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博 士 論 文

平成 27 年 12 月

神戸大学大学院経済学研究科

経済学専攻

指導教員 柳川隆

生田祐介

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(独占的な市場における公平な競争のための構造規制)

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Introduction

Purpose of this study

In various industries or markets, to say nothing when a market is monopoly, even though when a market is oligopoly, there exists a dominant firm. Dominant firm may exert market power in the market where it is active or may give market power to its adjacent markets. Then, the behavior results in harming fair competition. This thesis aims to study whether or how structural regulation is needed for markets where a dominant firm exists. In particular, the thesis focuses on a dominant firm in the context of vertical relationship in industry.

We can consider structural regulation in various settings. First one is the case where rival firms exist against a dominant firm. If the rivals take any behaviors, the competition may work well in the market. On the other hand, if anti-competitive effect can happen after that, regulation on the rival's behaviors are needed. Second one is the case that even if the rival firms are active in the market, fair competition can be detrimental because the rivals cannot improve their productive efficiencies by themselves. Efficiency gap between an incumbent and entrants can be a matter in liberalized market. Third one is the case of natural monopoly, where rival firms do not exist. The industry of natural monopoly has problems that what regulation is needed on price or behavior of monopolistic unit and that how vertical structure of the industry should be reformed. While there is a lot of study for above issues, it remains important problems ought to be reconsidered by adding significant data which has been ignored or modifying model settings. This thesis investigates three issues picked up above by supposing specific cases empirically and theoretically. Next, I explain the structure of thesis for each chapter.

Structure of thesis

This thesis is consists of three chapters. Chapter 1 is the empirical analysis on a horizontal merger case in Japanese steel industry. Chapter 2 theoretically examines the effects of ownership structures of nuclear power plants on fair competition and total output. Chapter 3 compares theoretically two patterns of vertical form of the industry where essential input is monopolistically supplied to downstream competing firms. I explain each chapter in detail as follow.

Chapter 1, related with the case where a dominant firm and its rival firms are competing, estimates the effect of the NKK and Kawasaki Steel merger in Japanese steel industry; NKK and Kawasaki Steel are the rival firms to a dominant firm, Nippon steel. Before the merger, Nippon steel supplied the output of crude steel is approximately twice as much as NKK and Kawasaki Steel by each. After the merger, the output of crude steel supplied by the merging firm rose to be comparable to the output supplied by Nippon steel. The estimation methodology is a conventional event study by

using stock returns data for each firm. The NKK and Kawasaki Steel merger is also studied by [Yanagida \(2011\)](#). While she focuses a subject of the investigation on only the merging firm and its rival firms, this chapter also focuses on customer firms. In this context, the customer firms are those who buy steel products as an input from the upstream merging firm and its rivals. The reason why we also focus on the customer firms is that to estimate if the merger is for anti-competitive or efficiency gain, following [Williamson \(1968\)](#) points out. As a result, as far as focusing on the abnormal stock returns to the merging firm and the rivals, the merger seems to be anti-competitive. However, taking into account of the abnormal returns to the customer firms and the transition of the price of steel product upstream, we conclude that the merger can be for efficiency gain.

Chapter 2 is related with the case where the rival firms cannot reduce the gap by themselves in productive efficiencies between the rivals and a dominant incumbent firm. Specifically, liberalized electricity market is assumed in this study. In France, the incumbent, EDF has been owned nuclear power plants exclusively since before the introducing of competition to the electricity retail market. Because nuclear power plants are operated in lower marginal cost, the entrant rivals without holding nuclear power plants could not become rivalry with the EDF. This situation was to be a matter of unfair competition. To tackle with the problem, France employed the policy that forces EDF to sell a portion of nuclear power at marginal cost to the rivals; the policy is called the NOME law. Referring a theoretical work by [Créti et al.\(2013\)](#), the NOME law is effective on expanding total output downstream. This chapter proposes public ownership; the idea is that taking nuclear power plants out of the incumbent to public firm upstream. We find under more realistic assumption that the NOME law is more desirable socially than public ownership and it also can benefit the incumbent's interest. Therefore, the NOME law has economic reasons rather than political compromise that public ownership is not employed.

Chapter 3 examines problems of vertically related industries consist of natural monopoly upstream and competitive downstream market. This vertical structure can be observed at various network industries: telecommunication, gas, electricity etc. and industries where scarce resources or patent licenses are sold to downstream firms. The upstream monopolist can not only exert market power in upstream market but also give market power to any downstream firms. There are mainly two strands of study for the issues of such industries, how to regulate a monopolist and how to design the vertical form. Chapter 3 focuses on the latter. When the upstream monopolist vertically integrates with a downstream firm, the integrated firm supplies the essential input to other downstream rivals and also supplies final goods/services to consumer in downstream market. Vertical integration is usually, as [Perry \(1989\)](#) summarizes, beneficial to not only the integrated firm but also consumers because it overcomes the double marginalization problem. It is said however that there are two anti-competitive concerns about the vertically integrated firm: sabotage (non-price

discrimination) and margin squeeze. To tackle with these potential issues, alternative vertical forms have been proposed by researchers and practitioners. Specifically, under the price for essential input is regulated, it is discussed with comparing vertical integration, legal unbundling and ownership separation. For instance, [Höfler and Kranz \(2011a\)](#) show that the total downstream output under legal unbundling can be larger than other forms. This is because the upstream monopolist does not have incentive to raise the downstream rival's cost when the essential input price is regulated constant exogenously. Chapter 3 shows as follow. If the upstream monopolist is unregulated, margin squeeze does happen but sabotage would not be taken when the downstream rival is more efficient, and then the rival can be active under vertical integration. Vertical integration outperforms legal unbundling in terms of total output and consumer surplus. Moreover, even when the downstream rival is foreclosed from the market, the result is maintained. Result obtained in Chapter 3 is opposite to current studies assuming regulated upstream monopolist.

The remainder of this thesis is constructed by each chapter. Chapter 1 is entitled "Analysis of the merger effect using the event study approach: Evidence from the steel industry in Japan". Chapter 2 is entitled "Ownership structure of nuclear power plants for fair competition and efficiency: The NOME law versus public ownership". Chapter 3 is entitled "Unregulated upstream monopolist in vertical structure: Vertical integration versus legal unbundling". In conclusion, I summarize the results obtained in each chapter and propose some ideas for future research.

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Chapter 1

Analysis of the merger effect using the event study approach:

Evidence from the steel industry in Japan

1.1. Introduction

Competition authorities regulate horizontal mergers ex ante and, along with corporate managers, seek to understand their effects. After being notified, they (e.g., the Japan Fair Trade Commission (JFTC) and the European Commission (EC)) have one month to decide whether a merger falls within their jurisdiction and whether it complies with regulations. This paper examines ways of determining, in advance, whether a merger will result in anticompetitive effects or production efficiency effects, by investigating the NKK and Kawasaki Steel merger in the Japanese steel industry, which was announced in April 2001 and completed in October 2002. The merged firms became the second-largest company in Japan and the third-largest company in the world in terms of quantity of crude steel production. As large mergers are likely to have large economic impacts, investigating this case can help in understanding the complex effects of mergers.¹

Williamson (1968) proposed that horizontal mergers involve a trade-off between production efficiency effects and anticompetitive effects. To consider the effects of mergers, I examine customers in vertical relationships with the merging firms. If steel prices decrease as a result of an efficiency gain, the customer firms in the steel industry would enjoy reduced steel input costs and would anticipate enhanced corporate valuation.² The JFTC and the EC evaluate each horizontal merger after notification, by verifying an efficiency-based consumer welfare standard.

We chose an event study approach for several reasons.³ In Japan, although merger notifications formally occur in advance, many planned mergers are announced via preliminary consultation prior to the official advance notification.⁴ The merger notification procedure is implemented within 30 days. The information used to judge mergers includes goods prices, production quantity, corporate

¹ The result of the NKK and Kawasaki Steel merger, JFE holdings, forecasted the following synergy effect in a corporate news release on April 13, 2001: “Building a solid business base by strengthening the capability to respond to global customer requirements.”

² As we explain in Section 1.2, customers’ steel procurement reforms, designed to strengthen customer firms, had begun before the merger, in Japan’s auto industry. This is considered to have strengthened the auto industry’s buying power relative to that of the steel industry.

³ Whinston’s (2006) and Davis and Garcés’ (2010) textbooks on antitrust economics and competition policy contain merger analyses using event studies. Whinston (2006) argues that event studies are particularly useful if they consider the mergers’ effects on customers.

⁴ In the United States and the European Union, merger plans are announced to the authorities in charge of competition policies in advance (i.e., prior to merger completion). See, for example, Kawahama (2008).

financial data, stock data, and surveys of firms with an interest in the merger. The merger of NKK and Kawasaki Steel was processed via preliminary consultation. We analyse the reactions of stock returns to merger announcements, including not only the merging and rival firms but also their customer firms.⁵

This study estimates abnormal returns based on four types of estimation windows, and examines three event windows with respect to each estimation window. We thus obtain results from twelve abnormal return patterns for each firm. In addition, we use a sampling of Japanese customer firms to further investigate the effects of the merger. The merger of NKK and Kawasaki Steel appears to yield an efficiency gain when we consider the event study results of customer firms.

The rest of this paper is organised as follows: Section 1.2 provides a timeline of events related to the merger of NKK and Kawasaki Steel. Section 1.3 surveys the relevant literature and proposes hypotheses. Section 1.4 describes our data sources and processes. Section 1.5 discusses the analysis methodology. Section 1.6 provides the results of the event study. Finally, Section 1.7 concludes this study.

1.2. Steel Industry in Japan

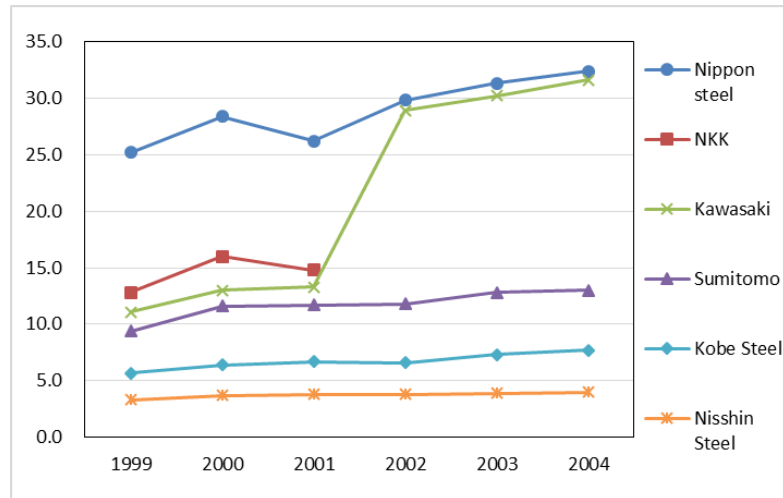
This section discusses news reported by *Nikkei* about the steel industry and its customer industries in Japan through April 2001, when Kawasaki Steel and NKK announced their merger.

- October 18, 1999. Nissan Motors announced its ‘Revival Plan’, which included selecting the cheapest steel suppliers to reduce costs.⁶
- April 7, 2000. NKK and Kawasaki Steel formed an alliance between their logistics and maintenance sections (excluding the production and sales sections) to counter the power of Nippon Steel.
- 2:00 PM, April 13, 2001. The CEOs of NKK and Kawasaki Steel announced that they would integrate their businesses and create a stock holding company, called ‘JFE Holdings’, with a jointly affiliated steel production unit. This substantial horizontal merger took place in October 2002.

⁵ Because merger guidelines recognize consumers as being not only final consumers but also intermediate consumers, this study examines steel-consuming customer firms.

⁶ Thus, the merger seems to have resulted in not only a production efficiency gain but also a stronger selling position to big steel consumers such as auto companies.

Figure 1-1: Crude steel output per firm (million metric tons)



Data source: Top Steel-Producing Companies, *World Steel Association*

Note: NKK is absent after 2002 because it merged with Kawasaki Steel.

Figure 1-1 shows the yearly change in the crude steel output of blast furnace firms in Japan. The merger of NKK and Kawasaki Steel increased their joint crude steel output in comparison Nippon Steel after the merger's completion in October 2002.

1.3. Related literature and hypotheses

This section reviews the related literature. Many US studies of horizontal mergers have successfully used the event study method. Eckbo (1983) and Stillman (1983), who examined the reactions of merging firms and their industry rivals, are representative. They argue that the positive abnormal returns enjoyed by merging and rival firms result from anticompetitive mergers, not efficiency gains. Mullin et al. (1995), using the event study method to analyse railroad companies as customer firms, argue that steel prices would decrease and railroad companies would increase their surplus if US Steel was dissolved.

Fee and Thomas (2004) and Shahrur (2005), using a large sample, examine the reactions of merging firms, their rivals, and their corporate customers and suppliers. Fee and Thomas (2004) and Shahrur (2005) find evidence about mergers that is inconsistent with collusion theory but consistent with buying power motivation. In particular, Shahrur (2005), using input-output tables to identify downstream industries, finds significant positive abnormal returns going to rivals, suppliers, and corporate customers. Thus, he suggests that the average takeover in his sample is driven by the efficiency objective.⁷

⁷ Along this line, Bhattacharya and Nain (2011) and Ahern (2012) also use large firm samples as well as event studies and performance studies. They are interested in the general interactions within supply chains

Utilizing stock price evidence, [Fridolfsson and Stennek \(2005, 2010\)](#) show the welfare effect of mergers in their theoretical study. While the anticompetitive effect can be identified immediately around the merger announcement date, the efficiency effect takes longer to emerge; thus, only the anticompetitive effect is reflected in stock value. These studies emphasise the importance of examining customer firms when analysing the impact of mergers on economic welfare.⁸

[Yanagida \(2011\)](#) reports that the merger between Kawasaki Steel and NKK was value enhancing for both the merging and rival firms.

The terms ‘anticompetitive effects’ and ‘production efficiency effects’ must be defined. In an anticompetitive effect, the merging and rival firms increase their profits by exerting market power and, thus, enjoy higher stock market valuations. Meanwhile, customer firms lose profits because of increased input costs and, thus, suffer lower stock market valuations.

The effect of production efficiency brought by mergers influence the customer firms in two ways. When economies of scale get larger, both the price of intermediate goods and the customer firms’ input costs fall; they increase, on the other hand, when economies of scale shrink.

An event study is an evaluation methodology that calculates abnormal stock returns in order to identify the reaction of stock market participants to unexpected events, such as merger and acquisition announcements. Event studies have conventionally assumed a semi-strong efficient stock market. This assumption carries three implications: First, stock market participants usually cannot arbitrage using public information. Second, new information is reflected in stock prices immediately and correctly. Third, stock market participants cannot avoid systematic risk, although they can avoid unsystematic risk by composing a portfolio. Thus, a firm’s stock price reflects its fundamental value, and changes in stock prices result from new information about a firm’s value. This paper follows the above assumptions.

Table 1-1, following [Shahrur \(2005\)](#), shows the anticompetitive and production efficiency effects relevant to the signs of the abnormal stock returns flowing to the merging firms, rival firms, and customer firms, as observed on the merger announcement date.

caused by horizontal mergers. They explain bargaining power, particularly buying power, as an outcome of horizontal mergers.

⁸ Duso et al. (2011) examine the effectiveness of merger control in the European Union, focusing on whether competition authorities deter anticompetitive mergers effectively.

Table 1-1: Signs of abnormal returns in merger announcement

	Merging firm	Rivals	Customers
Anticompetitive effect	Positive	Positive	Negative
Efficiency effect	Positive	Negative	Positive/Negative

1.4. Data

First, the event study approach requires an event date. In this study, the event date is defined as the merger announcement date (i.e., the day when stock market participants become sure of the merger). The *Nikkei* newspaper reports that the CEOs of Kawasaki Steel and NKK held a joint press conference on Friday April 13, 2001, at 2 PM to say that they would complete the merger by October 2002. Because the Tokyo Stock Market is open until 3 PM, information about the merger was first reflected in the stock values on that date. We, therefore, identify the event date as April 13, 2001.

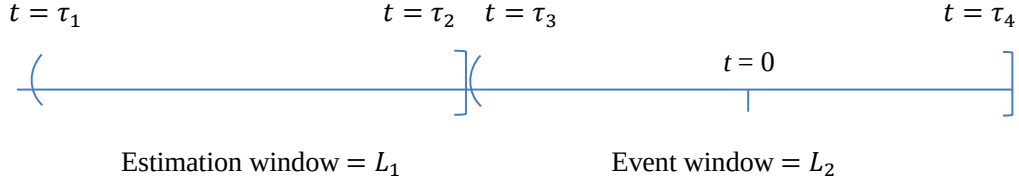
Stock price data were obtained from the Nikkei NEEDS Financial QUEST database. Every stock price we use in this study was selected from the Tokyo Stock Market First Section. The sample's data period spans from March 10, 2000, to May 16, 2001, for the firms' daily returns. The daily stock return for firm i at time t is defined as $R_{i,t} = (P_{i,t} - P_{i,t-1})/P_{i,t-1}$, where $P_{i,t}$ is the stock price at time t . We explain the key terms in this study below. The merging industry is the steel industry, consisting of blast furnace steelmakers in Japan. The merging firms under study are the acquiring firm, Kawasaki Steel, and the acquired firm, NKK. The horizontal rivals are all other firms in the merging firms' industry.

It is also important to identify the customer firms in the merging firms' industry.⁹ These have been drawn from the auto, shipbuilding, construction, and steel-processing industries; the latter firms consist of manufacturers of steel pipe, steel plate, and/or steel wire and are classified using the three-digit Nikkei Industry List Small Classification (NKILS) in Financial QUEST.

Their relevant classification code numbers are 17162 (for open-arc furnace/single steel process), 17163 (for special steel), and 1716 (for other steel metals), which correspond to the Japan Standard Industry Code 3 (JSIC3). We selected a maximum of 10 firms belonging to each industry using the market capitalization rank from the Tokyo Stock Market First Section.

⁹ In preparing this paper, I was asked about the size of each transaction. COSMOS, the database of Teikoku Data Bank, lists the names of the main customers but not the quantity of steel involved in the transaction. Therefore, I could not find detailed evidence of individual transactions.

Figure 1-2: Image of event study



There were six firms in the steel industry before the merger and five afterwards. There were ten customer firms in the auto industry, ten in the construction industry, eight in the steel-processing industries, and six in the shipbuilding industry.

1.5. Methodology

Following [McKinlay \(1997\)](#), we calculate the abnormal return around the announcement date, and its sign, and then test its statistical significance. We define the event date as the day when the stock market reacted to the information about the merger. We set the announcement date at April 13, 2001. We set four types of estimation windows, and three event windows with respect to each estimation window. In this regard, we examine the abnormal returns in twelve patterns. [Figure 1-2](#) presents the daily time interval used in this event study.

1.5.1 Estimation model

First, we estimate the ordinary least square (OLS) parameters in a market model represented as equation (1) to obtain the normal return. A market model is a statistical model used to explain the individual return on a market value-weighted return based on the efficient-market hypothesis.

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \quad (1-1)$$

where $R_{i,t}$ is the return to firm i , $R_{m,t}$ is the market value-weighted return, which is the return of TOPIX, and $\varepsilon_{i,t}$ is the error term for firm i at time t . $\varepsilon_{i,t}$ is distributed with a mean of zero and a variance of σ^2 . The announcement date is defined as $t = 0$; L_1 is the estimation window, the daily time interval for estimate parameters α_i and β_i in equation (1). Finally, L_2 is the event window reflecting the merger- related information influencing stock prices.

The procedure is as follows. First, we use the data of $R_{i,t}$ and $R_{m,t}$ in the estimation window and then perform an OLS regression. Many studies use 200 days as the estimation window. However, because there is no theoretical reason to use only 200 days, this study uses four types of estimation windows (i.e., 250-day, 200-day, 150-day and 100-day) in order to check robustness over the lengths

of estimation windows. The event windows provide three different lengths: $L_2 = 41$, $L_2 = 31$, and $L_2 = 21$. The length of each estimation window is adjusted according to the length of the event windows in the following way. We change the length of the event window to reflect the merger-related information on stock prices. For example, the 250-day estimation window would be $L_1 = 250$, $L_1 = 255$, and $L_1 = 260$ according to each event window: $L_2 = 41$, $L_2 = 31$, and $L_2 = 21$. In other words, the estimation window would run from $\tau_1 = -271$ to $\tau_2 = -21$ for an event window running from $\tau_3 = -20$ to $\tau_4 = +20$. Likewise, it would run from $\tau_1 = -221$ to $\tau_2 = -16$ for an event window running from $\tau_3 = -15$ to $\tau_4 = +15$. Now,

$$\hat{\varepsilon}_{i,t} = R_{i,t} - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t}) \quad (1-2)$$

where $\hat{\alpha}_i$, $\hat{\beta}_i$, and $\hat{\varepsilon}_{i,t}$ are estimated parameters. Specifically, $\hat{\varepsilon}_{i,t}$ is the residual between the actual return and the estimated normal return. If the estimated parameters were not statistically significant for a specific firm, we did not include the firm in the event study.

