategy; that is (predation, not-entering) is equilibrium.

4.3.3 Low-tech Leader case

The case where leader has relatively big variable cost was studied in this chapter. Figure 4.10 shows the whole profit functions of leader and follower over possible production output range. Figure 4.11 is magnified profit function where follower's profit goes negative. According to Figure 4.11, leader is in disadvantageous position contrary to above 'low-tech follower case' and 'reference case'. In most of production output range for predation, leader have to bear relatively big deficit. Thus, it can be inferred that implementing predatory pricing requires somewhat big capital for leader in this case.

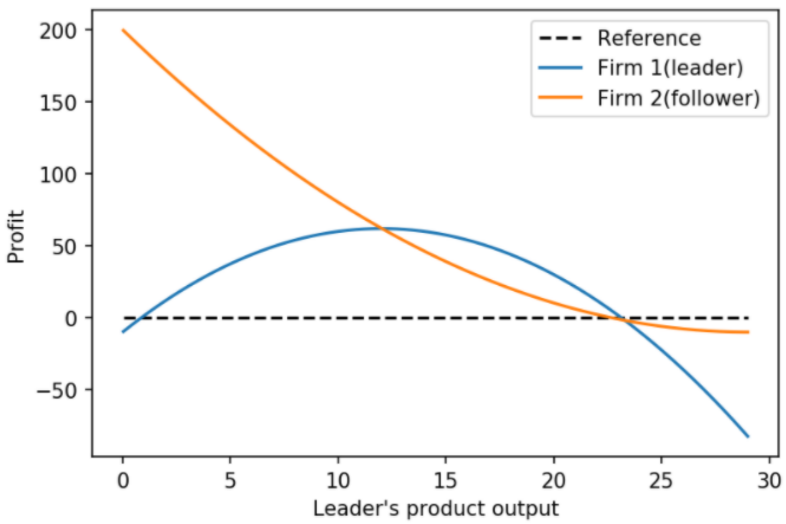

Figure 4.10: Profit functions of each player in low-tech leader case

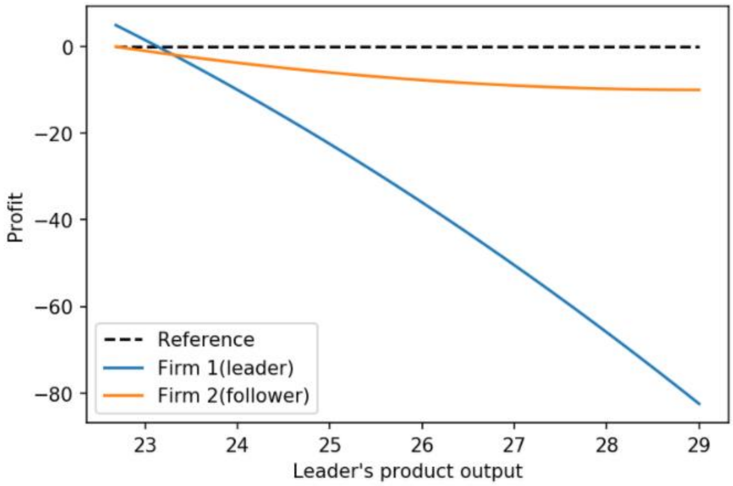

Figure 4.11: Magnified profit functions of each player in low-tech leader case

According to Figure 4.12 predation doesn't give better accumulated profit in this case. Even though predation is possible by attacking its opponent until 7 periods, it is impossible to recoup the deficits incurred in predation periods. It also means there is no pay-back period in this example.