Second, we use the data for the returns in each event window and the estimated parameters $\hat{\alpha}_i$ and $\hat{\beta}_i$ in order to compute abnormal returns. Because $R_{i,t}^*$ and $R_{m,t}^*$ are returns in an event window, the abnormal return (AR) $\hat{\varepsilon}_{i,t}^*$ is calculated as

$$AR \equiv \hat{\varepsilon}_{i,t}^* = R_{i,t}^* - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t}^*) \quad (1-3)$$

Equation (3) shows that an abnormal return is the difference between the observed return and the estimated normal return in an event window. A normal return in an event window is the return that would be expected were the merger not to occur. To test whether an abnormal return is statistically significant in an event window, the variance of the abnormal return is estimated. For example, if the estimation window is $L_1 = 200$, the variance of the abnormal return is estimated as

$$\hat{\sigma}_i^2 = \frac{1}{200 - 2} \sum_{t=-221}^{-21} (\hat{\varepsilon}_{i,t})^2 \quad (1-4)$$

Equation (4) is a sample variance. The variance of $\hat{\varepsilon}_{i,t}$ in an estimation window is substituted for variance $\hat{\varepsilon}_{i,t}^*$ in an event window.

A cumulative abnormal return (CAR) is generally defined as in equation (5). A CAR represents the change in stockholders' wealth when they buy and hold stocks. Now,

$$\widehat{CAR}_i(\tau_1, \tau_2) = \sum_{t=\tau_1}^{\tau_2} \hat{\varepsilon}_{i,t}^* \quad (1-5)$$

where $\widehat{CAR}_i(\tau_1, \tau_2)$ is normally distributed in event window $-21 < \tau_1 \leq \tau_2 \leq 20$; that is,

$$\begin{aligned} \widehat{CAR}_i(\tau_1, \tau_2) &\sim N(0, \text{Var}[\widehat{CAR}_i(\tau_1, \tau_2)]) \\ \text{where } \text{Var}[\widehat{CAR}_i(\tau_1, \tau_2)] &= \hat{\sigma}_i^2(\tau_1, \tau_2) = \sum_{t=\tau_1}^{\tau_2} \hat{\sigma}_{i,t}^2 \end{aligned} \quad (1-6)$$

The test statistic of $\widehat{CAR}_i(\tau_1, \tau_2)$ is

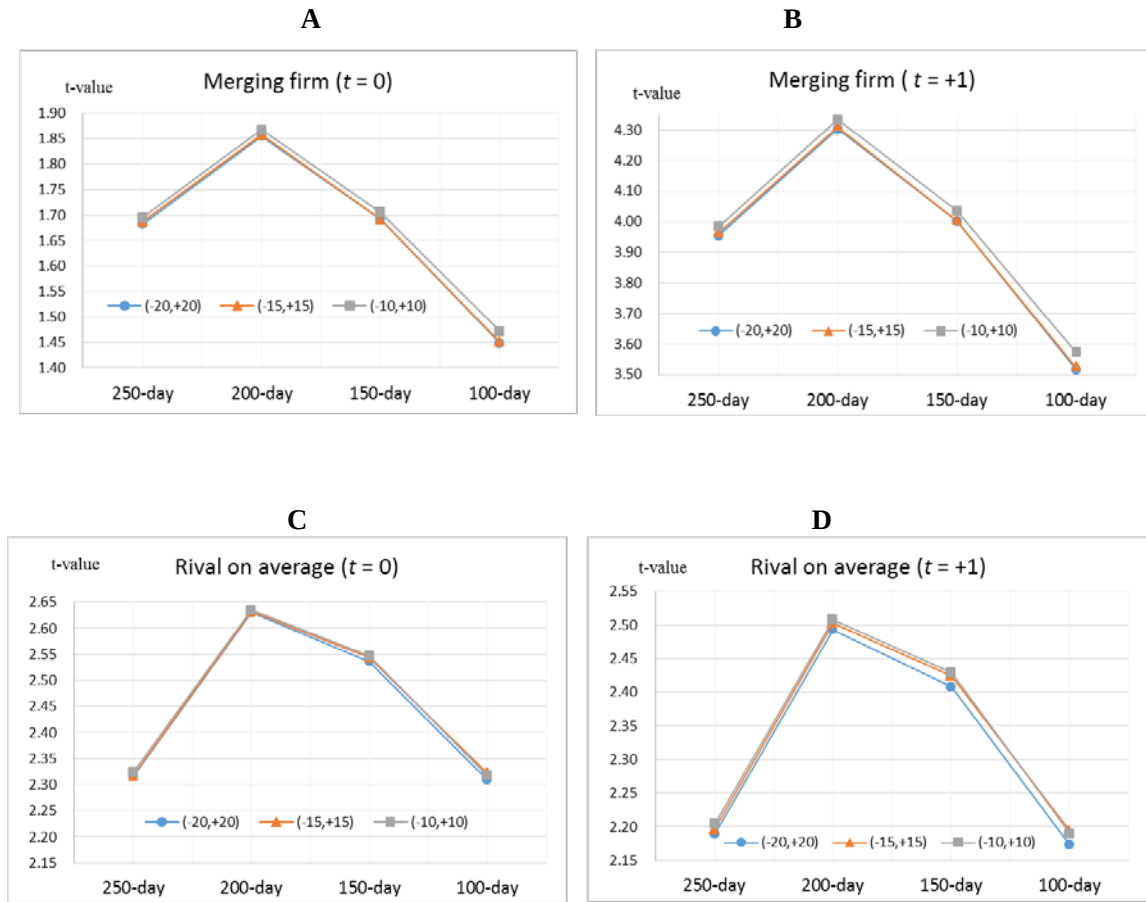
$$SCAR_i(\tau_1, \tau_2) = \frac{\widehat{CAR}_i(\tau_1, \tau_2)}{\sqrt{\text{Var}[\widehat{CAR}_i(\tau_1, \tau_2)]}} \sim^a N(0,1) \quad (1-7)$$

Moreover, we test the null hypothesis that AR or CAR equals zero. The test statistic (7) conforms to t distribution with a degree of freedom of $L_1 - 2$. However, because the estimation window is large enough, test statistic (7) conforms to normal distribution asymptotically.

1.6. Results

Because this merger was substantially announced at $t = 0$ in the afternoon and announced to the press at $t = +1$ in the morning, we observe AR and CAR, in particular, at $t = 0$ and $t = +1$. An abnormal return to the merging firm is computed as the weighted average abnormal return based on market capitalization at the end of March 2001. For NKK and Kawasaki Steel, these amount to 299,830,520,000 and 403,698,450,000 yen, respectively. The ARs and CARs are obtained for 250-day, 200-day, 150-day, and 100-day estimation windows. Each window is tested at three event windows: $L_2 = (-20, +20)$, $L_2 = (-15, +15)$, $L_2 = (-10, +10)$ and $L_2 = (-1, +1)$. This yields twelve AR patterns for each firm.

Figure 1-3: Average changes in statistical significance of abnormal returns



Note: Figures 1-3-A and 1-3-B show positive abnormal returns to the merging firm at $t = 0$ and $t = +1$ over four estimation windows and three event windows. Figures 1-3-C and 1-3-D show the same for a rival firm.

1.6.1. Merging firm's industry

Figure 1-3 (A to D) shows average changes in the statistical significance of abnormal returns to the merging firm and its rival. The significance levels show a concave pattern and are maximized at the 200-day window. Thus, the 200-day estimation window is deemed most significant. We find that while the statistical significance levels of the ARs change over the four estimation windows, the event study of the merging industry is robust to all of the estimation windows. A detailed explanation of these results follows.

At $t = 0$, the AR to the merging firm (i.e., NKK) is significantly positive, with Kawasaki Steel being evaluated lower (negative but insignificant), and NKK being evaluated higher (positive and significant). Likewise, the AR to rival firms is significantly positive on average. Moreover, at $t = +1$, the ARs to NKK and Kawasaki Steel are both significantly positive, and the AR to the

rival firms on average is also significantly positive. For the steel firms, the qualitative results are unchanged across the four estimation windows.

Based on the findings of [Eckbo \(1983\)](#) and [Shahrur \(2005\)](#), this merger may be consistent with the collusion hypothesis. In other words, the gain resulting from the merger may come from the exertion of increased market power in the steel industry. So far, we have ignored the customer firms. Thus, in the next section, we examine the event study results for the customer firms.

1.6.2. Customer firms' industries

[Table 1-2 \(A to D\)](#) provides a rough explanation of the results of the event study. It shows the significant ARs and their signs for firms in the customer industries (i.e., the steel-processing industry, auto industry, construction industry, and shipbuilding industry). However, it does not include the results for firms in the merging industry. As mentioned in Subsection 1.6.1, we observe that the ARs to all of the firms are significantly positive somewhere in the time interval $(-1, +1)$, and the event study results are qualitatively consistent with the four estimation windows.¹⁰ Here, the statistical significance level is 10% when the t -value is more than 1.65, 5% when it is more than 1.96, and 1% when it is more than 2.58 in the standard normal distribution for abnormal returns. Some firms' theoretical stock returns could not be explained well by the market model; thus, we do not compute the ARs to such firms.

The JFTC investigated the merger's effect on the following four steel products: non-oriented electrical steel sheets (i.e., a type of steel sheet), steel plates for vessels (contained in steel plates), pipes and sheet tubes for piping (contained in steel pipe), and high-tensile-strength steel (contained in steel sheets for cars and steel plates for construction). These products are consumed by the customer industries studied in this paper.

We were able to find statistically significant ARs only for a limited number of customer firms. Among these, the results were mixed between positive and negative ARs. Next, we examine the event study result, for each customer industry.

¹⁰ Upon request, a detailed explanation of the results of the event study using other tables could be prepared. [Table 1-2](#) shows the AR, CAR, and their statistical significance for each firm in the merging firms' and customer firms' industries, focusing on the interval of $(-5, +5)$ in four event windows.

Table 1-2(A): AR in Steel-processing Industry

Event windows	250-day				200-day				150-day				100-day			
	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)
Date (1)	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1
Yodogawa																
Toyo																
Sunitomo	+	+	+	+					+	+	+	+				+
Maruchi																
Sanyo	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nippon Pipe	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tokyo Steel																
Nichia																

Table 1-2(B): AR in Construction Industry

Event windows	250-day				200-day				150-day				100-day			
	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)
Date (1)	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1
Kajima																
Shimizu																
Taisei																
Ohbayashi																
Hasegawa																
Nishinatsun																
Sunitomo-Mitsui																
Maeda																
Okumura																
Toda																

Note: + indicates positive AR with at least a 10% significance level; Steel-processing
 - indicates negative AR with at least a 10% significance level.
 Blank space indicates no significant AR.
 "Not explained" means that firm's theoretical stock return could not be explained well by the market model.

Table 1-2(C): AR in Shipbuilding Industry

Event windows	250-day				200-day				150-day				100-day			
	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)
Date (t)	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	0 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1
Mitsubishi Industry																
Kawasaki Industry																
IHI																
Mitsui Ship																
Hitachi Ship																
Sumitomo Industry																

Table 1-2(D): AR in Auto Industry

Event windows	250-day				200-day				150-day				100-day			
	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)	(-20,+20)	(-15,+15)	(-10,+10)	(-1,+1)
Date (t)	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	0 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1	-1 0 +1
Nissan																
Toyota																
Honda																
Suzuki																
Mazda																
Mitsubishi Motors																
Daihatsu																
Fuji Industry																
Hino																
Isuzu																

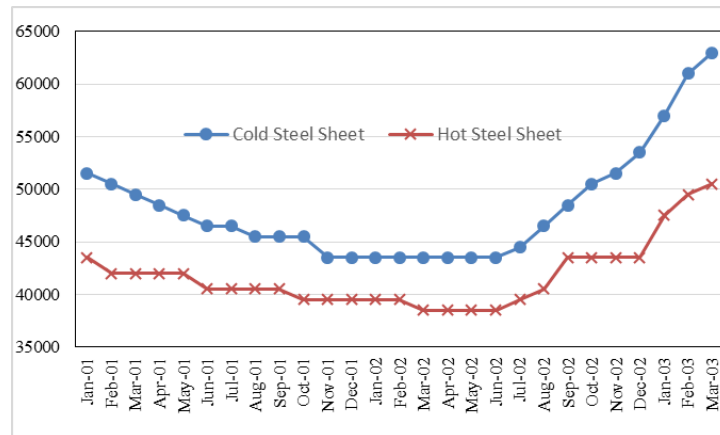
Note: + indicates positive AR with at least a 10% significance level.

— indicates negative AR with at least a 10% significance level.

Blank space indicates no significant AR.

"Not explained" means that the firm's theoretical stock return could not be explained well by the market model.

Figure 1-4: Monthly average price of steel sheets (Yen per Ton)



Data source: Market price, *Japan Metal Daily*

1.6.2.1. Steel-processing industry

This industry consumes pipes and sheet tubes for piping (contained in steel pipe) from steel blast furnace companies (i.e., the merging industry). At $t = 0$ and $t = +1$, there are two firms, Toyo and Maruichi, for which we observe negative (but insignificant) ARs for the four estimation windows. However, as most of the steel-processing firms have positive ARs at $t = 0$ and $t = +1$, albeit with low significance, their stock market value may be expected to increase around the announcement date.

1.6.2.2. Auto industry

This industry uses, as intermediates, non-oriented electrical steel sheets from steel blast furnace companies. We observe a positive sign for Hino's ARs in the four estimation windows, but a negative sign for Daihatsu's.

One might wonder why the signs of the ARs would be different for these firms. First, let me explain the competition situation of vehicle markets. Daihatsu not only supplied consigned/OEM vehicles to Toyota, but also competed intensely with Suzuki in the small-size passenger vehicle market. Hino specializes in large-size commercial vehicles, including buses and trucks, and has maintained a top share and leading position in the market.¹¹

I think the logic is as follows. The merger triggered a decrease in the average price of steel sheets as Figure 1-4 shows. Then, competition in the small-size passenger vehicle market became

¹¹ Daihatsu has already been a consolidated subsidiary of Toyota since April 2001. At that time, Hino had also formed a business alliance with Toyota. See Daihatsu motor Co., Ltd. Annual Report 2001, and Toyota Motor Corporation. Global Website.

stronger while competition in the large-size commercial vehicle market did not increase so much.¹² Therefore, Daihatsu expected to gain lower profits while Hino expected to gain higher profits. This can be a reason why Daihatsu's ARs are negative, while Hino's are positive.

Figure 1-4 shows changes in the prices of steel sheets. Japanese blast furnace steelmakers have a comparative advantage in steel sheets. Thus, the prices of steel sheets depend on the business strategies and technological progress of blast furnace steelmakers. We can observe decreases in the average price of steel sheets when the merger was announced.

1.6.2.3. Shipbuilding industry

This industry consumes steel plates for vessels (contained in steel plates) from the merger industry. For the 200-day and 150-day estimation windows, we found positive significant ARs at $t = +1$ to two firms, Hitachi Shipbuilding and Sumitomo Heavy Industries.

1.6.2.4. Construction industry

This industry consumes high-tensile-strength steel from the merging industry. We found that only one firm, Taisei, has a significant and positive AR at $t = 0$ for three estimation windows (i.e., 200-day, 150-day, and 100-day)

1.7. Robustness check

So far, we have ignored if there are any extraordinary values for individual stock returns in estimation windows. If there are extraordinarily positive or negative returns in estimation windows, the estimated normal returns obtained by ignoring such extraordinary values can be different from those obtained by considering the extraordinary values. Hence, the result of testing ARs can be changed. This section briefly provides result by controlling the extraordinary values of stock returns.

We observed the extraordinary values (peaks and bottoms), and made sure that the extraordinary values are accompanied with relevant events occurring within three days around the date in which extraordinary values are observed. Specifically, we observed extraordinary values to four firms in construction industry and one firm in auto industry. In construction industry, extraordinary values for Taisei are negative at $t = -241$ and positive at $t = -240$, an extraordinary value for Shimizu is positive at $t = -240$, an extraordinary value for Sumitomo-Mitsui is negative at $t = -94$, and an extraordinary value for Hasegawa is positive at $t = -91$. In auto industry, an extraordinary value for Hino is positive at $t = -270$.

¹² By using data from METI (2001 and 2002), I observed a trend that monthly average sales unit prices of midjet passenger vehicle were decreasing. However, monthly average sales unit prices of large trucks did not show such a decreasing trend. Upon request, I would prepare the result from the data.

To estimate normal returns again, regression model turns to following formula (1-8). We control the extraordinary values in stock return for firm i in estimation window by dummy variable $D_{i,t}$.

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i D_{i,t} + \varepsilon_{i,t} \quad (1-8)$$

A dummy variable takes $D_{i,t} = 1$ if $t \in \{E - 1, E, E + 1\}$ or takes $D_{i,t} = 0$ otherwise, where E is the event date in which the extraordinary values are observed. Following procedure above, we estimated normal returns and then tested ARs.

Finally, we summarize this section. Dummy variables are statistically significant to estimate normal returns for each firm. Comparing the results before and after controlling extraordinary values by dummy variable, however, we could not find any different result about ARs in the event. Therefore, we leave to show the result before introducing dummy variable in this chapter.

1.8. Conclusion

Using a conventional event study approach, we tested the abnormal returns and cumulative abnormal returns to individual firms in order to forecast the economic effect of the NKK and Kawasaki Steel merger. Focusing on the merging industry, the event study result shows that this merger is anticompetitive. However, taking the industry's customer firms into consideration, the merger may have had the opposite effect. Our results for the customer firms are as follows: We observed relatively more significant abnormal returns in the steel-processing industry than in the other three customer industries. For the auto industry, construction industry, and ship-building industry, there were fewer customer firms with significant abnormal returns. Regarding the signs of abnormal returns to customer firms, we observed both positive and negative abnormal returns around the merger announcement date along with a few significant abnormal returns. As shown in [Table 1-1](#), the merger of NKK and Kawasaki Steel may have been for efficiency gains.

Based on the work of [McAfee and Williams \(1988\)](#), the event study examined in this paper showed no evidence that the merger was anticompetitive. As [Shahrur \(2005\)](#) suggests, if the abnormal returns to customer firms were, on average, positive and significant at the announcement date, then we can propose that the merger was expected to achieve efficiency improvements.

The recent literature (e.g., [Davis and Ormosi, 2012](#)) argues that event studies are a useful way to evaluate mergers from the standpoint of competition policy. However, due to the stock market efficiency hypothesis, the value of event studies is still in question. This study does not engage in that debate; doing so would require improved data processing and better quantitative techniques. Moreover, future studies are recommended to investigate what happened after the merger in real terms (e.g., steel prices and steel production), rather than merely in financial terms.

Chapter 2

Ownership structure of nuclear power plants for fair competition and efficiency: The NOME law versus public ownership

2.1. Introduction

In France, a vertically integrated incumbent power supplier, Électricité de France (EDF), exclusively owns the country's nuclear power plants. Even after competition was introduced to the nuclear power generation and retail subsectors, the EDF continues to own its nuclear power plants, which are more cost efficient than thermal power plants. Thus, it has come to be recognized that competition has not been thriving in the electricity retail market, in spite of it being liberalized. To address this issue, in December 2010, the French Congress approved the “Nouvelle organisation du marché de l'électricité” (New Organization for the Market of Electricity, NOME¹³) law, which contains “l'accès régulé à l'électricité nucléaire historique” (regulated access to incumbent nuclear electricity, ARENH¹⁴). Under the ARENH, EDF is obliged to transfer about 25% of its nuclear-generated electricity capacity at marginal cost to other electricity suppliers. In other words, EDF is allowed to use 75% of its nuclear power capacity and is responsible for all fixed costs related to the nuclear power plants.

Créti et al. (2013) undertook an economic analysis of the NOME law. Their study assumes that incumbent firm *A* owns nuclear power plants and entrant firm *B* owns thermal power plants. Neither firm supposedly has any capacity constraint. $K(> 0)$ represents the transfer rights to sell nuclear power from firm *A* to firm *B*. If firm *A* sells nuclear power so as to match firm *B*'s market share α , firm *B* can use nuclear power for $q_B \leq \alpha K$, where q_i denotes the quantity of electricity supplied by firm i ($= A, B$). Otherwise, firm *B* switches to thermal power. The literature shows that under Cournot competition, the total quantity of power supplied increases owing to the NOME law.

Hence, Créti et al. (2013) found that it is good to introduce the NOME law and leave nuclear power plants in the hands of the incumbent. However, the authors did not consider an alternative policy that takes transfers nuclear power plants from the incumbent to a state company. Hence, we come to consider the issue of public ownership. If such a policy were employed and the marginal cost incurred by a market entrant were the same as that incurred by the incumbent, the market outcome could be improved. Therefore, in the current study, we compare the NOME law with public ownership to consider which policy is more desirable in terms of the performance of the electricity market.

¹³ Conseil de la Concurrence (2010)

¹⁴ CRE (2011)

The ownership structure of nuclear power plants is under discussion in other countries as well as in France. In Japan, for example, following the Great East Japan Earthquake in March 2011, all operations of nuclear power plants stopped, and full liberalization of the Japanese electricity retail market is set to be completed in April 2016. If nuclear power plants were to come back online after 2016, entrants with no nuclear power capacity would be at a clear disadvantage. Since, incumbents have been subsidized very much for nuclear power plants, nuclear power generation itself is not appropriate to liberalized electricity market. Moreover, in June 2014, one political party submitted a bill, unsuccessfully, to the Japanese Diet concerning the ownership structure of Japan's nuclear power plants. This bill asserts that nuclear power plants should be owned by the state.

The remainder of this paper is constructed as follows. Section 2.2 presents the framework of the model. In Section 2.3, we show the equilibrium without policy intervention as a benchmark scenario. In Section 2.4, we obtain the equilibria with and without capacity constraint, and with and without fixed cost of nuclear power plants under the second scenario of the NOME law. In Section 2.5, we obtain the corresponding equilibria under the third scenario of public ownership, and compare the welfare effects of the alternative policies. In Section 2.6, we consider a problem for an incumbent to approve the NOME law without political compromise rather than public ownership. Finally, we provide concluding remarks in Section 2.7.

2.2. Model

The current literature touches upon a number of issues pertaining to competition in the electricity market. [Bushnell et al. \(2008\)](#), using data from PJM Interconnection and California pertaining to the electricity market, studied the structure of the market, including spot transactions and forward contracts in which vertically integrated firms compete; they found Cournot competition in the retail market. For this reason, the current study makes use of the Cournot model. [Allaz and Vila \(1993\)](#) used a model that obtains equilibrium under a Cournot model while considering forward contracts. The current study, however, considers only spot transactions, so as to simplify our analysis. Our model is based on [Dixit \(1980\)](#)¹⁵ and [Créti et al. \(2013\)](#), both of which used the property of reaction functions that kink at different marginal costs.

We assume that incumbent firm A and entrant firm B choose their respective quantities simultaneously, à la Cournot competition, in a duopolistic electricity market. Firm A owns nuclear power plants and firm B owns thermal power plants. While thermal power plants are assumed to have no capacity constraint, nuclear power plants may or may not have them. c_A and c_B are the marginal cost of nuclear power and thermal power, respectively; each is constant, and $c_A < c_B$.

¹⁵ [Belleflamme and Peitz \(2010\)](#) provide proper explanation for it.

We consider three scenarios. The first is a benchmark in which there is no policy intervention and firm A owns all the nuclear power plants. In the second scenario, under the NOME law, less than or equal to one-half of the capacity of nuclear power that firm A owns is transferred to firm B . Then, firm B can use nuclear power from that capacity, at the price of its marginal cost. Third, we examine a scenario in which all nuclear power plants are transferred from firm A to state firm U , which then sells nuclear power to firms A and B . In the second and third scenarios, we solve both models while assuming there either is or is not a capacity constraint on nuclear power plants; in addition, in both cases, we assume that there either are or are not fixed costs associated with nuclear power.

2.3. Benchmark equilibrium

First, we consider a market structure in which incumbent firm A owns all nuclear power plants, and firm B owns only thermal power plants. We consider this structure the *benchmark*, and we solve it under Cournot competition.

The inverse demand function $P(Q)$ is assumed to be $P'(Q) < 0$, $P''(Q) \leq 0$ and $c_B < 1$; in particular, $P(Q) = 1 - Q$. We represent q_i as the electricity quantity supplied by each firm to final consumers; then, $Q = q_A + q_B$. We define π_i as the profit function of firm i ($= A, B$), and it is represented as $\pi_i = [P(Q) - c_i]q_i$. Subscript i represents firm $i = A, B$. By solving the profit-maximization problem, we obtain best-response functions $BR_i(c_i)$ for firm $i \neq j$ ($j = A, B$) as follows.

$$BR_i(c_i): q_i = -\frac{1}{2}q_i + \frac{1 - c_i}{2} \quad (2-1)$$

Solving both best-response functions simultaneously, we obtain quantities at Nash equilibrium defined as (q_A^b, q_B^b) . Then,

$$(q_A^b, q_B^b) = \left(\frac{1 - 2c_A + c_B}{3}, \frac{1 - 2c_B + c_A}{3} \right), \quad Q^b = q_A^b + q_B^b. \quad (2-2)$$

In [Figure 2-1](#), this gives point B .¹⁶ Defining (q_A^n, q_B^n) as an equilibrium in which both firms supply

¹⁶ The Japan Electric Power Information Center reports domestic electricity supply share in France in 2012 one year after the introduction of the NOME law. According to the report, EDF supplies 80% of the supplier share, and nuclear power supplies 75% in terms of generation share. According to data from [Agency for Natural Resources and Energy \(2014\)](#) in Japan, the proportion of nuclear-generated electricity in general power production in 2011 and 2012—after the Great East Japan Earthquake—was 10.7% and 1.7%, respectively; however, before 2011, it was around 30%.

nuclear-generated electricity, we obtain

$$(q_A^n, q_B^n) = \left(\frac{1 - c_A}{3}, \frac{1 - c_A}{3} \right), \quad Q^n = q_A^n + q_B^n. \quad (2-3)$$

This gives point N in [Figure 2-1](#), and it is obvious that $Q^b < Q^n$. For the sake of comparison, let us define (q_A^t, q_B^t) as an equilibrium in which both firms supply thermal-generated electricity.

$$(q_A^t, q_B^t) = \left(\frac{1 - c_B}{3}, \frac{1 - c_B}{3} \right), \quad Q^t = q_A^t + q_B^t. \quad (2-4)$$

This gives point T in [Figure 2-1](#), and $Q^t < Q^b < Q^n$.

Moreover, for the sake of consistency with later sections to aid comparability, let us focus on the case in which firm A considers the fixed cost $F(> 0)$ of the nuclear power plant. Then, firm A 's profit function is represented by $\pi_A = [P(Q) - c_i]q_i - F$. In firm A 's maximization problem, however, the fixed cost does not affect the firm, and the result is the same as before.

2.4. Equilibria under the NOME law

In this section, we consider the effect of the NOME law. Specifically, we assume a policy in which incumbent firm A sells a portion of its nuclear power to entrant firm B at marginal cost. First, we examine the case under no capacity constraint to nuclear power. Next, we do so under capacity constraint. Finally, we analyze the model by taking account of not only capacity constraint but also the fixed cost of nuclear power plants.

2.4.1. Equilibria without capacity constraint

In this subsection, we assume that there is no capacity constraint with regard to nuclear power, following [Cr  ti et al. \(2013\)](#), and show that the NOME law is effective in terms of expanding the total quantity supplied to the retail electricity market. The profit function of firms A and B can be given as follows.

$$\pi_A = [P(Q) - c_A]q_A \quad (2-5)$$

$$\pi_B = \begin{cases} [P(Q) - c_A]q_B & \text{if } q_B \leq \alpha K \\ [P(Q) - c_B]q_B + [c_B - c_A]\alpha K & \text{otherwise} \end{cases} \quad (2-6)$$

$K(> 0)$ is the nuclear-power capacity (transfer rights) of firm A that can be transferred to firm B at marginal cost. However, nuclear power itself is not supposed to be bound by a capacity constraint.

Nuclear power is transferred to firm B in a ratio of α , where $\forall \alpha \in (0, 1/2]$ —a ratio that is assumed to be exogenous in the current study. Thus, firm B actually uses nuclear power by αK .¹⁷

While the best-response function of firm A is the same as that in benchmark, the best-response function of firm B can take one of two forms, depending how much nuclear power the firms uses. We do so, for the following reason. When $q_B \leq \alpha K$, firm B maximizes its profit, by using only nuclear power. On the other hand, when $q_B > \alpha K$, firm B maximizes its profit, by using thermal power, as the quantity of nuclear power is given (i.e., because it has already finished using nuclear power).

Then, the best-response functions for firm A can be obtained as follows.

$$BR_A(c_A): q_A = -\frac{1}{2}q_B + \frac{1 - c_A}{2} \quad (2-7)$$

In addition, the best-response functions for firm B can be obtained as follows.

$$\begin{aligned} BR_B(c_A): q_B &= -\frac{1}{2}q_A + \frac{1 - c_A}{2} & \text{if } 1 - c_A - 2\alpha K < q_A \\ BR_B(\alpha K): q_B &= \alpha K & \text{if } 1 - c_B - 2\alpha K \leq q_A \leq 1 - c_A - 2\alpha K \\ BR_B(c_B): q_B &= -\frac{1}{2}q_A + \frac{1 - c_B}{2} & \text{if } q_A < 1 - c_B - 2\alpha K \end{aligned} \quad (2-8)$$

For the best-response functions for firm B , $BR_B(c_A)$ is one when $q_B \leq \alpha K$, and $BR_B(c_B)$ is one when $q_B > \alpha K$. These three functions are found in [Figure 2-1](#).

Let (q_A^*, q_B^*) be the equilibrium quantities when the NOME law is in effect. We consider two extreme cases. In one, point N marks an equilibrium when $\alpha = 1/2$, and in another, point B marks an equilibrium when $\alpha = 0$. The arrow from point B to point N in [Figure 2-1](#) shows that equilibrium moves from point B to point N as α becomes large, given constant K . Note that neither quantity supplied by firm B nor total quantities increase; regardless of whether the regulator increases αK more than the quantity supplied by firm B at equilibrium point B . This result is similar to that of [Créti et al. \(2013\)](#).

¹⁷ [Créti et al. \(2013\)](#) studied α , which represents the market share of firm B under both exogenous and endogenous conditions, in which $\alpha = q_B / (q_A + q_B)$. In Subsection 2.4.1, we recreate the model under conditions in which α is exogenous.

2.4.2. Equilibria with capacity constraint

In Subsection 2.4.1, firm A was assumed to be able to supply all electricity by nuclear power. However, nuclear power actually faces a capacity constraint, and so, an incumbent firm uses not only nuclear power but also thermal power. In this subsection, we assume there is a capacity constraint to nuclear power. The profit function of firms A and B are given as follows.

$$\pi_A = \begin{cases} [P(Q) - c_A]q_A & \text{if } q_A \leq (1 - \alpha)K \\ [P(Q) - c_B]q_A + [c_B - c_A](1 - \alpha)K & \text{otherwise} \end{cases}, \quad (2-9)$$

$$\pi_B = \begin{cases} [P(Q) - c_A]q_B & \text{if } q_B \leq \alpha K \\ [P(Q) - c_B]q_B + [c_B - c_A]\alpha K & \text{otherwise} \end{cases}, \quad (2-10)$$

Assuming that firm A transfers less than one-half the nuclear-generated power it owns, we say that $\forall \alpha \in [0, 1/2]$. The best-response functions of firms A and B are obtained as follows.

$$\begin{aligned} BR_A(c_A): q_A &= -\frac{1}{2}q_B + \frac{1 - c_A}{2} & \text{if } 1 - c_A - 2(1 - \alpha)K < q_B \\ BR_A(\alpha K): q_A &= (1 - \alpha)K & \text{if } 1 - c_B - 2(1 - \alpha)K \leq q_B \leq 1 - c_A - 2(1 - \alpha)K \\ BR_A(c_B): q_A &= -\frac{1}{2}q_B + \frac{1 - c_B}{2} & \text{if } q_B < 1 - c_B - 2(1 - \alpha)K \end{aligned} \quad (2-11)$$

and

$$\begin{aligned} BR_B(c_A): q_B &= -\frac{1}{2}q_A + \frac{1 - c_A}{2} & \text{if } 1 - c_A - 2\alpha K < q_A \\ BR_B(\alpha K): q_B &= \alpha K & \text{if } 1 - c_B - 2\alpha K \leq q_A \leq 1 - c_A - 2\alpha K \\ BR_B(c_B): q_B &= -\frac{1}{2}q_A + \frac{1 - c_B}{2} & \text{if } q_A < 1 - c_B - 2\alpha K \end{aligned} \quad (2-12)$$

The best-response function of firm i ($= A, B$) is $BR_i(c_A)$ or $BR_i(c_B)$, depending on the marginal cost and whether the power is generated by nuclear or thermal. Then, we obtain the kinked best-response function as we showed in Subsection 2.4.1

Given K is constant, in choosing α , the intersections of two kinked response functions are determined simultaneously. Let the intersections be $(\bar{q}_A, \bar{q}_B)$. If we assume $K = Q^b$, an equilibrium of $(\bar{q}_A, \bar{q}_B)$ is realized at any point on the line where there is a downward -1 degree and point B (i.e., (q_A^b, q_B^b) as one of the sides on the line). The line is described as

$$q_B = -q_A + \frac{2 - c_A - c_B}{3}$$

subject to $q_B \leq q_A$. (2-13)

The equilibrium is equal to (q_A^b, q_B^b) when $\alpha = 0$; and when $\alpha = 1/2$, it is equal to (q_A^s, q_B^s) , as follows.

$$(q_A^s, q_B^s) = \left(\frac{2 - c_A - c_B}{6}, \frac{2 - c_A - c_B}{6} \right), Q^s = q_A^s + q_B^s \quad (2-14)$$

Notice that $Q^s = Q^b$. In [Figure 2-2](#), (q_A^s, q_B^s) is shown as point S. The equilibrium is realized on the line between B and S, depending on the size of α .

Under the NOME law, when comparing a case with capacity constraint to one without it, both similar and divergent features are found. For similar features, the quantity supplied by firm B increases, as it does in the case with no capacity constraint. This happens because the nuclear power transferred from firm A to firm B increases when α becomes large. For divergent features, the increase in quantity supplied by firm B is restrained compared to the case with no capacity constraint. The total quantity is constant at Q^b . However, the quantities for both firms will equalize; the reason is that the composition of electrical source for each firm becomes identical. Summarizing this subsection, when we consider the effect of the NOME law taking account of capacity constraint, we can see that the law results in only surplus transfer between firms, but not an increase in total quantity if we assume $K = Q^b$ which is one case of the size of capacity constraint.

The reason of assuming $K = Q^b$ is, first, derived from the fact that the NOME law was introduced not to shrink but to expand the downstream output, and second, that it is easy to handle and see what happens under capacity constraint on [Figure 2-2](#). Instead if we assume $K \in (Q^b, Q^n)$, the equilibrium would be realized on a line that starts from point B to the intersection of $BR_A(c_A)$ and the K line with downward 45° slope for a while. After that, the equilibrium would be realized on the K line and would end up with a symmetric point between point T and point N. The larger capacity constraint which assumed alternatively shows that the NOME law expands the downstream output. If you are interested in the result of analysis by assuming $K \in (Q^b, Q^n)$, see Supplementary Analysis in Appendix.

2.4.3. Equilibria under fixed costs of nuclear power plant

As in Subsection 2.4.2, we suppose in this subsection that there is a capacity constraint on nuclear power plants. Moreover, we assume that firm A considers the fixed costs of nuclear power plants, so that firm A's profit function is represented as $\pi_A = [P(Q) - c_A]q_A - F$. Although firm A takes into

account its own profit, under the NOME law, electricity is sold to firm B at marginal cost. This additional assumption does not affect the behavior of firm A , based on the maximization principle. The results are the same as those discussed in Subsection 2.4.2. Note that it requires a condition that the fixed cost is not as large as firm A 's profit would be negative: $\pi_A = [P(Q) - c_A]q_A - F \geq 0$.

2.5. Equilibrium under public ownership

In Section 2.4, we examined the effect of the NOME law which is aim for improving the equilibrium under benchmark. The results show that the total quantities are the same as in the benchmark and do not expand when we take account of capacity constraint with even fixed costs, while total quantities expand when we do not take account of it. However, point B at the equilibrium is not good because it does not ensure fair competition between the incumbent and the entrant. For example, the incumbent might deal with the entrant unfairly when it sells nuclear power. Thus, we consider taking all nuclear power plants out of the hands of the incumbent.

In this section, suppose that the ownership of all nuclear power plants is transferred from firm A to another firm, state firm U . Then, firms A and B can buy nuclear power from state firm U and supply the thermal power electricity that they themselves generated. In addition, it is assumed that firms A and B use the same amount of nuclear power, and that a symmetrical equilibrium is realized. Like in Section 2.4, we consider three cases: with and without capacity constraint of nuclear power, and with capacity constraint and fixed costs. It is assumed that the public firm U sells electricity to firm A and firm B by arm's lengths transaction. This assumption comes from that the wholesale electricity price can rise sharply under the market transaction.

2.5.1. Equilibrium without capacity constraint

To compare the results in this subsection with the effects of the NOME law in Subsection 2.4.1, we solve for equilibrium, which is realized under public ownership without capacity constraint. We define π_U as the profit function of state firm U , and express π_U and $\pi_i (i = A, B)$ as follows.

$$\pi_U = [w - c_A]K \quad (2-15)$$

$$\pi_i = [P(Q) - w]q_i \quad (2-16)$$

where w and K are each the wholesale price of nuclear power and the quantity of nuclear power chosen by state firm U , respectively. State firm U chooses K , subject not to profit maximization but to balancing its earnings and expenses; here the balancing condition $wK = c_A K$ comes into play. State firm U sets a wholesale price of $w = c_A$, and supplies nuclear power quantity K corresponding to demands by firm A and B . Hence, firms A and B choose their quantities in the retail electricity

market as w is given.

The best-response functions for firm $i \neq j (i, j = A, B)$ are,

$$BR_i(c_A): q_i = -\frac{1}{2}q_j + \frac{1-c_A}{2}, \quad (2-17)$$

respectively. In solving these equations simultaneously, we obtain

$$(q_A^n, q_B^n) = \left(\frac{1-c_A}{3}, \frac{1-c_A}{3} \right). \quad Q^n = q_A^n + q_B^n. \quad (2-18)$$

This equilibrium is showed at point N in [Figure 2-3](#). The market-clearing condition of wholesale is

$$K = q_A + q_B. \text{ By substituting } q_A^n + q_B^n = 2 \left(\frac{1-c_A}{3} \right) \text{ into the market-clearing condition, } K^* = q_A^n + q_B^n.$$

This means that state firm U can supply to firms A and B as much nuclear power electricity as they request.

We summarize this subsection by comparing its results to those of Subsection 2.4.1. The equilibrium obtained in the current subsection—which considers no capacity constraint on the nuclear power plant—is identical to that obtained in Subsection 2.4.1 (i.e., point N in [Figure 2-2](#)). Note that, in Subsection 2.4.1, the equilibrium of point N is achieved only if some actor—for example, a regulator—intervenes and makes $\alpha = 1/2$. However, in the current subsection, the equilibrium of point N is achieved autonomously, in the absence of any intervention. Therefore, in comparing the results under the NOME law and those under public ownership, when we do not consider the capacity constraint applied to nuclear power, public ownership appears to be a policy superior to the NOME law.

2.5.2. Equilibrium with capacity constraint

In Subsection 2.5.1, we assumed that there is no capacity constraint with regard to nuclear power, and thus, firms A and B utilized only nuclear power to supply the retail electricity market. Here, like in Subsection 2.4.2, we examine the case of nuclear capacity constraint. We express π_U and $\pi_i (i = A, B)$ as follows.

$$\pi_U = [w - c_A]K \quad (2-19)$$

$$\pi_i = \begin{cases} [P(Q) - w]q_i & \text{if } q_i \leq k_i \\ [P(Q) - c_B]w + [c_B - c_A]k_i & \text{otherwise} \end{cases} \quad (2-20)$$

We assume that $k_A + k_B = K$ is completed. Likewise, in Subsection 2.5.1, we obtain the best-response functions for firm $i \neq j (i, j = A, B)$,

$$\begin{aligned} BR_i(c_A): q_i &= -\frac{1}{2}q_j + \frac{1-c_A}{2} \\ BR_i(c_B): q_i &= -\frac{1}{2}q_j + \frac{1-c_B}{2} \end{aligned} \quad (2-21)$$

respectively. When the nuclear power capacity is sufficiently large, $q_A \leq k_A \wedge q_B \leq k_B \Rightarrow Q \leq K$, the best-response functions of firms A and B are $BR_A(c_A)$ and $BR_B(c_A)$, and we obtain equilibrium at point N —that is, (q_A^n, q_B^n) . On the other hand, let us consider when there is a capacity constraint, $q_A > k_A \wedge q_B > k_B \Rightarrow Q > K$. While the best-response function for firm $i \neq j (i = A, B)$ follows $BR_i(c_A)$ when q_j is large, thereafter, the function kinks and follows $BR_i(c_B)$ when q_j is small. As [Figure 2-3](#) shows, the equilibria exist on the intermediate between point T point and the N points.

To compare two different policies, we assume that capacity K is as large under the NOME law. Then, we can solve the problem under public ownership taking account of the capacity constraint by assuming that the capacity is $k_i, \forall i$ by means of firm symmetry.

In this case, equilibrium is realized at point S . State firm U chooses its quantity subject for $w = c_A$, like in Subsection 2.5.1; however, because there is a capacity constraint such that $K < Q^n$, state firm U actually chooses K^* , such that

$$K^* < \frac{2(1-c_A)}{3} \quad (2-22)$$

This K^* is due to there being a capacity constraint on nuclear power. As a result, neither firm A nor B can use much nuclear power and instead, they use thermal power, which has a comparatively higher marginal cost. Thus, the total quantities supplied to the market decrease.

Finally, we compare the results of Subsections 2.5.1 and 2.5.2. In Subsection 2.5.1, because we do not consider a capacity constraint for nuclear power, regardless of the intervention of the regulator, the equilibrium is achieved at point N . In Subsection 2.5.2, on the other hand, because we consider a capacity constraint, the equilibrium is never achieved at point N . Thus, the total quantities of electricity at the equilibrium are smaller for the case in which we consider a capacity constraint. Comparing the results of Subsections 2.4.2 and 2.5.2, the total quantities of electricity are obviously identical. However, taking account of the producer surplus for each firm, the market equilibrium is

realized at point S where producer surpluses for each firm are identical to those in Subsection 2.5.2, while the producer surplus is never identical between firms regardless of whether regulator sets $\alpha = 1/2$, as in Subsection 2.4.2. Thus, it matters how much surplus loss the incumbent firm can approve when the regulator exercises the NOME law compared with the benchmark case. We discuss this topic in Section 2.6.

2.5.3. Equilibrium with fixed cost of nuclear power plant

As explained in Subsection 2.4.3, when nuclear power plants are held by firm A , which maximizes its profit, fixed costs does not affect the result. However, assuming that state firm U is subject to a balancing condition, we expect that the fixed costs do affect the result. In this subsection, we suppose that there is a capacity constraint for nuclear power, like in Subsection 2.5.2; however, we introduce $F > 0$, or the fixed cost of nuclear power plants for state firm U . Then, the profit function of state firm U is redefined as

$$\pi_U = [w - c_A]K - F. \quad (2-23)$$

Solving the problem of state firm U subject to the balancing condition obviously expresses

$$w = c_A + \frac{F}{K}. \quad (2-24)$$

As we can see in Equation (2-24), the wholesale price w is equal to the average cost. We define r as the wholesale price based on the average cost. In comparing r to the wholesale price—in which the fixed costs are ignored—then $w = c_A$. Then,

$$r > c_A. \quad (2-25)$$

When r is applied to this model, the best-response function for firm $i (= A, B)$ shifts downward, from $BR_i(c_A)$ to $BR_i(r)$. Suppose that $BR_i(r)$ is upward from $BR_i(c_B)$ and downward from $BR_i(c_A)$. An equilibrium to be realized there would be conditional on the size of average cost (r) determined by the size of fixed cost (F).