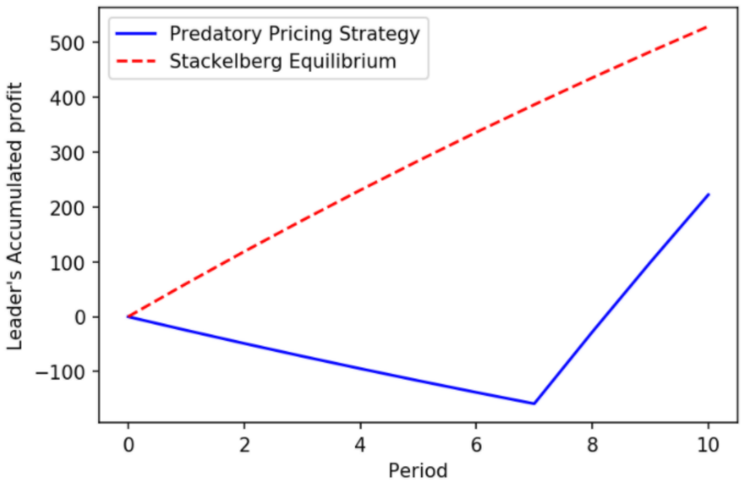

Figure 4.12: Accumulated profit function in low-tech leader case

Figure 4.13 below shows once again that there is no profitable predation strategy set. Of course, Figure 4.13 below doesn't provide accurate NPV of predation strategy. However, it is already suggested that difference between NPV derived from optimal solution and NPV from alternative method(same output during predation period) is not that big. Thus, conclusion that predatory pricing isn't dominant strategy in this case can be obtained from Figure 4.13.

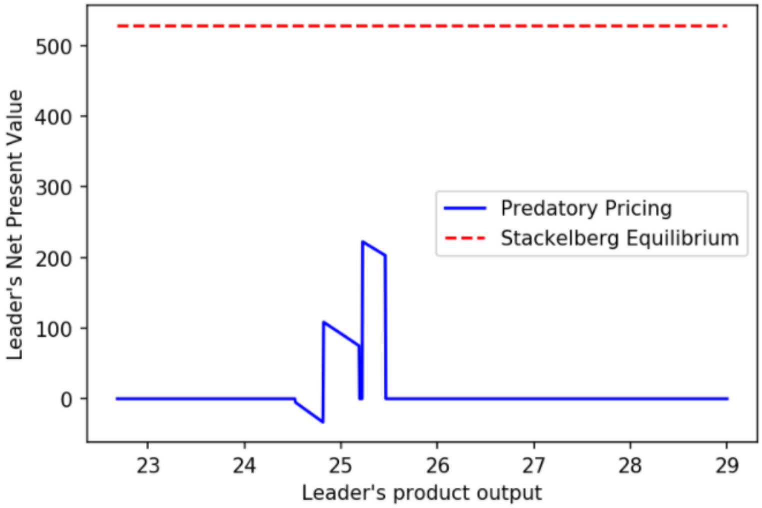

Figure 4.13: Net present value profile in low-tech leader case

Output set which make leader's profit maximum in this scenario is $q_{1,1} = 24.96$, $q_{1,2} = 24.45$, $q_{1,3} = 25.05$, $q_{1,4} = 24.14$, $q_{1,5} = 25.31$, $q_{1,6} = 25.40$, $q_{1,7} = 25.48$, $q_{1,8} = 14.50$, $q_{1,9} = 14.50$, $q_{1,10} = 14.50$ and NPV of this output set is 223.05. Non-adjusted predatory pricing strategy's output set which provides biggest NPV is $q_{1,1} = 25.22$, $q_{1,2} = 25.22$, $q_{1,3} = 25.22$, $q_{1,4} = 25.22$, $q_{1,5} = 25.22$, $q_{1,6} = 25.22$, $q_{1,7} = 25.22$, $q_{1,8} = 14.50$, $q_{1,9} = 14.50$, $q_{1,10} = 14.50$ and NPV of this method is 222.28. And, continual Stackelberg equilibrium's NPV is 528.87.

Strictly saying, these predatory pricing output set isn't satisfying constraint (3.12) in chapter 3.2 because NPV is inferior to NPV of continual Stackelberg equilibrium.

In this scenario, accomodation is dominant strategy for leader in modified game. Therefore, leader's accomodation when follower enters the market and follower's entering the market are each player's optimal strategy; that is, (accomodation, entering) is equilibrium in this case. Thus if leader implements predatory pricing after follower enters the market, follower will interpret this leader's predation policy as non-credible threat and it will continually remain in the market.

4.3.4 Low-capital Leader Case

Difference between reference case and this 'low-capital leader case' is that in this case leader has less capital than reference case. That is, profit functions profile of each player is exactly same with reference case. In this case, leader have to carefully ponder over capital loss in implementing predation because less capital means high risk of bankruptcy for leader.

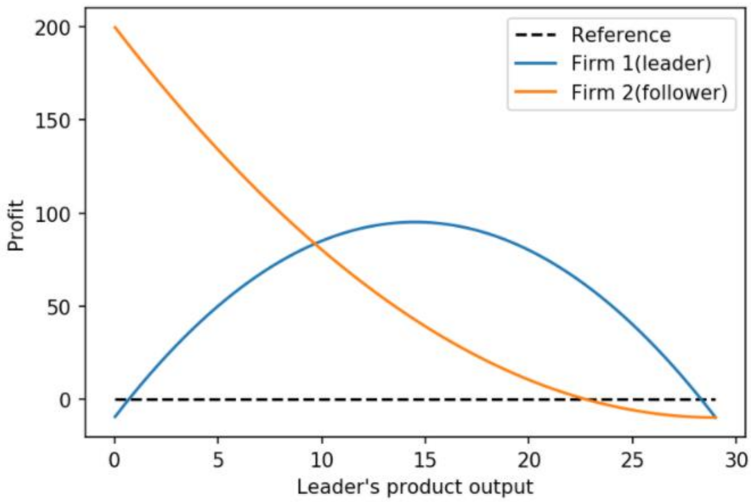

Figure 4.14: Profit functions of each player in low-capital leader case

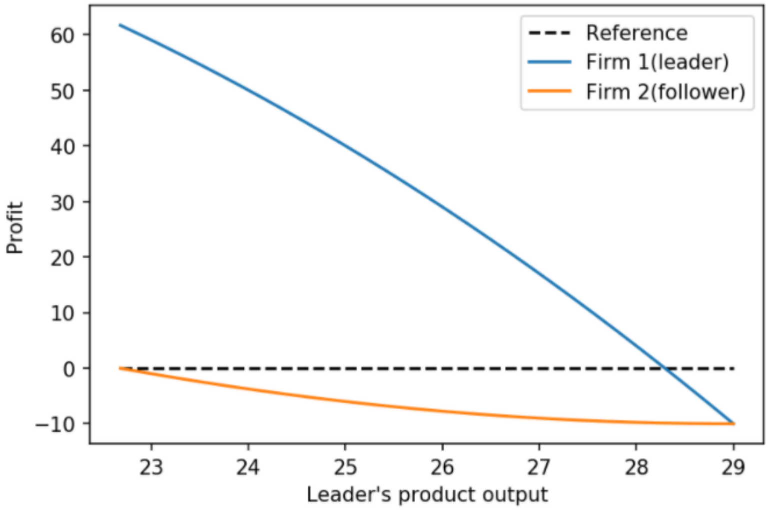

Figure 4.15: Magnified profit functions of each player in low-capital leader case

As shown in Figure 4.16 there is optimal predation output set which provide better long-term profit without experience of deficit, or capital loss.

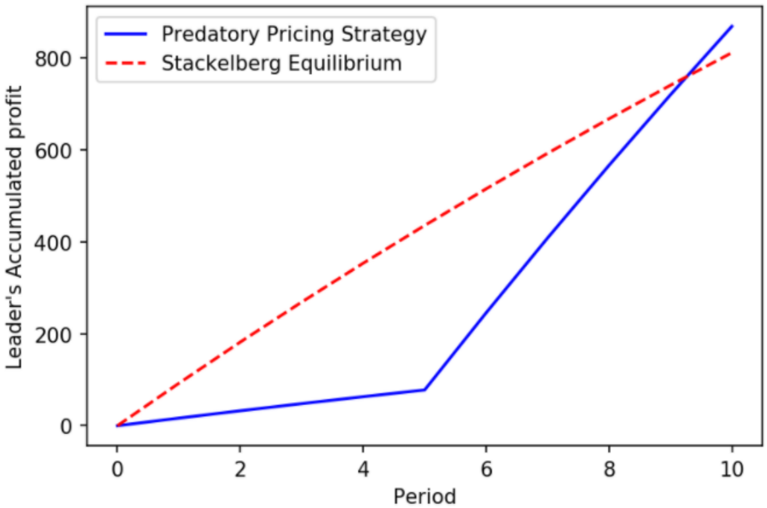

Figure 4.16: Accumulated profit function in low-capital leader case

Figure 4.17 below is same with that of reference case; that is, Figure 4.5. It means that even though leader has lower capital endowment level than reference case, certain amount of capital reduction may not influence the whole game structure.