Specifically, we assume that $k_i = q_i^S$ and increase r . Then, the larger r becomes, the closer $BR_i(r)$ gets to $BR_i(c_B)$. According to this, the intersection of kinked best-response functions is to be equivalent ultimately to the intersection point R of $BR_A(r)$ and $BR_B(r)$; that is, equilibrium moves closer to point T as r increases, while it moves closer to point S as r decreases. Point S is

an identical equilibrium under the NOME law as $\alpha = 1/2$ taking account of the nuclear power capacity constraint.

By means of the property that brings such an equilibrium, we can construct the condition that an equilibrium under the NOME law is better (realized in the outer parts of [Figure 2-3](#)) than one under public ownership, as follows.

Condition:

The wholesale price r , which is based on the average cost, should be large and proximate to c_B .

Specifically, we show a proof that for the extent to which r makes equilibrium quantity under the NOME law larger than one under public ownership. Let us assume that the average cost of nuclear power becomes higher since its fixed cost increases. We then consider the case in which the wholesale price—based on the average cost principle—is higher; assuming that $r > c_B$ holds.¹⁸ Note that we can consider the case in which average cost increases as fixed cost increases because fixed cost is independent of capacity.¹⁹ Defining q_i^r as equilibrium quantity for firm i when r is applied, q_i^r is identical to the intersection of kinked best-response functions. Note that the capacity constraint is fixed to k_i , $\forall i$ and best-response functions kink at q_i^s , $\forall i$, then the intersection of the kinked best-response functions would be equivalent to point S when r is small, while it would be equivalent to the intersection of $BR_A(r)$ and $BR_B(r)$ when r is large. Then, taking $r \equiv c_A + \frac{F}{K}$ into account for $q_i^r = \frac{1-r}{3}$, this becomes

$$(q_A^r, q_B^r) = \left(\frac{1 - c_A - \frac{F}{K}}{3}, \frac{1 - c_A - \frac{F}{K}}{3} \right) \quad (2-26)$$

Next, we consider the condition that satisfies $q_i^r \leq q_i^s$. Then,

$$q_i^r \leq q_i^s$$

$$\frac{1 - c_A - \frac{F}{K}}{3} \leq \frac{2 - c_A - c_B}{6}$$

¹⁸ We suppose in the current study that the fixed cost F is independent of the capacity constraint K . Some might say that $F = F(K)$. Even if we assume that the fixed cost is a function of capacity size, we can consider a situation in which the average cost increases when we suppose decreasing returns to scale, as the increase in capacity size is smaller compared with the increase in the fixed cost. However, if the function has constant returns to scale, the average cost would be constant, and the position at which the best-response functions kink would not change when the fixed cost increases.

¹⁹ From the viewpoint of installed generation capacity, the ratio of nuclear power is 18.7%. In the past, this figure has been lower than 20%.

$$c_B - c_A \leq 2 \frac{F}{K} \quad (2-27)$$

This inequality is the condition such that total quantity at equilibrium under the NOME law is equal to/larger than that under public ownership. As far as the inequality is satisfied at equilibrium, point R is realized inside the area, including point S .

Finally, some might say that no policy is needed because total quantities are identical between points B and S . To address this claim, we should be reminded of our starting point to create a policy. The reason why point B is not good is that the incumbent exclusively holds cost-efficient nuclear power plants, which undermines fair competition under a liberalized market. We can ascertain that social welfare is identical between points B and S in terms of efficiency, while point S is better than point B in terms of fairness. However, we can also consider that social welfare is not fair, because the entrant's profit at equilibrium point S is created at the expense of the incumbent's profit. In Section 2.6, we seek equilibria relevant to practice by also taking account of the incumbent's interests.

2.6. Comparison of approvable NOME law and public ownership

So far, we have compared the NOME law, or transfer of nuclear power at marginal cost in general, with public ownership in terms of a social optimum. As a result, we showed that the NOME law is better than public ownership. Hence, it is reasonable for a regulator to exercise the NOME law. On the other hand, the incumbent usually resists the reform of nuclear power plants. However, it may embrace the NOME law if political pressure forces the incumbent to accept either the NOME law or public ownership. The incumbent would accept the NOME law as a political compromise, if it is more profitable. In this section, we discuss under which condition of the transfer right α it is better for the incumbent to approve the NOME law.

For a preliminary step, we first obtain firm A 's profit at equilibrium under the NOME law and public ownership, and compare these profits. Thereafter, we define firm A 's equilibrium profit as a function of α , and find significant α^* such that firm A would approve the NOME law.

The incumbent firm A , under the NOME law, is able to utilize nuclear power at marginal cost, while it has to pay all the fixed cost of the nuclear power plants. On the other hand, firm A , under public ownership, is able to utilize nuclear power at average cost, while it does not pay the fixed cost. Thus, although firm A 's equilibrium quantity under the NOME law is larger than under public ownership, its profit under public ownership could be smaller than that under the NOME law.

Let $P = P(Q^b) = P(Q^s)$. Defining firm A 's equilibrium profit under the benchmark as π_A^b , it is represented by

$$\begin{aligned}
\pi_A^b &= [P - c_A]q_A^b - F \\
&= \left(\frac{1 - 2c_A + c_B}{3}\right)^2 - F \\
&= (q_A^b)^2 - F
\end{aligned} \tag{2-28}$$

The equilibrium of the benchmark is the same as that under the NOME law with $\alpha = 0$. Next, we consider the equilibrium under the NOME law with $\alpha = 1/2$, where total quantities and firm A's quantity are Q^s and q_A^s at point S, respectively. Defining firm A's equilibrium profit in this case as π_A^s , which is represented by

$$\begin{aligned}
\pi_A^s &= Pq_A^s - \left[c_A \frac{q_A^b}{2} + F\right] - c_B \left(q_A^s - \frac{q_A^b}{2}\right) \\
&= [P - c_B]q_A^s + (c_B - c_A) \frac{q_A^b}{2} - F \\
&= \left(\frac{1 + c_A - 2c_B}{3}\right) \left(\frac{2 - c_A - c_B}{6}\right) + \left(\frac{c_B - c_A}{2}\right) \left(\frac{1 - 2c_A + c_B}{3}\right) - F \\
&= q_B^b q_A^s + (q_A^b - q_A^s)q_A^b - F \geq 0
\end{aligned} \tag{2-29}$$

It is assumed that a non-negative condition is imposed on the equilibrium profit π_A^s . Finally, we focus on point R under public ownership equaling point S, which is the equilibrium under the NOME law with $\alpha = 1/2$. By doing so, we can easily compare profits at equilibria under the different policies. Correspondingly, let a condition be $q_A^r = q_A^s$. Consequently, we apply $(c_A + c_B)/2 = r \Rightarrow c_B - c_A = 2(F/K)$ upon analysis. In addition, we assume $K = q_A^{b20}$. Defining firm A's profit at the equilibrium of point R (= point S) under public ownership as π_A^r , it is represented by

$$\begin{aligned}
\pi_A^r &= Pq_A^s - \left(c_A + \frac{F}{K}\right) \frac{q_A^b}{2} - c_B \left(q_A^s - \frac{q_A^b}{2}\right) \\
&= [P - c_B]q_A^s + (c_B - c_A) \frac{q_A^b}{2} - \frac{F}{K} \frac{q_A^b}{2} \\
&= \pi_A^s + F - F \frac{q_A^b}{2} \\
&= \pi_A^s + \frac{F}{2}
\end{aligned} \tag{2-30}$$

²⁰ When we assume $K = q_A^b + q_B^b$, it will have $\pi_A^b - \pi_A^r < 0$. Then the result in this section would not be maintained.

Let us compare these profits. First, comparing profits at points B and S ,

$$\begin{aligned}\pi_A^b - \pi_A^s &= \left[(q_A^b)^2 - F \right] - \left[q_A^b q_A^s - (q_A^b - q_A^s) q_B^b - F \right] \\ &= q_A^s (q_A^b - q_B^b) > 0\end{aligned}\tag{2-31}$$

Thus, we find $\pi_A^b > \pi_A^s$. Next, comparing profits at points R and S ,

$$\begin{aligned}\pi_A^r - \pi_A^s &= \left[\pi_A^s + \frac{F}{2} \right] - \pi_A^s \\ &= \frac{F}{2} > 0.\end{aligned}\tag{2-32}$$

Thus, we find $\pi_A^r > \pi_A^s$. Finally, comparing profits at points B and R ,

$$\begin{aligned}\pi_A^b - \pi_A^r &= \left[(q_A^b)^2 - F \right] - \left[\pi_A^s + \frac{F}{2} \right] \\ &= \left[(q_A^b)^2 - \frac{F}{2} \right] - \left[q_A^b q_A^s - (q_A^b - q_A^s) q_B^b \right] \\ &= q_A^s (q_A^b - q_B^b) - \frac{F}{2} \\ &= \left(\frac{1 - 2c_A + c_B}{3} - \frac{2 - c_A - c_B}{6} \right) \left(\frac{2 - c_A - c_B}{3} \right) - \frac{F}{2} \\ &= \frac{(c_B - c_A)(2 - c_A - c_B)}{6} - \frac{F}{2}\end{aligned}\tag{2-33}$$

Now, we assume for firm A that the total cost of nuclear power is cheaper than that of thermal power at the benchmark equilibrium:²¹ $q_A^b c_B > q_A^b c_A + F$. Then, Equation (2-33) continues as follows.

$$\pi_A^b - \pi_A^r = \frac{(c_B - c_A)(2 - c_A - c_B)}{6} - \frac{F}{2}$$

²¹ In our model, firm A possesses both nuclear and thermal power. At the benchmark equilibrium, firm A supplies electricity only by means of nuclear power. Hence, the total cost of nuclear power must be cheaper than that of thermal power. This is the reason we assume inequality regarding total costs.

$$\begin{aligned}
&> \frac{(c_B - c_A)(2 - c_A - c_B)}{6} - \frac{(c_B - c_A)q_A^b}{2} \\
&= \frac{(c_B - c_A)(2 - c_A - c_B)}{6} - \left(\frac{c_B - c_A}{2}\right)\left(\frac{1 - 2c_A + c_B}{3}\right) \\
&= \frac{(1 + c_A - 2c_B)(c_B - c_A)}{6(2 - c_A - c_B)} > 0
\end{aligned} \tag{2-33}$$

Thus, we find that $\pi_A^b > \pi_A^r$.

In addition, we can identify the sign of $\pi_A^b - \pi_A^r$ by means of another methodology. First, we decompose $\pi_A^b - \pi_A^r$ into $(\pi_A^b - \tilde{\pi}_A) + (\tilde{\pi}_A - \pi_A^r)$, where $\tilde{\pi}_A$ is counterfactual profit for firm A. This is defined as firm A's equilibrium profit earned if firm A provides the benchmark equilibrium quantity by means of both nuclear and thermal power; the counterfactual profit is represented by

$$\tilde{\pi}_A = Pq_A^b - c_A \frac{q_A^b}{2} - \frac{F}{2} - c_B \frac{q_A^b}{2} \tag{2-34}$$

and $P = P(Q^b) = P(Q^s)$. Here, we assume that nuclear power plants are owned by a state firm (i.e., public ownership); then, firm A supplies electricity by means of both types of generation. As mentioned, we assume $q_A^b c_B > q_A^b c_A + F$ and $K = q_A^b$ as well. Next, we check the signs of two equations as follows.

$$\begin{aligned}
\pi_A^b - \tilde{\pi}_A &= [P - c_A]q_A^b - F - \left[Pq_A^b - c_A \frac{q_A^b}{2} - \frac{F}{2} - c_B \frac{q_A^b}{2}\right] \\
&= \frac{1}{2}[(c_B - c_A)q_A^b - F] > 0
\end{aligned} \tag{2-35}$$

$$\begin{aligned}
\text{and } \tilde{\pi}_A - \pi_A^r &= \left[Pq_A^b - c_A \frac{q_A^b}{2} - \frac{F}{2} - c_B \frac{q_A^b}{2}\right] - Pq_A^s - \left(c_A + \frac{F}{K}\right)\frac{q_A^b}{2} - c_B \left(q_A^s - \frac{q_A^b}{2}\right) \\
&= (q_A^b - q_A^s)(P - c_B) > 0
\end{aligned} \tag{2-36}$$

Thus, we can show that $\pi_A^b - \pi_A^r > 0$. Moreover, by representing P , q_A^b , and q_A^s as parameters,, $\pi_A^b - \pi_A^r = \frac{(c_B - c_A)(2 - c_A - c_B)}{6} - \frac{F}{2}$, which is identical to Equation (2-34).

All the above mentioned results are from comparing equilibrium profits for firm A. Next, we formulate the equilibrium profit for firm A as a function of the transfer ratio α , and find a range of α such that firm A prefers the NOME law to public ownership. Defining the equilibrium profit as $\pi_A(\alpha)$, and applying $q_A^b - q_A^s = (c_B - c_A)/2$, then,

$$\pi_A(\alpha) = P[q_A^b - \alpha(c_B - c_A)] - \{[(1 - \alpha)c_A + \alpha c_B]q_A^b - \alpha(c_B - c_A)c_B + F\}, \tag{2-37}$$

where $\forall \alpha \in [0, 1/2]$. We compare $\pi_A(\alpha)$ under the NOME law and π_A^r under public ownership at point S. We consider the difference between $\pi_A(\alpha)$ and π_A^r ,

$$\begin{aligned} & \pi_A(\alpha) - \pi_A^r \\ &= P[q_A^b - \alpha(c_B - c_A)] - \{[(1 - \alpha)c_A + \alpha c_B]q_A^b - \alpha(c_B - c_A)c_B + F\} - \left\{\pi_A^s + \frac{F}{2}\right\} \end{aligned} \quad (2-38)$$

This equation appears like a figure when taking $\pi_A(\alpha)$ and π_A^r on the vertical axis, and α on the horizontal axis. Our interest is to find α^* such that $\pi_A(\alpha) \geq \pi_A^r$. Taking account of

$\pi_A^s = [P - c_B] \left(q_A^b - \frac{c_B - c_A}{2} \right) + (c_B - c_A) \frac{q_A^b}{2} - \frac{F}{2}$, we compute as follows.

$$\begin{aligned} \pi_A(\alpha) &\geq \pi_A^r \\ 2\alpha(c_B - c_A)[P - c_B + q_A^b] &\leq (c_B - c_A)[P - c_B + q_A^b] - F \\ \alpha &\leq \frac{1}{2} \left\{ 1 - \frac{F}{(c_B - c_A)(P - c_B + q_A^b)} \right\} \\ \alpha &\leq \frac{1}{2} \left\{ 1 - \frac{F}{2(q_A^b - q_A^s)(q_A^s + q_B^s)} \right\} \end{aligned} \quad (2-39)$$

Applying $q_A^b - q_A^s = \frac{c_B - c_A}{2}$ to $(c_B - c_A)q_A^b > F$, it becomes $2(q_A^b - q_A^s)q_A^b > F$. Considering this inequality, Equation (2-39) is

$$\alpha \leq \frac{1}{2} \left\{ 1 - \frac{2(q_A^b - q_A^s)q_A^b}{2(q_A^b - q_A^s)(q_A^s + q_B^s)} \right\} < \frac{1}{2} \left\{ 1 - \frac{F}{2(q_A^b - q_A^s)(q_A^s + q_B^s)} \right\}. \quad (2-40)$$

Consequently,

$$\begin{aligned} \alpha &\leq \frac{1}{2} \left\{ 1 - \frac{q_A^b}{q_A^s + q_B^s} \right\} \\ &= \frac{1}{2} \left\{ \frac{q_A^s + q_B^s - q_A^b}{q_A^s + q_B^s} \right\} \\ &= \frac{1}{2} \left\{ \frac{Q^* - q_A^b}{Q^*} \right\} \\ \alpha^* &\leq \frac{1}{2} \left\{ \frac{q_B^b}{Q^*} \right\} \end{aligned} \quad (2-41)$$

We express $Q^*(= Q^b = Q^s)$, because total quantities of electricity at equilibrium points B and S are identical. This is the general expression of α^* .

Specifically, we use an estimate of the marginal cost of generation and show a numerical example; Taking account of the estimation derived from [Cabinet Office of Japan \(2011\)](#)²², we assume $c_B = 2c_A$. We substitute this relationship in the fourth equation of (2-41), we obtain

$$\alpha^* \leq \frac{1}{2} \left\{ \frac{1 + c_A - 2c_B}{2 - c_A - c_B} \right\} = \frac{1}{2} \left\{ \frac{1 - 3c_A}{2 - 3c_A} \right\} \equiv Z(c_A). \quad (2-42)$$

We can see that α^* is decreasing in c_A . Numerically, it is shown that $\alpha^* \approx 0.05$ when $c_A = 0.3$, $\alpha^* \approx 0.15$ when $c_A = 0.2$, $\alpha^* \approx 0.2$ when $c_A = 0.1$, and $\alpha^* = 0.25$ when $c_A = 0$. Taking a limit for c_A ,

$$\alpha^* \leq \lim_{c_A \rightarrow 0} Z(c_A) = \frac{1}{2} \left\{ \frac{1}{2} \right\} = 0.25. \quad (2-43)$$

The threshold α^* would never be larger than 0.25, hence, $\alpha^*(c_A) \in (0, 1/4]$ depending on c_A . Interestingly, the NOME law in France actually sets the transfer ratio at 0.25, which is relevant to our result drawn by numerical example.

We can summarize the results from comparing firm A's profits at each equilibrium. The equilibrium profit under the benchmark case or a non-effective NOME law ($\alpha = 0$) is larger than that under the most effective NOME law ($\alpha = 1/2$); Firm A's equilibrium profit decreases as α increases. Ultimately, when $\alpha = 1/2$, the equilibrium profit would be smaller than that gained under the most effective public ownership; in the sense that the total quantity of electricity at the equilibrium is equivalent to that under the NOME law when $\alpha = 1/2$.

From the numerical example, we also learn how crucial the transfer ratio is. Assuming the marginal cost of nuclear power is approximately zero, if $\alpha^* \leq 1/4$, an incumbent is able to gain more profit under the NOME law, otherwise the incumbent is able to gain more profit under public ownership. When we assume that the marginal cost of nuclear power is larger, the threshold α^* would be lower. In terms of regulatory practice, setting the transfer ratio at $\alpha^* \leq 1/4$ would make the NOME law not only socially optimal but also approvable by an incumbent firm.

²² Due to the inability to obtain the estimation of marginal cost of thermal power in France, we instead use the estimation of generation costs in Japan. From the estimation derived during the cost investigation commission in the [Cabinet Office of Japan \(2011\)](#), while the marginal cost of nuclear power is 50% of that of thermal power, the average cost of nuclear power is 80% of the marginal cost of thermal power. Additionally, from the estimation derived during the summary of the public thematic report by the [Cour des Comptes \(2012\)](#) in France, while the wholesale price of nuclear power energy is €42/MWh, the current economic cost of nuclear power energy is €49.5/MWh.

2.7. Conclusion

This research studied ownership structure of nuclear power plants in terms of efficiency; more specifically, we compared the NOME law and public ownership. Recently, [Créti et al. \(2013\)](#) showed that employing the NOME law would bring about larger quantities of power than before. We first set up a simple model, as well as the model used in [Créti et al. \(2013\)](#), and then compared the NOME law and public ownership. As a result of that comparison, we found that the quantity of electricity under public ownership is larger than that under the NOME law. Thus far, it appears that public ownership is superior to the NOME law.

Next, we arranged the model so as to more closely approximate reality: in line with this, we considered capacity constraint and fixed costs with regard to nuclear power plants. We found that depending on the presence of condition on fixed costs, either the NOME law or public ownership becomes preferable to the other. The public ownership of nuclear power plants appears to be a fair policy tool; however, in selling nuclear-generated power, public ownership does embrace the average cost principle. Therefore, the effect of public ownership on outcome in the electricity retail market would be weaker than that under the NOME law, on account of the aforementioned conditions: fixed cost for nuclear power plants. The NOME law has economic significance than does any proposed political compromise that the incumbent prefers public ownership to the NOME law.

Figure 2-1: Equilibrium under benchmark and the NOME law without capacity constraint

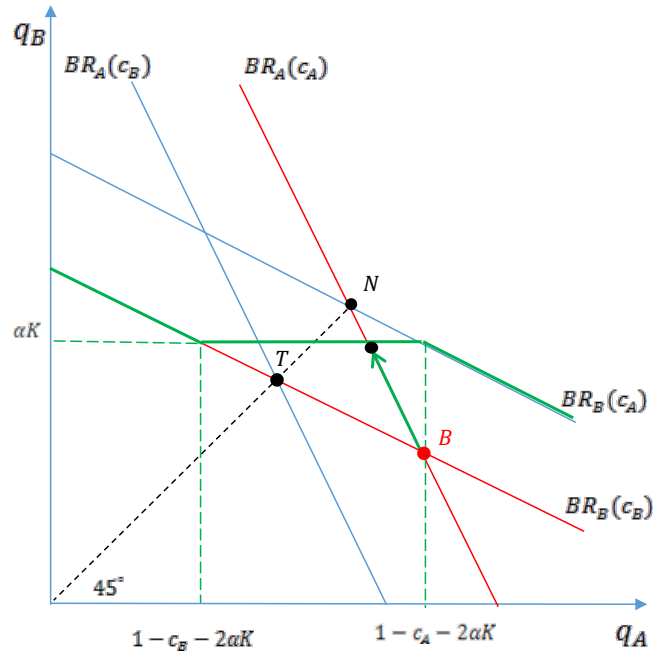


Figure 2-2: Equilibrium under the NOME law with capacity constraint, $K = Q^b$.

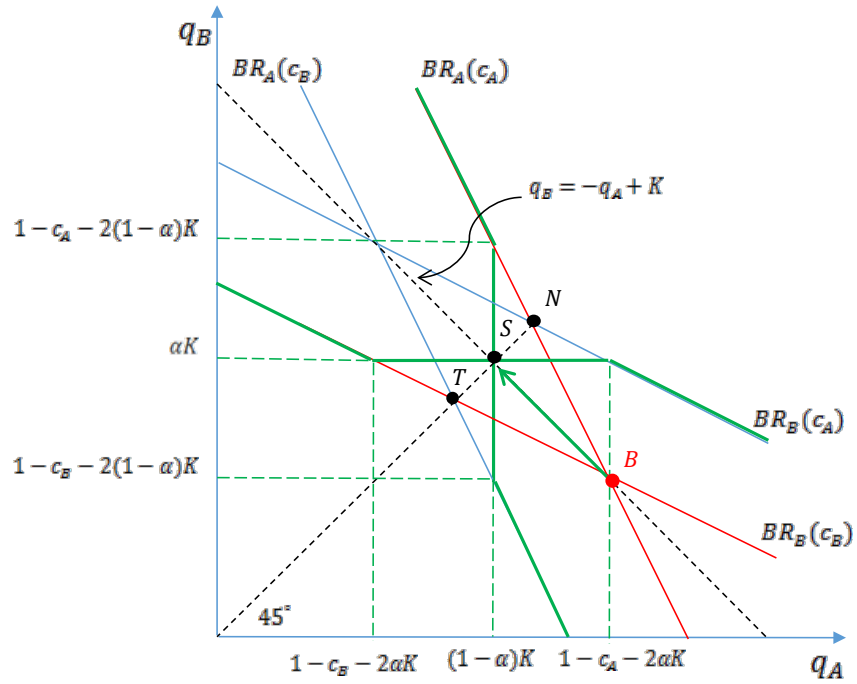
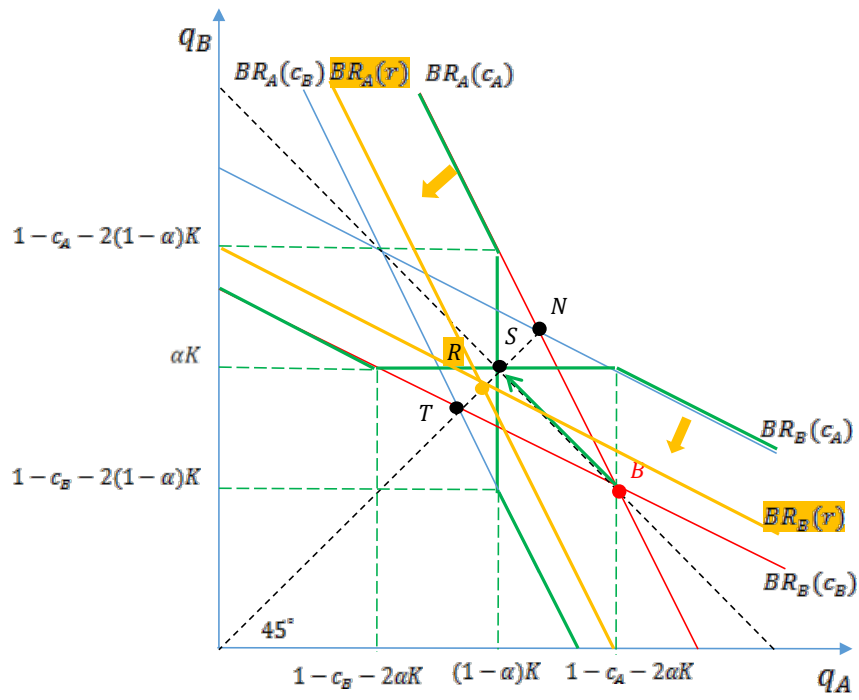


Figure 2-3: Equilibria under public ownership with capacity constraint and fixed cost



Appendix: Supplementary analysis

In Chapter 2, we obtained main result of Subsection 2.4.2 by assuming $K = Q^b$. This appendix provides the result of analysis by assuming $K \in [Q^b, Q^n)$.

First, we solve for a threshold α^* that the best-response function of firm A subject to lower marginal cost, $BR_A(c_A)$ kinks effectively by transferring nuclear power by α from firm A to firm B. Before solving for α^* , we explain kinking points on best response functions for each firm. For firm A, $BR_A(c_A)$ kinks at $\widehat{q}_B(\alpha, K) \equiv 1 - c_A - 2(1 - \alpha)K$ and $BR_A(c_B)$ kinks at $\widetilde{q}_B(\alpha, K) \equiv 1 - c_B - 2(1 - \alpha)K$. For firm B, $BR_B(c_A)$ kinks at $\widehat{q}_A(\alpha, K) \equiv 1 - c_A - 2\alpha K$ and $BR_B(c_B)$ kinks at $\widetilde{q}_A(\alpha, K) \equiv 1 - c_B - 2\alpha K$. As we can see [Figure 2-4-A and 2-4-B](#), if $BR_A(c_A)$ kinks effectively, the following inequality holds.

$$\begin{aligned}\widehat{q}_B(\alpha, K) &> q_B^b \\ 1 - c_A - 2(1 - \alpha)K &> \frac{1 - 2c_B + c_A}{3} \\ \frac{1 - 2c_A + c_B}{3} &> (1 - \alpha)K\end{aligned}$$

Solving for α ,

$$\alpha > 1 - \left(\frac{1 - 2c_A + c_B}{3K} \right) \equiv \alpha^*(K) \quad (\text{A-1})$$

The condition for non-negative $\alpha^*(K)$ is that $\alpha^*(K) \geq 0$ if $K \geq \frac{1 - 2c_A + c_B}{3}$, which is rewritten to $\alpha^*(K) \geq 0$ if $K \geq q_A^b$. What the inequality (A-1) tells that if $\alpha > \alpha^*(K)$, $BR_A(c_A)$ kinks effectively. [Figure 2-4-A](#) shows that $BR_A(c_A)$ kinks ineffectively; $(1 - \alpha)K' = q_A^b$ for $K' > K = Q^b$. In contrast, [Figure 2-4-B](#) shows that $BR_A(c_A)$ kinks effectively; $(1 - \alpha')K' < q_A^b$ for $\alpha' > \alpha$. As [Figure 2-5](#) shows, the threshold becomes higher as the capacity constraint becomes larger such that $\alpha^*(K') > \alpha^*(K)$ for $K' > K = Q^b$. Therefore, it requires higher transfer ratio $\alpha' > \alpha^*(K') > \alpha$ to make $BR_A(c_A)$ kink effectively.

Capacity constraint and transfer ratio affect best response function for each firm as follow. For firm A, its kinked best response function shifts down when capacity constraint becomes larger than Q^b given $\alpha > 0$ constant, but it shift up when transfer ratio becomes higher than before. For firm B, its kinked best response function shifts leftward either when capacity constraint becomes larger or transfer ratio becomes higher; $K' > Q^b$ or $\alpha' > \alpha^*(K')$.

Next, we explain how total output changes as α becomes higher under $K \in [Q^b, Q^n)$. As we can see [Figure 2-4-C](#), an intersection on kinked best response functions for each firm exists upon $f(q_A, K) : q_B = -q_A + K$ when the following equality holds.

$$\begin{aligned}\widehat{q}_B(\alpha, K) &\geq \alpha K \\ 1 - c_A - 2(1 - \alpha)K &\geq \alpha K\end{aligned}$$

Solving for α ,

$$\alpha \geq 2 - \left(\frac{1 - c_A}{K}\right) \equiv \alpha^{**}(K) \quad (\text{A-2})$$

The condition for non-negative $\alpha^{**}(K)$ is that $\alpha^{**}(K) \geq 0$ if $K \geq \frac{1 - c_A}{2}$. This condition is interpreted that capacity of nuclear power has to be more than or equal to monopolistic supply by means of nuclear power. What the inequality (A-2) tells that if $\alpha > \alpha^{**}(K)$, total output at equilibrium just equals to the capacity of nuclear power. As K becomes larger, the threshold $\alpha^{**}(K)$ becomes higher. It is easy to understand the inequality (A-2) by comparing what each of [Figure 2-4s](#) illustrates. [Figure 2-4-A](#) shows that total output at the equilibrium exists in the area inside $f(q_A, K')$ under $\alpha^{**}(K') > \alpha$. [Figure 2-4-B](#) shows that total output at the equilibrium exists upon $f(q_A, K')$ under $\alpha^{**}(K') = \alpha' > \alpha$. Either does [Figure 2-4-C](#) under $\alpha' > \alpha^{**}(K') > \alpha$.

Finally, we show that

$$\alpha^{**}(K) \geq \alpha^*(K) \text{ if } K \geq \frac{2 - c_A - c_B}{3} = Q^b \quad (\text{A-3})$$

As K becomes larger than Q^b , the transfer ratio when consumes nuclear power becomes large after best response function for firm A kinks effectively. Specifically, substituting $K = Q^b = \frac{2 - c_A - c_B}{3}$ to the inequality (A-1) and (A-2), they turn to

$$\alpha > \frac{1 + c_A - 2c_B}{2 - c_A - c_B} \equiv \alpha^* = \alpha^{**} \text{ if } K = Q^b \quad (\text{A-4})$$

Rewriting (A-4), it turns to $\alpha > \frac{q_B^b}{Q^b} \equiv \alpha^* = \alpha^{**}$ if $K = Q^b$.

Figure 2-4-A: Equilibrium under the NOME law with capacity constraint, $K' \in (Q^b, Q^n)$

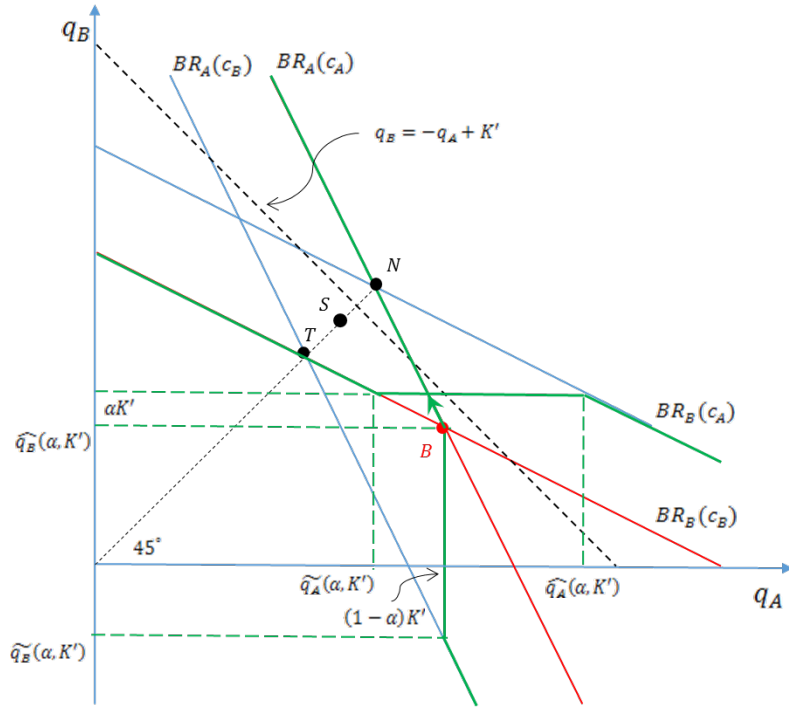


Figure 2-4-B: Equilibrium under the NOME law with capacity constraint, $K' \in (Q^b, Q^n)$

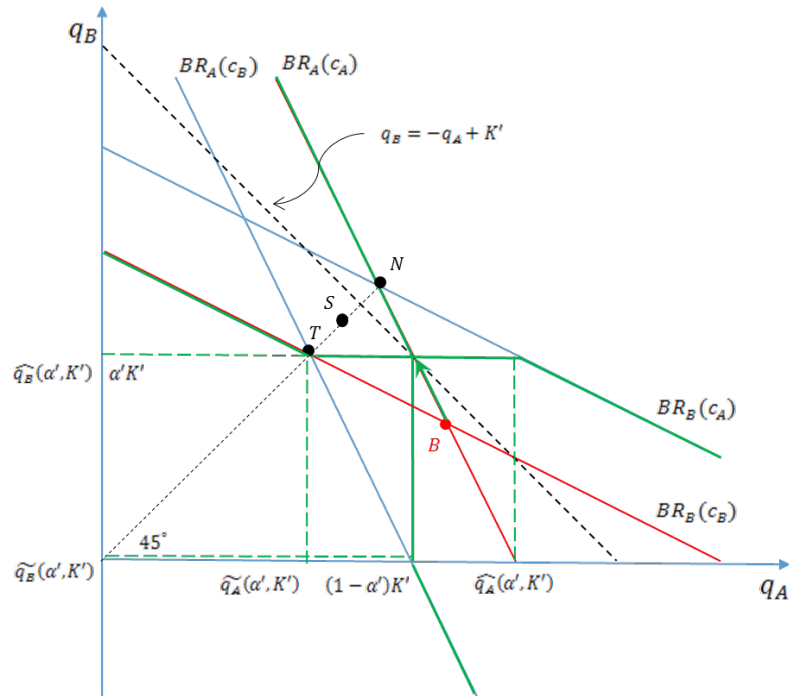
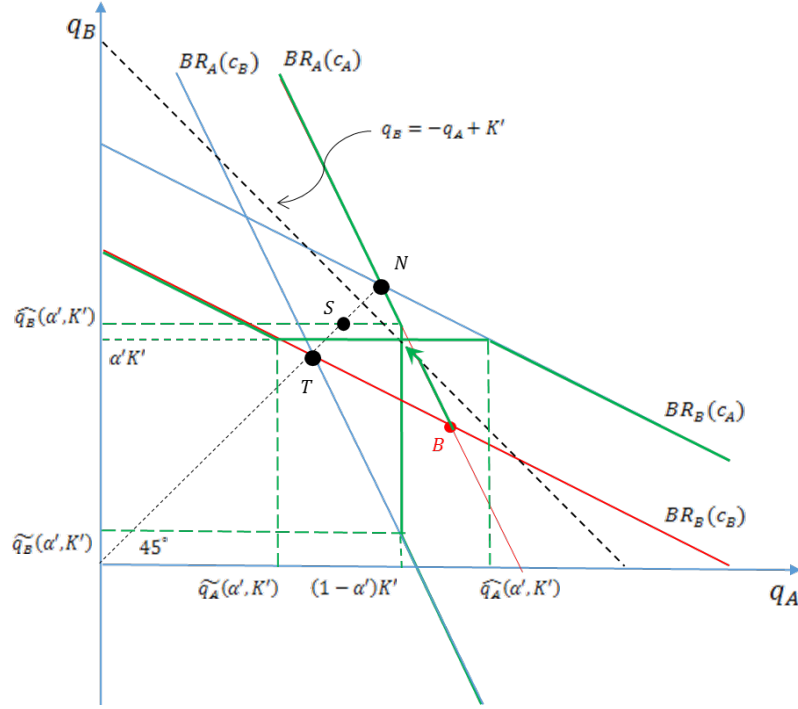


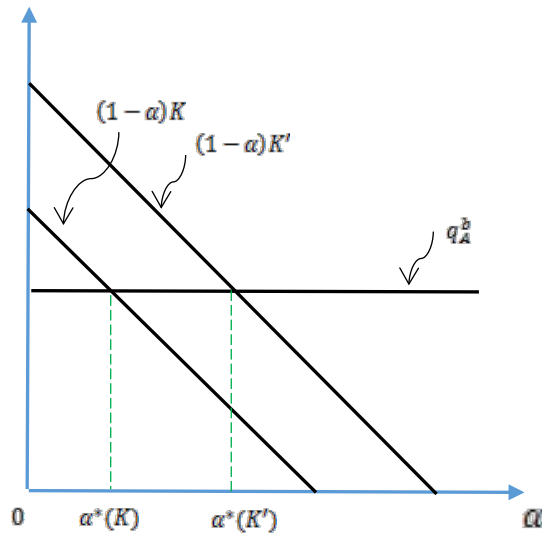
Figure 2-4-C: Equilibrium under the NOME law with capacity constraint, $K' \in (Q^b, Q^n)$



Note: Notation in Figure 2-4 is as follow.

$$\begin{aligned} \widehat{q}_A(\alpha, K) &\equiv 1 - c_A - 2\alpha K, & \widetilde{q}_A(\alpha, K) &\equiv 1 - c_B - 2\alpha K \\ \widehat{q}_B(\alpha, K) &\equiv 1 - c_A - 2(1 - \alpha)K, & \widetilde{q}_B(\alpha, K) &\equiv 1 - c_B - 2(1 - \alpha)K \\ K &= Q^b < K' < Q^n & \alpha' > \alpha > 0 \end{aligned}$$

Figure 2-5: Threshold of transfer ratio $\alpha^*(K)$ on equilibrium



$$\text{Note: } \alpha^*(K) \equiv 1 - \frac{1 - 2c_A + c_B}{3K}$$

Chapter 3

Unregulated upstream monopolist in vertical structure: Vertical integration versus legal unbundling

3.1. Introduction

We can see widely the industries consist of upstream monopolist with competitive downstream. The upstream monopolist supplies the downstream competitors essential input, which is often called the access to network operated by the upstream²³. In some of the industries, the upstream monopolist is vertically integrated with a downstream firm: in particular, liberalized sectors such that telecommunication, gas and electricity. Industries of such vertical structure are subject to be investigated by regulators, because the integrated firm might take exclusionary behaviors to its downstream rivals. To tackle with these potential issues, some regulatory reforms for vertical structure, access charge or downstream prices are proposed in the industries.

Reforms for vertical structure are proposed, because the integrated firm has incentive to degrade quality of access such that raises the cost of downstream rivals. This non-price discrimination is defined as “sabotage” following [Beard et al. \(2001\)](#); sabotage is similar to “raising rival’s costs (RRC)” in nature and observed in telecommunication and electricity industry²⁴. Taking account of that vertically integrated firm can do sabotage, then the merit of vertical integration, that is overcoming the double marginalization problem is weakened. Accordingly, legal unbundling or ownership separation is proposed instead of vertical integration. Legal unbundling, originally proposed in Europe, is that the entity that supplies the essential input must be independent of its management from any other firm supplies downstream, but the firm is allowed to own the entity upstream²⁵. While the downstream firm cannot control operations of the entity, it can gain from the entity through shareholding. Ownership separation is that regulator requires not only independence on legal relationship but also independence on capital relationship between the upstream monopolist and a downstream affiliate: namely, vertical separation. In Europe, some countries employ legal unbundling and others ownership separation in electricity sector. But, vertical integration is still observed in telecommunication and electricity sectors in the U.S; they called “utility”. Like this, alternative vertical structures are considered to reform the current vertical structure with a problem.

It is also discussed that how much the essential input price should be regulated or whether retail

²³ Referring [Carlton \(2008\)](#) and [Jullien et al. \(2013\)](#), this vertical structure can be applied to not only network industries but also sectors where scarce resources or R&D is bottleneck upstream.

²⁴ [European Commission, Energy Sector Inquiry \(Jan. 10, 2007\)](#), Competition report on energy sector inquiry, part 1, para 169, or para 493, p. 163

²⁵ The explanation about legal unbundling follows mainly [Höffler and Kranz \(2011 a, 2011b\)](#) and [Fiocco \(2013\)](#) who refer Directive 2009/72 EC and 2009/73/EC for electricity market and gas market by each.

price should be regulated. When the essential input price is regulated, the integrated firm can have incentive to do sabotage. When the downstream retail market is unregulated, margin squeeze can happen as a result from that the integrated firm chooses quantity or price optimally. Margin squeeze is namely an excessive decrease in price for downstream goods supplied by the integrated firm, which may result in foreclosing the rival from the downstream market without violating regulation of predatory pricing; the pricing of margin squeeze is expressed as “the price of goods supplied by the integrated firm < the marginal cost of the downstream affiliate of the integrated firm + the price of essential input”, and the predatory pricing is expressed as “the price of goods supplied by the integrated firm < the marginal cost of the downstream rival firm + the price of essential input”. From these two expressions, we can see that if the marginal cost of the downstream affiliate of the integrated firm is lower than that of the downstream rival firm, the integrated firm clears the predatory pricing successfully but its pricing brings margin squeeze to the downstream market. Margin squeeze can be the most concern when the price of essential input is high enough. Higher input price would compress profit of the rival, and ultimately the rival is to be squeezed from the downstream market. Hence, it is important to see that how the essential input price related to vertical form would influence competition and output in the downstream market.

In this paper, we aim to reconsider vertical forms of the industry consists of upstream monopolist and downstream two competitors under vertical integration and legal unbundling. Existing literatures comparing legal unbundling with vertical integration or ownership separation study under which access charge is regulated at constant level exogenously. In our model, however, under which the access charge is set endogenously by the upstream firm, the upstream monopolist is supposed to choose a level of sabotage, then downstream competitors are supposed to choose quantity simultaneously, taking account of the degree of differentiation of goods or services.