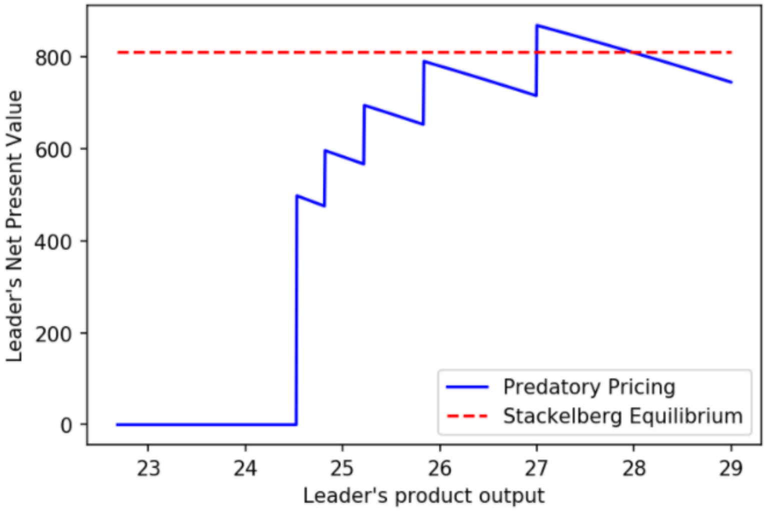

Figure 4.17: Net present value profile in low-capital leader case

Optimal output set in this scenario is $q^*_{1,1} = 26.90, q^*_{1,2} = 26.95$, $q^*_{1,3} = 27.00$, $q^*_{1,4} = 27.05$, $q^*_{1,5} = 27.10$, $q^*_{1,6} = 14.50$, $q^*_{1,7} = 14.50$, $q^*_{1,8} = 14.50$, $q^*_{1,9} = 14.50$, $q^*_{1,10} = 14.50$ and NPV of optimal output set is 869.03. Non-adjusted predatory pricing strategy's optimal output set is $q_{1,1} = 27.00$, $q_{1,2} = 27.00$, $q_{1,3} = 27.00$, $q_{1,4} = 27.00$, $q_{1,5} = 27.00$, $q_{1,6} = 14.50$ $q_{1,7} = 14.50$, $q_{1,8} = 14.50$, $q_{1,9} = 14.50$, $q_{1,10} = 14.50$ and NPV of this method is 868.86. Continual Stackelberg equilibrium's NPV is 811.44. As mentioned above, the whole optimal output set is same with reference case. Therefore, predatory pricing is dominant strategy for leader in terms of modified game. When it comes to original game, leader's predation whenever follower enter the market and follower's not-entering the market composes equilibrium; that is, (predatory pricing, not-entering) is equilibrium in this parameter setting.

4.3.5 High-capital Follower Case

The case where follower had quite large capital endowment level was analyzed in this numerical case. Because every parameter is same with reference case except follower's capital endowment level, the graph of profit function is also identical with reference case as shown Figure 4.18 and Figure 4.19 below.

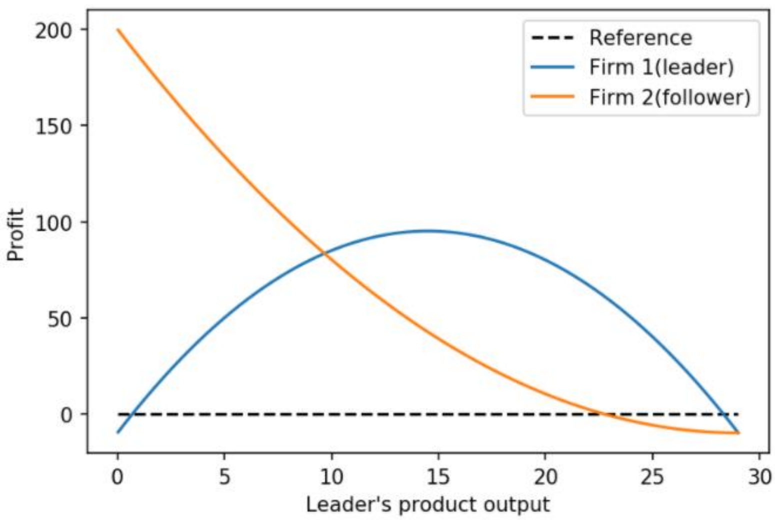

Figure 4.18: Profit functions of each player in high-capital follower case

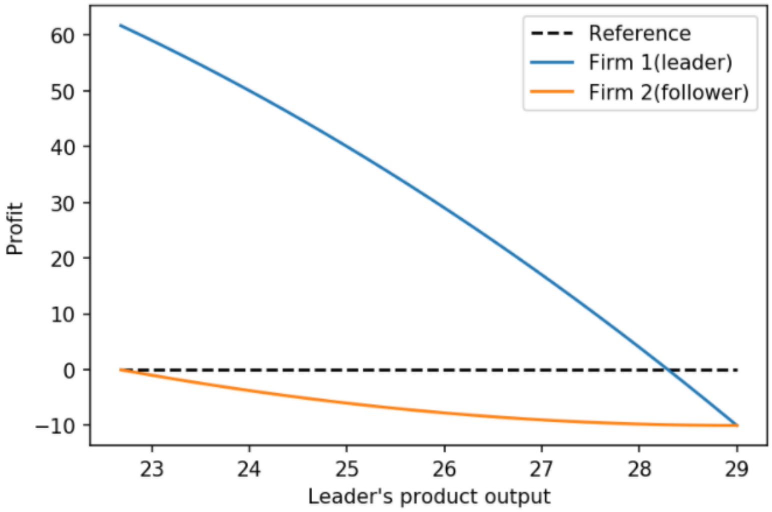

Figure 4.19: Magnified profit functions of each player in high-capital follower case

Even though profit function profile is same with reference case, follower's relatively big amount of endowment capital makes singular feature in this case. That is, leader cannot let follower out of market by predation because of follower's sufficient capital. Thus, it can be said that follower's capital plays a role as 'shield' against leader's predatory pricing in this case. If leader over-produce its product in this parameter setting, that predation will be interpreted as 'Non-credible threat' to follower. Figure 4.20 shows that leader's predation to take up all market is impossible once again.

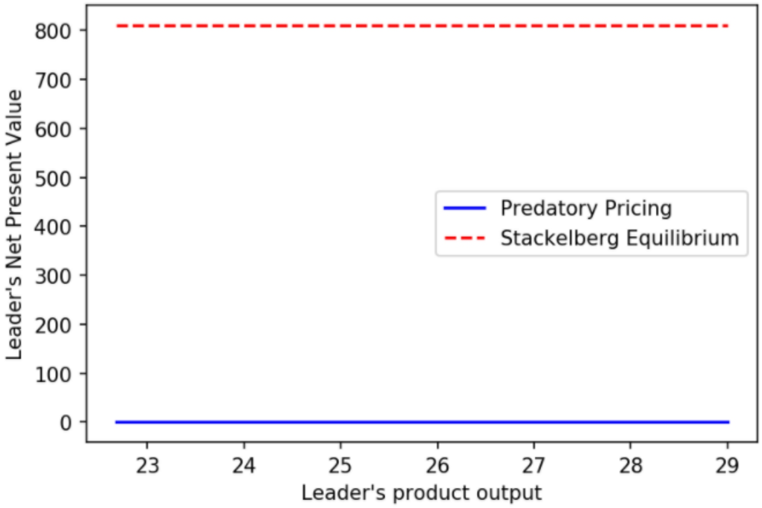

Figure 4.20: Net present value prfile in high-capital follower case

Since leader cannot predate follower at all in this case, there are no optimal predation output set in modified game and also original game. Continual Stackelberg equilibrium's NPV is 811.44. And leader's dominant strategy is accommodation in modified game. When it comes to original game, leader's accomodation when follower enters the market and follower's entering the market is each player's optimal strategy; that is, (accomodation, entering) is each player's equilibrium strategy in this case.

4.3.6 Implications

From numerical analysis results, some implications can be derived as follows. At first, how much endowment capital each agent has plays an important role in whether predatory pricing will occur or not in the market. Especially, relative ratio of each agent's endowment capital is more important in predicting the possibility of predatory pricing occurrence than merely absolute amount of each agent's capital level. For leader, having relatively a lot of endowment capital means it can over-produce aggressively in a certain period and it also can make leader continually attack its opponent over relatively long periods. On the other hands, follower's relatively big amount of endowment capital could act as a shield to protect follower from confronting predation. When follower has a lot of capital, the leader cannot easily attack him. Second, each firm's technology parameters like c_1, c_2, F_1, F_2 also play an important role in predicting occurrence of predation, because these technology factors influence how much each firm earns or losses while the game progress between firms. In other words, how much endowment capital each agent has can be assessed by these technology factors. In other words, even though a firm has lots of endowment capital in terms of absolute amount, the firm can be in vulnerable position to predation if the agent's variable cost and fixed cost are inferior, or high.