We find that vertical integration outperforms legal unbundling in terms of aggregated quantity and consumer surplus. Moreover, even when the downstream rival firm is foreclosed from the market, the result is maintained. The result obtained in this paper is contrary to others that show that legal unbundling can bring large total output in downstream than vertical integration.

3.2. Literature review

This paper is related with some works in sabotage/raising rival's costs. [Sibley and Weisman \(1998\)](#) examine in quantity competition the incentives to raise the cost of downstream rivals under which condition a regulated upstream monopolist is vertically integrated and owns a downstream affiliate: reverse legal unbundling as referred by [Höffler and Kranz \(2011a\)](#). The paper says that which vertical form outperforms other is mixed. [Beard et al. \(2001\)](#) investigate the presence of incentive for sabotage under vertical separation and vertical integration. They indicate that an incentive for

sabotage arises only in the presence of regulated price for essential input.

As [Mandy and Sappington \(2007\)](#) refer, in homogeneous goods quantity competition studied by [Economides \(1998\)](#), and in differentiated goods price competition studied by [Beard et al. \(2001\)](#) and [Kondaurova and Weisman \(2003\)](#), if upstream profit and sabotage cost are zero or small enough, the integrated firm raises the downstream rival's cost at the equilibrium. However, if the upstream profit and initial increments cost of sabotage is large, the integrated firm does not raise the downstream rival's cost at the equilibrium. [Mandy and Sappington \(2007\)](#) also say that, in quantity competition with considering the degree of product differentiation, if sabotage cost is assumed to be zero, the integrated firm raises the rival's cost at foreclosing level or does not raise the rival's cost at all as following two reasons. When goods are perfect substitute, if the downstream rival is less efficient than the downstream affiliate of integrated firm, the integrated firm raises rival's cost at foreclosing level as noticed by [Economides \(1998\)](#) and [Mandy \(2000\)](#). However, when goods are perfect differentiated, the integrated firm does not raise rival's cost. In addition, assuming increasing cost function of sabotage, the integrated firm may raise the rival's cost at intermediate level.

There are some recent literatures with respect to legal unbundling comparing other vertical forms. [Höffler and Kranz \(2011a\)](#)²⁶ compare four patterns of vertical structure, where perfect legal unbundling at least equally outperforms vertical integration and ownership separation, and the reverse legal unbundling never outperforms ownership separation in terms of total output. They say that absence of access charge regulation may weaken appealing properties of legal unbundling. [Höffler and Kranz \(2011b\)](#) in homogeneous quantity competition study imperfect legal unbundling, which the upstream monopolist has bias in favor of its downstream parent company. If the bias is determined by the ownership share of parent company, it is interpreted as that the parent firm chooses sabotage variable under legal unbundling. They find that legal unbundling does not always outperform ownership separation because the bias can become active strongly when the downstream parent company initially holds ownership share. [Fiocco \(2013\)](#) compares ownership separation with legal separation under regulatory limited information about upstream costs. Because the legally separated upstream monopolist alleviates the regulator's control problem, welfare under legal separation is higher than ownership separation. [Cremer and De Donder \(2013\)](#) focus on network investment. Their setting is different from others in terms of that the upstream monopolist owns one downstream firm, which is referred to the reverse legal unbundling in [Höffler and Kranz \(2011a\)](#). These two literatures do not take sabotage into account of the model. Above all papers however compare vertical forms under access charge is given, or proposed by the regulator.

Literature examining margin squeeze is also related with our study. In the context of the U.S.

²⁶ They assume that the downstream rival is more efficient in terms of marginal cost than the downstream incumbent.

view, [Carlton \(2008\)](#) expresses that margin squeeze does not require a separate abuse, but it is enough to apply refusal to deal or predatory pricing. There is a discussion whether margin squeeze should be banned. [Jullien et al \(2013\)](#) overview anti-competitive margin squeeze and discuss widely under which condition a separate regulation is required. [Petulowa and Saavedra \(2014\)](#) study the effect of margin squeeze ban under differentiated price competition. They show that when access charge is unregulated, margin squeeze happens as a result of not exclusionary but competitive behavior of vertically integrated firm²⁷. Similarly, this paper finds that margin squeeze does not foreclose the downstream rival.

An idea preventing both sabotage and margin squeeze is studied by [Weisman \(2014\)](#). He points out that there is access charge such that the integrated firm neither takes sabotage nor margin squeeze. He calls the combinations of such access charge and retail price “safe harbor margin ratio”. It is shown that safe harbor margin ratio has some ranges when downstream goods are differentiated with some degree while it is unique when the downstream goods are homogeneous.

The remainder of this paper is organized as follow. Section 3.3 introduces basic setting, where we derive the inverse demand function considering product differentiation, and assume profit functions and the timing of game. In Section 3.4, we obtain equilibrium under vertical integration and in Section 3.5, we obtain equilibrium under legal unbundling. In both Section 3.4 and 3.5, we study with and without constant access charge regulation. The results obtained in Section 3.4 and 3.5 will be compared in Section 3.6. Finally, we discuss the results by comparing with ownership separation then conclude this chapter in Section 3.7.

3.3. Basic setting

In Section 3.3, we introduce the model to analyze the problem in this chapter; we first, derive inverse demand function from the utility of consumer by considering product differentiation, second, set up profit functions of firms, and finally, explain timing of game.

Consumer

Following [Singh and Vives \(1984\)](#), we employ consumer’s utility function in general form as $U(\mathbf{q}, m) = \sum_{i=1}^n q_i \alpha_i - \frac{1}{2} (\sum_{i=1}^n \beta_i q_i^2 + 2\gamma \sum_{i \neq j} q_i q_j) + m$, where q_i , α_i , m and γ represent quantity of goods i , degree of consumer’s preference for goods i , quantity of numéraire, and degree of differentiation of goods; goods are recognized by consumer as perfect differentiated if $\gamma = 0$, imperfect differentiated if $\gamma \in (0,1)$, and homogeneous if $\gamma = 1$, by each. In this study, we assume

²⁷ They also examine the effect of margin squeeze ban under regulated upstream market. They find that margin squeeze ban under regulated upstream decreases consumer surplus while the ban under unregulated upstream can increase consumer surplus because of the decreasing rival’s cost.

that two goods are supplied by two competitors in downstream market, and $\beta_1 = \beta_2 = 1$, so the utility function turns to $U(q_1, q_2, m) = q_1\alpha_1 + q_2\alpha_2 - \frac{1}{2}(q_1^2 + q_2^2 + 2\gamma q_1 q_2) + m$. The problem for consumer is solved by maximizing its utility with budget constraint binding on income I , which is formulized by $\max_{q_1, q_2} U(q_1, q_2, m) \text{ s.t. } \sum p_i q_i + m \leq I$. After solving the consumer's problem, we obtain inverse demand function, $P_i = \alpha_i - q_i - \gamma q_j > 0, i, j = 1, 2 (i \neq j)$. Taking goods into account of some degree of differentiation but not perfect differentiation, we focus on $\gamma \in (0, 1]$.

Firms

We construct an industry by two-tiers, upstream market and downstream market. There are an upstream monopolist and two downstream competitors. Subscript 0, 1 and 2 represent an upstream monopolist, downstream incumbent and its rival. Profits are defined as $\pi_0 = w(q_1 + q_2) - kd^2$ for monopolist, $\pi_1 = [P_1 - c_1 - w]q_1$ for incumbent, and $\pi_2 = [P_2 - c_2 - w - d]q_2$ for rival. P_i and c_i are price and constant marginal cost of downstream goods for competitors $i = 1, 2$ by each. w is access charge, assuming that one access charge is input to supply one good. $d(\geq 0)$ is effect of “sabotage” imposed by the monopolist. Sabotage is observed as foreclosing behavior taken by vertically integrated upstream monopolist in telecommunication or electricity sectors²⁸. When the monopolist takes sabotage, it can raise marginal cost of downstream rival while it expenses increasing cost in level of sabotage $kd^2, k > 0$. This sabotage cost is interpreted as fine to pay if sabotage is detected. Sabotage is in a model similar to raising rival's cost (RRC) and non-price discrimination. Joint profit of monopolist and downstream incumbent is defined as $\pi_{01} \equiv \pi_0 + \pi_1$, so $\pi_{01} = [P_1 - c_1]q_1 + wq_2 - kd^2$. Regarding marginal costs for each firm, we transform them and define $\Delta \equiv (\alpha_2 - c_2) / (\alpha_1 - c_1)$, and standardizing $\alpha_1 - c_1 = 1$, then $\Delta = (\alpha_2 - c_2)$, which parameter measures relative efficiency per quality of goods²⁹; Rival is more efficient if $\Delta > 1$, less efficient if $\Delta < 1$, and equally efficient if $\Delta = 1$.

Timing of game

The game constructed here corresponds to two environments with respect to access charge: exogenously regulated access charge and endogenously unregulated access charge. Our analysis mainly focus on environment under unregulated access charge, where in stage 1 and stage 2, the monopolist sets access charge $w(\geq 0)$, consecutively chooses sabotage variable $d(\geq 0)$, and finally in stage 3, downstream competitors choose their quantities q_1 and q_2 simultaneously³⁰. To compare

²⁸ European Commission, Energy Sector Inquiry (Jan. 10, 2007), Competition report on energy sector inquiry, part 1, para 169, or para 493, p. 163

²⁹ We follow this model to Häckner (2000), Zanchettin (2006) and Petulowa and Saavedra (2014).

³⁰ Following Créti et al.(2013) and Bushnell et al.(2008), in liberalized electricity industry, downstream firms are assumed to choose quantities.

with the environment under regulated access charge, the game is reduced to be two stages; stage 1 in which the upstream monopolist chooses access charge is to be removed from the game.

We compare outcomes from two vertical forms in this industry. Under vertical integration, it is natural to model that objective functions for both the incumbent and monopolist are the joint profit π_{01} . Under legal unbundling, following [Höfler and Kranz \(2011 a\)](#)³¹, we model that objective function for the incumbent is the joint profit π_1 , while objective function for the monopolist is its own profit π_0 . We solve the three stage game backward, then obtain Subgame Perfect Nash Equilibrium (SPNE).

3.4. Equilibrium under vertical Integration

This section studies vertical integration under regulated access charge in Subsection 3.4.1 and unregulated access charge in Subsection 3.4.2. In both environments, we solve the game backward to obtain SPNE.

3.4.1. Regulated access charge

Stage 3

Vertically integrated firm and its downstream rival choose their quantities simultaneously to maximize their objective functions such that $q_1^* \in \arg\max \pi_{01}$ and $q_2^* \in \arg\max \pi_2$. Then, derived best response functions are $q_1(q_2) = \frac{1}{2}(\alpha_1 - c_1 - \gamma q_2)$ and $q_2(q_1) = \frac{1}{2}(\alpha_2 - c_2 - w - d - \gamma q_1)$. Solving these equations simultaneously, which leads to equilibrium prices and quantities at stage 3 denoted by superscript * as follow.

$$q_1^* = \frac{2 + \gamma(d + w - \Delta)}{4 - \gamma^2}, q_2^* = \frac{2(\Delta - d - w) - \gamma}{4 - \gamma^2}, Q^* \equiv q_1^* + q_2^* = \frac{1 - d - w + \Delta}{2 + \gamma}.$$

$$P_1^* = c_1 + w + \frac{2 - \gamma\Delta - w(4 - \gamma - \gamma^2) + d\gamma}{4 - \gamma^2}, P_2^* = c_2 + w + \frac{2\Delta - \gamma - 2w + d(2 - \gamma^2)}{4 - \gamma^2} \quad (3-1)$$

Substituting these prices and quantities to each profit function, then we obtain the equilibrium profits at stage 3 denoted by superscript * as

$$\pi_{01}^* = \frac{(2 + \gamma[d + w - \Delta])^2}{(4 - \gamma^2)^2} - \frac{w[\gamma + 2[d + w - \Delta]]}{4 - \gamma^2} - d^2k, \pi_2^* = \left(\frac{\gamma + 2[d + w - \Delta]}{4 - \gamma^2} \right)^2. \quad (3-2)$$

³¹ See also [Höfler and Kranz \(2011 b\)](#), [Cremer and De Donndor \(2013\)](#) and [Fiocco \(2013\)](#).

Stage 2

The integrated firm chooses sabotage as $d^V \in \operatorname{argmax} \pi_{01}^* \text{ s.t. } d \geq 0$. Then, we derive that the first order condition is $\frac{\partial \pi_{01}^*}{\partial d} = \frac{2\gamma(2-\gamma\Delta)-4(2-\gamma^2)w+2(\gamma^2-k(4-\gamma^2)^2)d}{(4-\gamma^2)^2}$ and the second order condition is $\frac{\partial^2 \pi_{01}^*}{\partial d^2} = \frac{2\gamma^2}{(4-\gamma^2)^2} - 2k < 0, \forall k > \frac{\gamma^2}{(4-\gamma^2)^2}$. Because the profit function π_{01}^* is quadratic with respect to d , and the second order condition is negative, π_{01}^* is concave function of d . In advance, we define that $\tilde{k} \equiv \frac{1}{4-\gamma^2}$ and $\tilde{\Delta} \equiv \frac{[k(4-\gamma^2)+1]\gamma}{2k(4-\gamma^2)}$ for the condition to ensure the rival's quantity positive later.

(i) Sabotage

After maximizing the profit of integrated firm, we have the optimal sabotage level d^V :

$$d^V = \frac{\gamma(2-\gamma\Delta) - 2(2-\gamma^2)w}{k(4-\gamma^2)^2 - \gamma^2}. \quad (3-3)$$

The condition for $d^V > 0$ with respect to k is obtained as below.

$$d^V > 0$$

$$\text{if } w < \tilde{w} \equiv \frac{\gamma(2-\gamma\Delta)}{2(2-\gamma^2)} \text{ when } k \geq 1 > \tilde{k} > \frac{\gamma^2}{(4-\gamma^2)^2}. \quad (3-4)$$

Following [Mandy and Sappington \(2007\)](#) who study in differentiated quantity competition, assuming no cost for sabotage ($k = 0$) in our model, the integrated firm was expected to do sabotage at foreclosing level when $\gamma = 1$. However, the integrated actually does not do sabotage at all. We also define the foreclosing sabotage level d^F such that $q_2^* = 0$:

$$d^F = \frac{2(\Delta - w) - \gamma}{2} \quad (3-5)$$

(ii) Margin squeeze

In a theory of predatory pricing, it is prohibited that the vertically integrated firm prices below its rival's marginal cost. Predatory pricing is expressed as $P_1 < c_1 + c$ in which c is marginal cost of upstream and we assume $c = 0$ in this study. This form of pricing is regulated in antitrust or

competition policy. However, it is possible for the integrated firm to foreclose its downstream rival with avoiding predatory pricing. When the integrated firm sets access charge imposed to its downstream rival higher, the access charge can be such that $c_1 + w > P_1 > c_1 + c$. While an increase in w results in $P_1 < c_1 + w$, rival's marginal profit can be negative $P_2 - c_2 - w < 0$, then it would make rival to be foreclosed from the downstream market. It is discussed that under which condition margin squeeze should be regulated. Following existing literature, we say that under regulated access charge w , margin squeeze happens at the equilibrium when the inequality holds as below³².

$$P_1^*(d^V) < c_1 + w$$

$$\text{if } w > \hat{w} \equiv \frac{k(4 - \gamma^2)(2 - \gamma\Delta)}{\gamma - \gamma^2 + k(4 - \gamma^2)(4 - \gamma - \gamma^2)} \text{ when } k \geq 1 > \tilde{k} \text{ given } \Delta > \tilde{\Delta} \quad (3-6)$$

(iii) Safe harbor access charge

We defined $\hat{w}$ and $\tilde{w}$ in Eq.(3-4) and Eq.(3-5). Next, we check whether $\hat{w} \geq \tilde{w}$ holds. When final goods are imperfect substitute $\gamma \in (0,1)$, it holds $\hat{w} > \tilde{w}$ if $k > \tilde{k}$ given $\Delta \in \left(\tilde{\Delta}, \frac{2}{\gamma} \right)$. Then, we say that $\hat{w}$ is the upper bound such that margin squeeze does not happen under no sabotage, and $\tilde{w}$ is the lower bound such that sabotage is not taken under no margin squeeze. Thus, if access charge is set at $w \in [\tilde{w}, \hat{w}]$, neither margin squeeze nor sabotage happen³³. Following [Weisman \(2014\)](#), we say the access charge that exists between the upper bound and the lower bound *safe harbor access charge*³⁴. When final goods are perfect substitute $\gamma = 1$, the upper bound and the lower bound converge to unique value $w^e \equiv \hat{w} = \tilde{w}$, and so does safe harbor access charge.

Subgame perfect Nash equilibrium

Substituting the optimal sabotage d^V which realizes at stage 2 into both q_1^* and q_2^* which realize at stage 3, we obtain the SPNE values.

The quantities are

$$q_1^*(d^V) = \frac{\gamma(k(4 - \gamma^2) - 1)}{k(4 - \gamma^2)^2 - \gamma^2} w + \frac{k(4 - \gamma^2)(2 - \gamma\Delta)}{k(4 - \gamma^2)^2 - \gamma^2}$$

$$\text{and } q_2^*(d^V) = - \left(\frac{2(k(4 - \gamma^2) - 1)}{k(4 - \gamma^2)^2 - \gamma^2} \right) w + \frac{k(4 - \gamma^2)(2\Delta - \gamma) - \gamma}{k(4 - \gamma^2)^2 - \gamma^2} \quad (3-7)$$

³² This margin squeeze formulation is following [Petulowa and Saavedra \(2014\)](#)

³³ Such a relationship between $\hat{w}$ and $\tilde{w}$ was also assured by [Weisman \(2014\)](#) in more general model.

³⁴ The range of safe harbor access charge is derived from $\hat{w} - \tilde{w} = \frac{(1-\gamma)(k(4-\gamma^2)^2 - \gamma^2)(2-\gamma\Delta)}{2(2-\gamma^2)(k(4-\gamma^2)((4-\gamma-\gamma^2)-\gamma^2+\gamma)}$.

and aggregating them,

$$Q^*(d^V) \equiv q_1^*(d^V) + q_2^*(d^V) = \frac{k(4 - \gamma^2)(2 - \gamma)(1 + \Delta - w) + (2 - \gamma)w - \gamma}{k(4 - \gamma^2)^2 - \gamma^2}$$

Downstream incumbent can be active, $q_1^*(d^V) > 0$ if $w > 0$ and $\Delta \in \left(\tilde{\Delta}, \frac{2}{\gamma}\right)$. Downstream rival

can be active, $q_2^*(d^V) > 0$ if $w < w^* \equiv \frac{k(4 - \gamma^2)(2\Delta - \gamma) - \gamma}{2[k(4 - \gamma^2) - 1]}$ and $\Delta > \tilde{\Delta}$. Each of them holds for

any $k \geq 1 > \tilde{k}$ and $\gamma \in (0, 1]$.

The prices are

$$P_1^*(d^V) = c_1 + \frac{\gamma(k(4 - \gamma^2) - 1)}{k(4 - \gamma^2)^2 - \gamma^2}w + \frac{k(4 - \gamma^2)(2 - \gamma\Delta)}{k(4 - \gamma^2)^2 - \gamma^2}$$

and $P_2^*(d^V) = c_2 + \frac{(2 - \gamma^2)(k(4 - \gamma^2) - 1)}{k(4 - \gamma^2)^2 - \gamma^2}w + \frac{k(4 - \gamma^2)(2\Delta - \gamma) + \gamma(1 - \gamma\Delta)}{k(4 - \gamma^2)^2 - \gamma^2}$ (3-8)

The sabotage level is as we showed

$$d^V = \frac{\gamma(2 - \gamma\Delta) - 2(2 - \gamma^2)w}{k(4 - \gamma^2)^2 - \gamma^2} \quad (3-9)$$

The profits are

$$\pi_{01}^* = \frac{w(w - \gamma) + k(-w^2(8 - 3\gamma^2) + (2 - \gamma\Delta)^2 + w(\gamma^3 + 8\Delta - 4\gamma^2\Delta))}{k(4 - \gamma^2)^2 - \gamma^2},$$

and $\pi_2^* = \left(\frac{-2(k(4 - \gamma^2) - 1)w + k(4 - \gamma^2)(2\Delta - \gamma) - \gamma}{k(4 - \gamma^2)^2 - \gamma^2}\right)^2 = (q_2^*(d^V))^2$ (3-10)

The condition on parameters $\{k, \Delta\}$ for $d^F > d^V > 0$ such that $q_2^* > 0$ is drawn as follow.

Condition

Under regulated access charge w is given, if $w < w^* \equiv \frac{k(4 - \gamma^2)(2\Delta - \gamma) - \gamma}{2[k(4 - \gamma^2) - 1]}$, the rival would be active

in the downstream market ($q_2^* > 0$) while the integrated firm does sabotage optimally ($d^V > 0$) to the extent under which parameters $\{k, \Delta\}$ are larger than $\{\tilde{k}, \tilde{\Delta}\}$. This condition is consistent with the assumption $k \geq 1$ because it holds $k \geq 1 > \tilde{k}$ for any $\gamma \in (0, 1]$.