Chapter 5

Conclusion

Predatory pricing model was constituted in this thesis by applying concept of capital endowment level and condition of banktrupcy to multi-period Stackelberg model. After constituting predation model, properties that this model had were studied such as the relationship between each firm's relative capital ratio and possibility of predatory pricing. Particularly, unique approach this thesis proposed was two-step analysis; 'Original game' which had quite complex characteristics was solved by quite simply defining and solving 'Modified model or Modified game'.

In this thesis original game was basically squnetial Stackelberg game between leader and follower, but each of player has capital endowment level and follower has option to leave out the market at each period. Modified model is simplified version of original game where follower has no option to leave out the market so it has to run business if it is not going bankrupt. This modified game's solution gives each player useful information about which strategy is optimal for leader in original game. In this regard, equilibrium of original game can be found by solving modified model. Since this modified game's solution provides a clue to finding equilibrium of original game, most of the paper in this thesis was assigned to solving the problem of modified game.

This modified game can be seemed to be a merely tool for solving original predatory pricing game in this thesis, but this kinds of market competitions in the situation of modified game are often occuring in real market. For example, most of shale oil companies which are mentioned in introduction chapter were in the situation of modified game structure as follower firm rather than that of original game; that is, they already entered the crude oil market raher than pondering about entering before starting a business. After entering, most of shale oil companies were liquidated or went bankrupt. On the surface, the reason why most of shale oil companies went bankrupt was predatory pricing of existing oil companies which had market power and market influence. But fundamentally, most of shale oil companies had not taken into account the risk of predation. Had there been an economic model to quantify the risk of predatory pricing, most shale companies would have been more cautious about entering the market. However, there are few economic models that can assess the risk of predatory pricing and shale oil industry merely seemed to be blinded by high crude oil price at that time. In this regard, the model presented in this thesis can help firms assess the risk of predatory pricing.

In this thesis, predatory pricing model that can occur between large companies with market power and small companies with weak market power was constituted. For further study, different types of predation model could be modeled by using exsiting competition model. For example, it would be possible to create a predatory pricing model that could occur between companies with similar size and market power using existing models such as the Cournot model. In this way, just applying the concept of endowment capital and condition of player's bankruptcy to any other existing competitive model would be simple and effectvie way to constitute predatory pricing model and this application to existing model could be a means to reinforce the concept of equilibrium that existing game models have showing exactly when the equilibrium holds.

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국문초록

기업들이 보유하고 있는 자본의 양은 그 기업들이 속한 시장에서 약탈적 가격책정 상황의 발생 가능성에 대한 예측력 있는 정보를 제공할 수 있다. 특정 시장 참가자가 과잉생산을 통해 모든 시장 참가자들에게 이윤 측면에서 불리한 상황을 의도적으로 형성한 뒤 수익성이 떨어지거나 적자인 상황을 버티지 못하고 시장에서 퇴출되는 시장 참가자가 생기면 제품의 과잉생산이나 약탈가격책정을 중단하고 이전보다 많은 이익을 향유하는 것이 약탈적 가격책정 전략의 핵심이라면, 특정 기업에게 이러한 전략을 가능하게 하는 것은 의도적으로 모든 시장참가자에게 불리한 상황을 발생시키고, 그리고 그 상황에서 견딜 수 있는 능력이 있는가 하는 점이다. 즉, 어떤 기업이 시장지배력이 있는지 그리고 충분한 양의 자본을 보유하고 있는지에 대한 정보는 약탈적 가격책정의 발생 가능성을 예측하는데 좋은 정보가 되며 이는 기존 약탈적 가격책정이 발생한 사례의 분석을 통해서도 확인할 수 있다. 이에 따라 본 논문에서는 시장지배력의 유무에 대한 개념을 포괄하고 있는 슈타켈버그 게임에 부존 자본량이라는 개념을 접목하여 약탈적 가격책정 모델을 구성하였다. 자본량이라는 개념을 토대로 약탈적 가격책정 모델을 구성한 기존의 모델이나 연구가 거의 없는 현 상황에서 본 논문에서 제안하는 모델은 시장 지배력을 이미 가지고 있는 기업이나 어떤 시장에 진입하기를 고민하는 기업 그리고 특정 시장의 구조를 분석하고자 하는 모든 이에게 약탈적 가격책정과 관련된 양질의 정보를 제공할 수 있을 것이다.

주요어: 약탈적 가격책정, 약탈 전략, 부존 자본량, 자본 기반 약탈적 가격책정 모델, 다기간 슈타켈버그 게임

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