The condition is derived as following manner. To find the optimal sabotage $d^V > 0$ such that $q_2^* > 0$, by using $d^F - d^V = \frac{(4-\gamma^2)\{-2(k(4-\gamma^2)-1)w+k(4-\gamma^2)(2\Delta-\gamma)-\gamma\}}{2(k(4-\gamma^2)^2-\gamma^2)}$, we draw a condition on parameters $\{k, \Delta\}$ for $d^V < d^F$. Taking account of d^V , if $w < \frac{k(4-\gamma^2)(2\Delta-\gamma)-\gamma}{2[k(4-\gamma^2)-1]} \equiv w^*$ satisfying with $k > \frac{1}{4-\gamma^2} \equiv \tilde{k}$ and $\Delta > \frac{[k(4-\gamma^2)+1]\gamma}{2k(4-\gamma^2)} \equiv \tilde{\Delta}$, it results in $d^V < d^F$ and then $q_2^*(d^V) > 0$. On the other hand, if $w = w^*$, it results in $d^V = d^F$ and then $q_2^*(d^V) = 0$; w^* is a crossing point such that d^V is equivalent to d^F .

Effect of access charge

We provide three cases for which threshold w^* or $\tilde{w}$ become lower than another or are equivalent (1) $\min[w^*, \tilde{w}] = \tilde{w}$ if $\Delta > \gamma$, (2) $w^* = \tilde{w}$ if $\Delta = \gamma$, (3) $\min[w^*, \tilde{w}] = w^*$ if $\Delta < \gamma$. These conditions are relevant with $k > \tilde{k}, \forall \gamma \in (0,1]$. Under the regulated access charge, we can explain four cases as shown in [Figure 3-1](#). We can see that $d^V > 0$ and $q_2^*(d^V) > 0$ go together from case (i) to (iii) while that $d^V > 0$ and $q_2^*(d^V) = 0$ from case (iv) below.

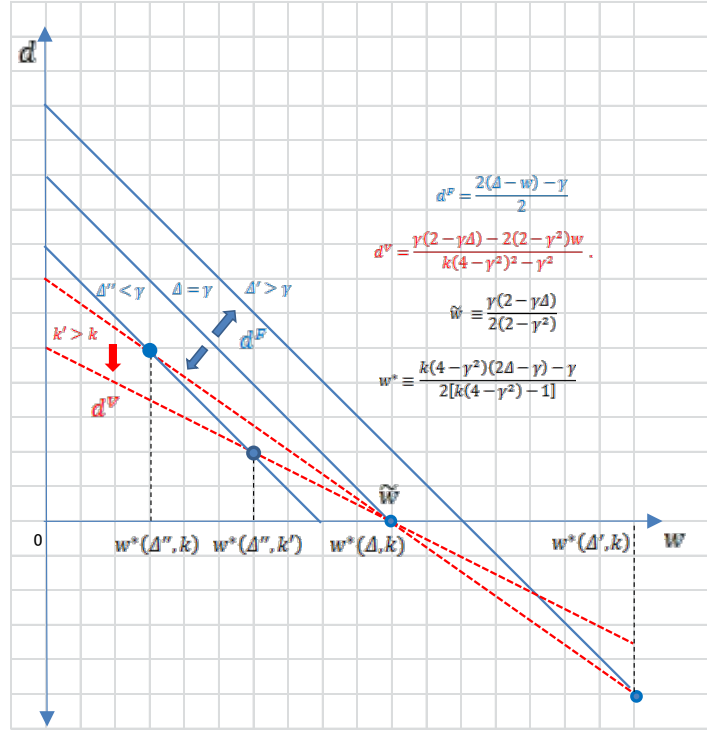
- (i) $w < \tilde{w} = w^*(\Delta, k)$ if $\Delta = \gamma \Rightarrow d^F > d^V > 0$ and $q_2^*(d^V) > 0$
- (ii) $w < \tilde{w} < w^*(\Delta', k)$ if $\Delta' > \gamma \Rightarrow d^F > d^V > 0$ and $q_2^*(d^V) > 0$
- (iii) $w < w^*(\Delta'', k) < \tilde{w}$ if $\Delta'' < \gamma \Rightarrow d^F > d^V > 0$ and $q_2^*(d^V) > 0$
- (iv) $w^*(\Delta'', k) \leq w < \tilde{w}$ if $\Delta'' < \gamma \Rightarrow d^F = d^V > 0$ and $q_2^*(d^V) = 0$

When the rival can be equally efficient to the downstream incumbent like $\Delta = \gamma$, the integrated firm optimally chooses sabotage at no foreclosing level as long as $w < \tilde{w} = w^*(\Delta, k)$, the rival is to be active in the downstream market.

In case (i) and (ii), an increase in the degree of cost of sabotage like $k' > k$ does not change the extent of access charge to which the rival is not foreclosed. In case (iii), the rival can be foreclosed easily by taking sabotage because the extent of access charge to which the rival is not foreclosed becomes narrower. However, an increase in the degree of cost of sabotage like $k' > k$ makes foreclosing harder because the extent of access charge to which the rival is not foreclosed becomes wider: $w < w^*(\Delta'', k) < w^*(\Delta'', k') < \tilde{w}$.

Hence, under the exogenously regulated access charge, how costly sabotage is important for the rival not to be foreclosed easily when the rival is never efficient than the downstream incumbent while it is not important for the rival so much not to be foreclosed when the rival can be equally or more efficient.

Figure 3-1: Effect of regulated access charge w^* on sabotage



Note: The solid line shows d^F and the dotted line shows d^V . The d^F line shifts in parallel upward or downward by Δ and γ . The d^V line moves counterclockwise as k becomes larger. Intercept on vertical axis of d^F is higher than that of d^V since the sign of the difference between them is

calculated as $\frac{2\Delta - \gamma}{2} - \frac{\gamma(2 - \gamma\Delta)}{k(4 - \gamma^2)^2 - \gamma^2} = \frac{(4 - \gamma^2)(k(4 - \gamma^2)(2\Delta - \gamma) - \gamma)}{2(k(4 - \gamma^2)^2 - \gamma^2)} > 0$ if $k > \frac{\gamma}{(4 - \gamma^2)(2\Delta - \gamma)}$ and $2\Delta > \gamma$.

3.4.2. Unregulated access charge

To obtain equilibrium values under unregulated access charge, we solve for the access charge at stage 1 by substituting equilibrium values obtained under regulated access charge into the profit of integrated firm.

Stage 1

The profit functions for each firm obtained at stage 2 by solving backward are explained as Eq. (3-10). The integrated firm chooses access charge such that $w^V \in \arg\max \pi_{01}^*$. Then we have,

$$w^V = \frac{4k(2 - \gamma^2)\Delta + k\gamma^3 - \gamma}{2k(8 - 3\gamma^2) - 2}. \quad (3-11)$$

It holds $w^V > 0$ no matter which $\Delta \geq 1$ or $\Delta < 1$ ³⁵.

³⁵ This is proven in Appendix 1.

Subgame perfect Nash equilibrium

By substituting the equilibrium values obtained at stage 1 and stage 2 to the equilibrium values at stage 3, we derive the SNPE values under the vertical integration. The SPNE values $q_i^V, P_i^V, d^V, \pi_{01}^V, \pi_2^V$ and CS^V are quantities, prices, sabotage, profits and consumer surplus, which are expressed by only parameters, the degree of substitution of final goods γ , the degree of relative efficiency Δ , and the degree of cost for sabotage k . By rewriting the utility function, we have $U(q_1, q_2) = q_1\alpha_1 + q_2\alpha_2 - \frac{1}{2}(q_1^2 + q_2^2) - \gamma q_1 q_2 - (P_1 q_1 + P_2 q_2) + I$. Substituting P_i^V and q_i^V into P_i and q_i for $i = 1, 2$ and then replacing $\alpha_1 = 1 + c_1$ and $\alpha_2 = \Delta + c_2$, which leads to consumer surplus. We provide the SPNE values in next page.

The quantities are

$$q_1^V = \frac{k(8 - \gamma^2 - 2\gamma\Delta) - 1}{2(k(8 - 3\gamma^2) - 1)} \quad \text{and} \quad q_2^V = \frac{4k(\Delta - \gamma)}{2(k(8 - 3\gamma^2) - 1)}.$$

and aggregating them, (3-12)

$$Q^V \equiv q_1^V + q_2^V = \frac{k(8 + 4[\Delta - \gamma] - 2\Delta\gamma - \gamma^2) - 1}{2(k(8 - 3\gamma^2) - 1)}.$$

Downstream incumbent can be active, $q_1^*(d^V) > 0$ if $\frac{8k - \gamma^2 k - 1}{2\gamma k} > \Delta$. Downstream rival can be active, $q_2^*(d^V) > 0$ if $\Delta > \gamma$.

The prices are

$$P_1^V = c_1 + \frac{k(8 - \gamma^2 - 2\gamma\Delta) - 1}{2[k(8 - 3\gamma^2) - 1]}$$

$$\text{and } P_2^V = c_2 + \frac{2\Delta[2k(3 - \gamma^2) - 1] - \gamma[k(4 - \gamma^2) - 1]}{2[k(8 - 3\gamma^2) - 1]}.$$
(3-13)

The sabotage level is

$$d^V = \frac{\gamma - \Delta}{k(8 - 3\gamma^2) - 1} \geq 0 \quad \text{if } \gamma \geq \Delta.$$
(3-14)

The profits are

$$\pi_{01}^V = \frac{k(8 + \gamma^2 - 8\gamma\Delta + 4\Delta^2) - 1}{4(k(8 - 3\gamma^2) - 1)}$$

$$\text{and } \pi_2^V = \frac{4k^2(\Delta - \gamma)^2}{(k(8 - 3\gamma^2) - 1)^2} = (q_2^V)^2 > 0 \quad \text{if } \Delta > \gamma$$
(3-15)

Finally, the consumer surplus is

$$CS^V \equiv \frac{1 + k^2[9\gamma^4 + 12\gamma^3\Delta + 4(4 - 3\gamma^2)\Delta^2 + (1 - \gamma^2)64] - 2k(8 - 5\gamma^2 + 2\gamma\Delta)}{8(k(8 - 3\gamma^2) - 1)^2} + I.$$
(3-16)

We can see that immediately $P_1^V = c_1 + q_1^V$, and that $P_2^V > c_2$ ³⁶.

When it holds $\Delta = \gamma$, while the rival cannot be active in the downstream market ($q_2^V = 0$), the integrated downstream monopolizes the market without sabotage ($d^V = 0$) and supplies more than duopoly level it engaged before; we can see that decrease in Δ to be equal to γ makes q_1^V increase. Even if the cost of sabotage is assumed to be an increasing function in our model, the integrated firm does sabotage up to the foreclosing level when there is an incentive for sabotage. This result is unexpected one because we expected that the integrated firm would choose sabotage at intermediate level in which the rival would not be foreclosed from the downstream market³⁷. This can be explained that the integrated firm benefits from monopolization more than paying fine for foreclosing the rival.

It is necessary to hold $\Delta > \gamma$ for the rival to be active ($q_2^V > 0$). This implicates that the more homogeneous the final goods are, the more required to be efficient the rival is. Ultimately, when final goods are perfect substitute ($\gamma = 1$), the rival must be more efficient ($\Delta > 1$). The condition for the rival to be active is inconsistent with the condition for sabotage ($\gamma > \Delta$). In other words, the condition for the rival to be active is equivalent to the condition for the integrated firm not to do sabotage. Together all, both firms supply if $\Delta \in \left(\gamma, \frac{8k - \gamma^2 k - 1}{2\gamma k}\right)$. The relative efficiency for the rival (Δ) is only the factor to sabotage, but not the degree of cost of sabotage k .

When the rival can be at least equally efficient to the downstream incumbent $\Delta \geq \gamma$, then the integrated firm chooses access charge not to do sabotage: $\tilde{w} < w^V < w^*$. When the rival is never efficient than the downstream incumbent $\Delta' < \gamma$, then the integrated firm chooses access charge to do sabotage at foreclosing level: $w^* < w^V < \tilde{w}$.

By taking account of unregulated access charge w^V , we rewrite the condition under which margin squeeze happens as

$$w^V > \hat{w} \text{ if } \Delta > \Delta^M > \gamma > \tilde{\Delta} \text{ where } \Delta^M \equiv \frac{k(8 - \gamma^2 - \gamma^3) + \gamma - 1}{2k(4 + \gamma - 2\gamma^2)} \text{.} \quad (3-17)$$

Even if margin squeeze happens, the rival supplies to downstream market and the integrated firm does not do sabotage; that is $q_2^V > 0$ but $d^V = 0$. As we know under regulated access charge, if the relative efficiency for the rival is $\Delta > \gamma$, margin squeeze can happen instead of sabotage. Under unregulated access charge, if the rival is more efficient such that $\Delta > \Delta^M > \gamma$, margin squeeze does

³⁶ This is proven in Appendix 2.

³⁷ Mandy and Sappington (2007) say that when the cost function of sabotage is increasing, there might be an interior solution of sabotage. That level of sabotage is not foreclosing but intermediate one.

³⁸ This condition is proven in Appendix 4.

happen, where q_2^V is smaller than the case in no margin squeeze. Increase in Δ more than Δ^M makes q_1^V decrease. This result is consist with [Petulowa and Saavedra \(2014\)](#), who show that under unregulated upstream market margin squeeze happens if the downstream rival is relatively more efficient³⁹.

To understand the condition for margin squeeze more intuitively, think the case of $\gamma = 1$. Then, we can see what to the extent that the degree of relative efficiency is acceptable for the integrated firm; that is $q_1^V(\Delta, k) > 0$ if $\frac{7k-1}{2k} > \Delta$ when $k > \frac{1}{3}$. Assuming $k = \frac{2}{3} > \frac{1}{3}$ for example, the condition turns to be $2.75 > \Delta$. Thus, the integrated firm does not care about how much the rival is more or less efficient so much.

We are interested in how the relationship between Δ and γ affects Q^V , because the positive $\Delta - \gamma$, as we know, is the condition for make the rival be active in downstream market, and increases Q^V while Q^V decreases in $\Delta\gamma$. Thereby, Q^V is affected by whether $4[\Delta - \gamma] - 2\Delta\gamma - \gamma^2$ is positive or negative; formally, Q^V is larger if $\Delta \geq \frac{\gamma(4+\gamma)}{2(2-\gamma)}$ compared with $\Delta < \frac{\gamma(4+\gamma)}{2(2-\gamma)}$. In numerical explanation, Q^V is larger if $\Delta \geq 2.5$, $\Delta \geq 1$ and $\Delta \geq 0.75$ when $\gamma = 1$, $\gamma \approx 0.6$ and $\gamma = 0.5$ by each.

Effect of access charge

We show that the unregulated access charge does not let $q_2^V > 0$ and $d^V > 0$ go together by two properties with respect to w^V as follow. First, the condition under which $w^V > 0$ such that $q_2^V > 0$ is drawn by $w^V < w^*$ if $\Delta > \gamma$. Second, the condition under which $w^V > 0$ such that $d^V > 0$ is drawn by $w^V < \tilde{w}$ if $\gamma > \Delta > \tilde{\Delta}$. These two properties bring three results as follow⁴⁰.

- (i) $w^* > w^V > \tilde{w}$ if $\Delta > \gamma \Rightarrow q_2^V > 0$ and $d^V = 0$.
- (ii) $w^* = w^V = \tilde{w}$ if $\Delta = \gamma \Rightarrow q_2^V = 0$ and $d^V = 0$.
- (iii) $\tilde{w} > w^V > w^*$ if $\Delta < \gamma \Rightarrow q_2^V = 0$ and $d^V > 0$.

Summarizing, we find that it is not feasible that $w^V < \min[\tilde{w}, w^*]$ where $q_2^V > 0$ and $d^V > 0$. Thus, we obtain proposition 1 in next page.

³⁹ This type of margin squeeze is called “technological margin squeeze” in their study.

⁴⁰ The relationship among w^* , $\tilde{w}$, $\hat{w}$ and w^V are proven in Appendix 3.

Proposition 1

Under unregulated access charge,

(A) when the downstream rival can be at least equally efficient to the integrated downstream, the integrated firm does not do sabotage, then the rival is active in the downstream market, and

(B) when the downstream rival is never efficient than the integrated downstream, the integrated firm does sabotage at foreclosing level, then the rival cannot be active in the downstream market which results in monopolization.

This proposition 1 is related with [Beard et al.\(2001\)](#) who investigated the incentive for sabotage under both regulated and unregulated access charge.

It is well known that the merit of vertical integration is to overcome double marginalization problem that happens if it were vertically separated. It is beneficial not only for firms' interests but also expanding outcome. This is a reason why firms have incentives to vertically integrate and vertical integration is desirable in terms of total welfare. However, under monopolistic upstream market, if vertically integrated firm can do sabotage/RRC by means of non-price discrimination to its downstream rival, vertical integration could be harmful for fair competition and market outcome. Hence, this is not only academic but also policy issue to rethink of the vertical structure of industry with upstream monopolist. In next section, we analyze model under legal unbundling when the upstream monopolist is assumed, contrary to previous studies, to be able to choose access charge.

3.5. Equilibrium under legal unbundling

In this section, we change our point of view on the vertical form from vertical integration to legal unbundling; the integrated firm is separated to a downstream incumbent as parent company and an independent upstream monopolist. The downstream incumbent is a perfect shareholder of the upstream monopolist while the upstream monopolist does not hold any ownership share of the downstream incumbent. Following [Höfler and Kranz \(2011a\)](#), legal unbundling in our study is modeled into two features. First, the downstream incumbent chooses its quantity at stage 3 to maximize joint profit as well as it were vertically integrated firm. Second, the upstream monopolist chooses the level of access charge at stage 1 and then the level of sabotage at stage 2 to maximize its own profit by each stage. Solving three stages game backward, we obtain equilibrium as follow in Subsection 3.5.1 for regulated access charge and Subsection 3.5.2 for unregulated access charge.

3.5.1. Regulated access charge

Stage 3

Now, the downstream incumbent fully holding the share of upstream monopolist and its downstream rival choose their quantities simultaneously as well as under vertical integration; formally, they choose $q_1^* \in \arg\max \pi_{01}$ and $q_2^* \in \arg\max \pi_2$. Then we obtain same equilibrium values at stage 3 as what we had in vertical integration model.

Stage 2

(i) Sabotage

We define d^L as the sabotage level that the upstream monopolist chooses optimally at stage 2 under legal unbundling. Solving the problem described as $d^L \in \arg\max \pi_0(q_i^*, P_i^*)$ s. t. $d \geq 0$ leads to

$$d^L = 0 . \quad (3-18)$$

Because the level of sabotage in this study is assumed to be non-negative ($d \geq 0$), the upstream monopolist chooses no sabotage instead of choosing sabotage at negative level⁴¹. When access charge is regulated, it is straightforward to see that total output under no sabotage is larger than that under choosing sabotage at positive level⁴². This result comes from that the upstream monopolist can increase its profit by only increasing in total output in downstream market. If the monopolist does sabotage, total output will not increase. Hence, when access charge is regulated, legal unbundling is better than vertical integration in terms of total output as mentioned in current studies. However, when access charge is unregulated and is set endogenously, we show that the result is reversed in next section.

(ii) Margin squeeze

Because margin squeeze is known as the problem that can happen under vertical integration, we ignore the analysis of margin squeeze here. For readers who are interested in investigation of margin squeeze under legal unbundling, see Appendix 5.

⁴¹ If we assume to the extent of negative sabotage, the solution would be $d^L = -\left(\frac{w}{2k(2+\gamma)}\right) < 0$. [Höffler and Kranz \(2011 a\)](#) also analyze in investments in reducing upstream marginal cost and into network capacity by means of sabotage variable d . Referring [Arya and Sappington \(2013\)](#), assuming that the upstream monopolist engages in R&D to help decrease its downstream rival's cost, it is possible to d takes negative.

⁴² This is formally expressed as $Q^*(d = 0) > Q^*(d > 0) \rightarrow \frac{1-w+\Delta}{2+\gamma} > \frac{1-d-w+\Delta}{2+\gamma}$.

Subgame perfect Nash equilibrium

The SPNE values under regulated access charge are expressed as follow.

The quantities are

$$q_1^*(d^L) = \frac{2 - \gamma(\Delta - w)}{4 - \gamma^2} \quad \text{and} \quad q_2^*(d^L) = \frac{2(\Delta - w) - \gamma}{4 - \gamma^2}$$

Aggregating them,

$$Q^*(d^L) \equiv q_1^*(d^L) + q_2^*(d^L) = \frac{1 + \Delta - w}{2 + \gamma} \quad (3-19)$$

Downstream incumbent can be active, $q_1^*(d^L) > 0$ if $\frac{2+w\gamma}{\gamma} > \Delta$. Downstream rival can be active, $q_2^*(d^L) > 0$ if $\Delta > \frac{2w+\gamma}{2}$.

The prices are

$$P_1^*(d^L) = c_1 + \frac{\gamma^2}{4 - \gamma^2}w + \frac{2 - \gamma\Delta}{4 - \gamma^2} \quad \text{and} \quad P_2^*(d^L) = c_2 + \frac{2 - \gamma^2}{4 - \gamma^2}w + \frac{2\Delta - \gamma}{4 - \gamma^2} \quad (3-20)$$

The profits are

$$\pi_0^*(d^L) = \frac{w(1 - w + \Delta)}{2 + \gamma},$$

$$\pi_1^*(d^L) = \frac{(2 - \gamma(\Delta - w))(2 - w(4 - \gamma - \gamma^2) - \gamma\Delta)}{(4 - \gamma^2)^2} \quad \text{and} \quad \pi_2^*(d^L) = \left(\frac{2(\Delta - w) - \gamma}{4 - \gamma^2} \right)^2 \quad (3-21)$$

Downstream incumbent gains $\pi_1^*(d^L) > 0$ if $\frac{2+w\gamma}{\gamma} > \frac{2-w(4-\gamma-\gamma^2)}{\gamma} > \Delta$. Downstream rival gains $\pi_2^*(d^L) > 0$ if $\frac{2-w(4-\gamma-\gamma^2)}{\gamma} > \Delta > \frac{2w+\gamma}{2}$. Together all, both downstream firms are to be active in the market and gain profits

$$\text{if } \frac{2 + w\gamma}{\gamma} > \frac{2 - w(4 - \gamma - \gamma^2)}{\gamma} > \Delta > \frac{2w + \gamma}{2}. \quad (3-22)$$

This inequality (3-22) holds because

$$\frac{2 + w\gamma}{\gamma} - \frac{2 - w(4 - \gamma - \gamma^2)}{\gamma} = w \left(\frac{4}{\gamma} - \gamma \right) > 0$$

$$\text{and } \frac{2 - w(4 - \gamma - \gamma^2)}{\gamma} - \frac{2w + \gamma}{2} = \frac{(1 - 2w)(4 - \gamma^2)}{2\gamma} > 0 \quad \text{if } \frac{1}{2} > w > 0 \quad (3-23)$$

3.5.2. Unregulated access charge

The upstream monopolist chooses w^L to maximize its own profit taking account of the equilibrium values realized at stage 2 and stage 3.

Stage 1

Solving the problem described as $w^L \in \arg\max \pi_0(d^L, q_i^*, P_i^*)$, which leads to

$$w^L = \frac{1 + \Delta}{2}. \quad (3-24)$$

As we can see that, the optimal unregulated access charge w^L is now not affected by the degree of differentiation of goods and the degree of cost for sabotage, but affected by only the degree of relative efficiency Δ . The more efficient downstream rival is, the higher access charge becomes.

Subgame perfect Nash equilibrium

Taking account of the equilibrium values obtained at stage 1 and stage 2 by solving backward, we have the SPNE values. The SPNE values under legal unbundling are $q_i^L, P_i^L, d^L, \pi_i^L$ and CS^L , which are expressed by only parameters: the degree of substitution of final goods γ , the degree of relative efficiency Δ , and the degree of cost for sabotage k .

The quantities are

$$q_1^L = \frac{4 + (1 - \Delta)\gamma}{8 - 2\gamma^2} \quad \text{and} \quad q_2^L = \frac{2(\Delta - 1 - \gamma)}{8 - 2\gamma^2}$$

Aggregating them,

$$Q^L \equiv q_1^L + q_2^L = \frac{1 + \Delta}{4 + 2\gamma}. \quad (3-25)$$

Downstream incumbent can be active $q_1^L > 0$ if $\frac{4+\gamma}{\gamma} > \Delta$. Downstream rival $q_2^L > 0$ can be active

if $\Delta > \gamma + 1$.

The prices are

$$P_1^L = c_1 + \frac{4 + (1 - \Delta)\gamma}{8 - 2\gamma^2}$$

$$\text{and } P_2^L = c_2 + \frac{2 + (6 - \gamma^2)\Delta - (2 + \gamma)\gamma}{8 - 2\gamma^2}. \quad (3-26)$$

The profits are

$$\pi_0^L = \frac{(1 + \Delta)^2}{4(2 + \gamma)},$$

$$\pi_1^L = \frac{(4 + (1 - \Delta)\gamma)(-4\Delta + \gamma(1 + \gamma - (1 - \gamma)\Delta))}{4(4 - \gamma^2)^2} \text{ and } \pi_2^L = \frac{(\Delta - \gamma - 1)^2}{(4 - \gamma^2)^2} \quad (3-27)$$

Downstream incumbent gains $\pi_1^L > 0$ if $\frac{\gamma + \gamma^2}{4 + \gamma - \gamma^2} > \Delta$. Downstream rival gains $\pi_2^L > 0$ if $\Delta > \gamma + 1$.

Together all, we can see that only one downstream firm is to be active in the market and gain profits⁴³. Only downstream incumbent is to be active and gain profit if $\frac{4 + \gamma}{\gamma} > \gamma + 1 > \frac{\gamma + \gamma^2}{4 + \gamma - \gamma^2} > \Delta$.

Otherwise, only downstream entrant is to be active and gain profit if $\frac{4 + \gamma}{\gamma} > \Delta > \gamma + 1 > \frac{\gamma + \gamma^2}{4 + \gamma - \gamma^2}$.

As we can see, these two inequalities cannot go together. There is a trade-off between downstream firms. The downstream market becomes monopoly. When access charge is unregulated, under legal unbundling, the rival must be more efficient than the downstream incumbent whatever γ takes because we assume that γ is larger than 0. In particular, when goods are homogeneous, the rival must be efficient to supply more than twice as much as the downstream incumbent is. This is very tough requirement on efficiency for the rival to be active in downstream market.

Finally, we calculate consumer surplus under legal unbundling in a same manner as before. Substituting the equilibrium values P_i^L and q_i^L for $i = 1, 2$ into the utility function rewritten, then we have

$$CS^L \equiv \frac{(4 - 3\gamma^2)(5 - (2 - \Delta)\Delta) - 4\gamma^3(1 - \Delta)}{8(4 - \gamma^2)^2} + I. \quad (3-28)$$

⁴³ We can derive the inequalities in the text by calculating

$$\frac{4 + \gamma}{\gamma} - (\gamma + 1) = \frac{4}{\gamma} - \gamma > 0$$

$$\frac{4 + \gamma}{\gamma} - \frac{\gamma + \gamma^2}{4 + \gamma - \gamma^2} = \frac{2(2 - \gamma)(2 + \gamma)^2}{\gamma(4 + \gamma - \gamma^2)} > 0$$

$$\text{and } \frac{\gamma + \gamma^2}{4 + \gamma - \gamma^2} - (\gamma + 1) = \frac{-(2 - \gamma)(1 + \gamma)(2 + \gamma)}{4 + (1 - \gamma)\gamma} < 0$$

3.6. Comparison of vertical integration and legal unbundling

In this section, we compare the SPNE values obtained under vertical integration with that under legal unbundling. We focus on values realized under unregulated access charge. The results are as follow. Both access charge and prices for each goods under vertical integration are lower than those under legal unbundling; $w^V < w^L$ and $P_i^V < P_i^L$ for $i = 1, 2$. Quantity for the downstream incumbent under vertical integration is also smaller than that under legal unbundling, while quantity for the rival is larger ; $q_1^V < q_1^L$ and $q_2^V > q_2^L$. Total quantity under vertical integration is larger than that under legal unbundling; $Q^V > Q^L$. In other words, compared to the individual quantities under vertical integration, under legal unbundling the reduction in rival's quantity is bigger than the increase in the incumbent's quantity. Under both vertical forms, the downstream incumbent supplies more than the rival; $q_1^f > q_2^f$ for $f = V, L$. Regarding the prices, if we assume $c_1 = c_2$, price of goods 1 is no higher than price of goods 2 when the rival is not less efficient so much for $\gamma \in (0, 1)$ or the rival is at least equally efficient for $\gamma = 1$; formally they are expressed that $P_1^V \leq P_2^V$ if $\Delta \geq \frac{k(8+\gamma(4-\gamma-\gamma^2))-(1+\gamma)}{2[k(2-\gamma)(3+2\gamma)-1]}$ and $P_1^L \leq P_2^L$ if $\Delta \geq \frac{1+\gamma}{3-\gamma}$. All above are calculated in Appendix 6. We obtain proposition 2 below.

Proposition 2

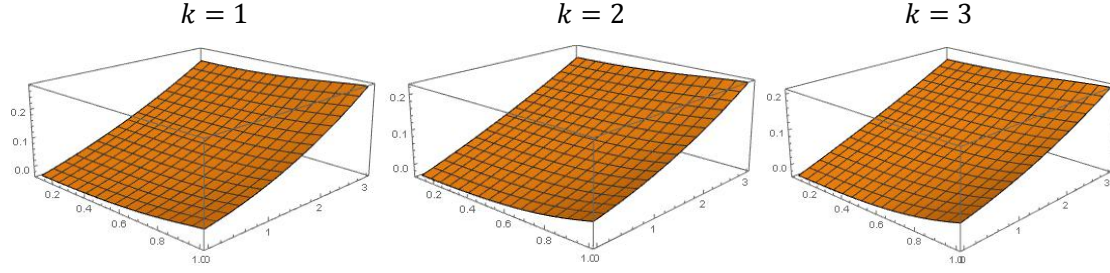
Under which the access charge is unregulated,

- (A)** *total output is larger and access charge is lower under vertical integration than legal unbundling,*
- (B)** *for downstream incumbent goods, its price is higher and its output is larger under legal unbundling than vertical integration, and*
- (C)** *the downstream incumbent is competitive under both vertical forms. In particular under legal unbundling, the downstream incumbent strengthens its competitiveness and expands its output.*

Proposition 2 can be interpreted as follow.

Proposition 2(A). Under vertical integration, no matter which the rival is equally, more or less efficient than the downstream incumbent, the effect of mitigating the double marginalization problem is more than the potential effect of raising rival's cost. The integrated firm can set access charge at profitable level without sabotage. Under legal unbundling, the upstream monopolist sets access charge at high level to enjoy monopolistic profit. Therefore, the access charge is higher under legal unbundling than vertical integration.

Figure 3-2: Variation in CS between vertical integration and legal unbundling



Note: For given $k \in \{1, 2, 3\}$, $CS^V - CS^L$ takes non-negative on height, Δ takes from 0 to 3 on width and γ takes from more than 0 to 1 on length by 0.1.

Proposition 2 (B). Under legal unbundling, the downstream incumbent expands its output by taking account of the upstream interest from the following reason. As we mentioned, the upstream monopolist sets access charge higher, which turns into higher marginal cost for the downstream firms. Consequently, the rival is to shrink its output, then its price increases. In contrast, the downstream incumbent responds to the rival by expanding its output. This is strategic substitution.

Proposition 2 (C). Under vertical integration, the downstream incumbent supplies more than the rival because of the effect of diminishing double marginalization problem. Under legal unbundling, the downstream incumbent supplies more than the rival because of considering the upstream profit and its effect on the downstream rival.

Calculating variation in consumer surplus between under vertical integration and legal unbundling,

$$\begin{aligned}
 & CS^V - CS^L \\
 &= \frac{1+k^2[9\gamma^4+12\gamma^3\Delta+4(4-3\gamma^2)\Delta^2+(1-\gamma^2)64]-2k(8-5\gamma^2+2\gamma\Delta)}{8(k(8-3\gamma^2)-1)^2} - \frac{(4-3\gamma^2)(5-(2-\Delta)\Delta)-4\gamma^3(1-\Delta)}{8(4-\gamma^2)^2} \\
 &= \frac{-(k(8-3\gamma^2+\gamma^2[\Delta-\gamma])+[\Delta-\gamma]-1)(\gamma(4+\gamma^2+3\gamma(1-\Delta))-4(1-\Delta)+k(32-64\Delta-\gamma^2(36+\gamma(28-3\gamma(3+3\gamma-5\Delta))-68\Delta)))}{8(4-\gamma^2)^2(k(8-3\gamma^2)-1)^2}
 \end{aligned} \tag{3-29}$$

It is difficult to see that which consumer surplus is larger by equation above because the equation is expressed by three parameters. Instead, we reduce the parameters from three to two by fixing k for some values: $k = 2$, $k = 1$ and $k = 0.5$, and numerically shows how $CS^V - CS^L$ changes in Δ and γ . In Figure 3-2, taking $CS^V - CS^L$ on height, Δ on widths, and γ on lengths, we can see that $CS^V - CS^L > 0$ for $k \in \{0.5, 1, 2\}$. Therefore, we say consumer surplus under vertical integration is larger than legal unbundling, and obtain Proposition 3 as follow.

Proposition 3

When access charge is unregulated, consumer surplus under vertical integration is higher than legal unbundling $CS^V > CS^L$.

In this section, under unregulated access charge, we compared the outcome of vertical integration to that of legal unbundling from the point of view of consumers. Summarizing, total output and consumer surplus are larger under vertical integration than legal unbundling. Vertical integration outperforms legal unbundling if the upstream monopolist is not regulated.

3.7. Discussion and conclusion

Under ownership unbundling, when access charge is unregulated, we can imagine that the double marginalization problem becomes more severe. In this sense, perfect legal unbundling without any bias is better than ownership unbundling. As [Höffer and Kranz \(2011 b\)](#) say, under regulated constant access charge, when legal unbundling is imperfect such that the upstream monopolist has a bias in favor of its parent firm in downstream, ownership unbundling can be better in terms of total output. Specifically, if the bias is to be active immediately after the parent downstream firm initially holds ownership share, downstream market becomes monopoly under legal unbundling, so ownership unbundling is desirable by shutting the bias out of the upstream monopolist.

In this study, assuming that access charge is unregulated and chosen endogenously by the upstream monopolist, we compared which vertical form is better in terms of total output and consumer surplus under vertical integration or legal unbundling in differentiated quantity competition model. We consider not only sabotage but also margin squeeze. Sabotage and margin squeeze are not coincident. When the access charge is unregulated, if the integrated firm has an incentive to do sabotage, the rival is to be foreclosed from the market, whereas if the integrated firm prices in which margin squeeze happens, the rival's quantity decreases but the rival can be active in the downstream market. We finally show that vertical integration is better, which result is contrast to existing literature which say that, under regulated access charge, the total output under legal unbundling is equal to or bigger than vertical integration. This result comes from what the effect of overcoming double marginalization problem is larger than potential effect of raising rival's cost.

Appendices

Appendix 1

$$w^V > 0$$

$$\text{if } k \geq 1 > \tilde{k} > \frac{1}{8-3\gamma^2} \geq \frac{\gamma}{4(2-\gamma^2)\Delta + \gamma^3} \text{ when } \Delta \geq 1 > \tilde{\Delta}$$

$$\text{or if } k \geq 1 > \tilde{k} > \frac{\gamma}{4(2-\gamma^2)\Delta + \gamma^3} > \frac{1}{8-3\gamma^2} \text{ when } 1 > \Delta > \tilde{\Delta}.$$

No matter which $\Delta \geq 1$ or $\Delta < 1$, it holds that $\tilde{k}$ is larger than both $\frac{1}{8-3\gamma^2}$ and $\frac{\gamma}{4(2-\gamma^2)\Delta + \gamma^3}$. Thus,

we have $w^V > 0$ for any $k \geq 1 > \tilde{k}$. Hence, the unregulated access charge is always positive $w^V > 0$, regardless the rival is more or less efficient than the integrated downstream, i.e. $\Delta \geq 1$ or $\Delta < 1$ ■

Appendix 2

Assuming $P_2^V \geq c_2$, it must satisfy

$$\frac{2\Delta[2k(3-\gamma^2)-1]-\gamma(k(4-\gamma^2)-1)}{2[k(8-3\gamma^2)-1]} \geq 0 \text{ if } k > \tilde{k} \text{ and } \Delta \geq \tilde{\Delta}' \equiv \frac{[k(4-\gamma^2)-1]\gamma}{2[2k(3-\gamma^2)-1]}$$

However,

$$\tilde{\Delta} - \tilde{\Delta}' = \frac{[k(4-\gamma^2)+1]\gamma}{2k(4-\gamma^2)} - \frac{[k(4-\gamma^2)-1]\gamma}{2[2k(3-\gamma^2)-1]} = \frac{\gamma(k(6-2\gamma^2+k(8-6\gamma^2+\gamma^4))-1)}{2k(4-\gamma^2)(2k(3-\gamma^2)-1)} > 0$$

Accordingly, $\Delta > \tilde{\Delta} > \tilde{\Delta}'$, thus $P_2^V > c_2$ ■

Appendix 3

Taking a difference between two values among w^* , $\tilde{w}$, $\hat{w}$ and w^V , they are calculated as

$$w^* - \tilde{w} = \frac{(k(4-\gamma^2)^2 - \gamma^2)(\Delta - \gamma)}{2(2-\gamma^2)(k(4-\gamma^2)-1)},$$

$$w^* - w^V = \frac{k(k(4-\gamma^2)^2 - \gamma^2)(\Delta - \gamma)}{(k(4-\gamma^2)-1)(k(8-3\gamma^2)-1)},$$

$$\tilde{w} - w^V = \frac{(k(4-\gamma^2)^2 - \gamma^2)(\gamma - \Delta)}{2(k(8-3\gamma^2)-1)(2-\gamma^2)}$$

$$\text{and } w^V - \hat{w} = \frac{(k(4-\gamma^2)^2 - \gamma^2)(-k(8-\gamma^2-\gamma^3) - \gamma + 1 + 2k(4+\gamma-2\gamma^2)\Delta)}{2(\gamma - \gamma^2 + k(4-\gamma^2)(4-\gamma-\gamma^2))(k(8-3\gamma^2)-1)}.$$

Appendix 4

Taking a difference between Δ^M and γ , we obtain its sign by calculating as

$$\Delta^M - \gamma = \frac{(1 - \gamma)[k(8 - 3\gamma^2) - 1]}{2k(4 + \gamma - 2\gamma^2)} \geq 0 \text{ if } k > \tilde{k} > \frac{1}{8 - 3\gamma^2}.$$

We can see that the sign of $\Delta - \gamma$ determines the sign of $w^* - \tilde{w}$, $w^* - w^V$ and $\tilde{w} - w^V$, and that the sign of $\Delta - \Delta^M$ and $\Delta^M > \tilde{\Delta}$ determines the sign of $w^V - \hat{w}$. Defined Δ^M is derived from a part of numerator of $w^V - \hat{w}$. Moreover, we have $\Delta^M > \gamma$ under $k > \tilde{k}$. Hence, each sign of factor must be consist with each other at the equilibrium ■

Appendix 5

Margin squeeze can happen if access charge violates imputation test such that ⁴⁴

$$w > \hat{w}^L \equiv \frac{2 - \gamma\Delta}{4 - \gamma - \gamma^2}$$

To know whether unregulated optimal access charge violates the imputation test, comparing w^L to $\hat{w}^L$,

$$w^L - \hat{w}^L = \frac{(4 + \gamma - \gamma^2)\Delta - \gamma(1 + \gamma)}{2(4 - \gamma - \gamma^2)}$$

$$w^L > \hat{w}^L \text{ if } \Delta > \frac{(1 + \gamma)\gamma}{4 + \gamma - \gamma^2} \equiv \Delta^{ML}$$

This condition of relative efficiency Δ^{ML} is very easy to clear for the rival, even though it is less efficient than the incumbent.

Appendix 6

For access charge,

$$w^V - w^L = - \left(\frac{(\Delta - \gamma)(k\gamma^2 - 1) + k(8 - 3\gamma^2) - 1}{2(k(8 - 3\gamma^2) - 1)} \right) < 0.$$

⁴⁴ The imputation test under legal unbundling is drawn by $P_1^* = c_1 + w + \frac{2 - \gamma\Delta - w(4 - \gamma - \gamma^2)}{4 - \gamma^2}$, which is different in $d^L = 0$ from that $d^V \geq 0$ under vertical integration.

For quantities for individual goods,

$$\begin{aligned}
q_1^V - q_1^L &= - \left(\frac{\gamma\{(\Delta - \gamma)(k\gamma^2 + 1) + k(8 - 3\gamma^2) - 1\}}{2(4 - \gamma^2)(k(8 - 3\gamma^2) - 1)} \right) < 0 \\
q_2^V - q_2^L &= \frac{(\Delta - \gamma)(k\gamma^2 + 1) + k(8 - 3\gamma^2) - 1}{(4 - \gamma^2)(k(8 - 3\gamma^2) - 1)} > 0 \\
q_1^V - q_2^V &= \frac{k(8 - \gamma^2 - 4(\Delta - \gamma) - 2\Delta\gamma) - 1}{2(k(8 - 3\gamma^2) - 1)} > 0 \\
\text{and } q_1^L - q_2^L &= \frac{3 - \Delta}{2(2 - \gamma)} > 0
\end{aligned}$$

For total quantity,

$$\begin{aligned}
Q^V - Q^L &= \frac{(\Delta - \gamma)(k\gamma^2 + 1) + k(8 - 3\gamma^2) - 1}{2(k(8 - 3\gamma^2) - 1)(2 + \gamma)} > 0 \\
\text{if } \Delta > \tilde{\Delta} > 0 &\geq \frac{1 + \gamma - k(8 - 3\gamma^2 - \gamma^3)}{k\gamma^2 + 1} \text{ and } k \geq \frac{1 + \gamma}{8 - 3\gamma^2 - \gamma^3} > \tilde{k}
\end{aligned}$$

For variation in prices,

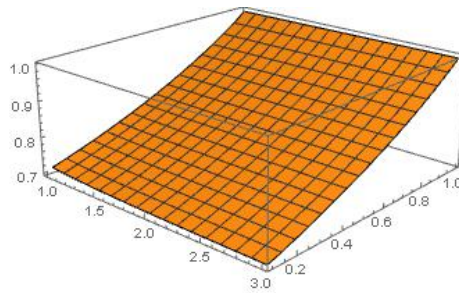
$$\begin{aligned}
P_1^V - P_1^L &= - \left(\frac{\gamma(k(8 - 3\gamma^2 + \gamma^2[\Delta - \gamma]) + [\Delta - \gamma] - 1)}{2(4 - \gamma^2)(k(8 - 3\gamma^2) - 1)} \right) < 0 \\
\text{and } P_2^V - P_2^L &= - \left(\frac{(2 - \gamma^2)(k(8 - 3\gamma^2 + \gamma^2[\Delta - \gamma]) + [\Delta - \gamma] - 1)}{2(4 - \gamma^2)(k(8 - 3\gamma^2) - 1)} \right) < 0
\end{aligned}$$

For price differences, assuming $c_1 = c_2$,

$$\begin{aligned}
P_1^V - P_2^V &= c_1 - c_2 + \frac{-1 - \gamma + 2\Delta + k(8 + \gamma\{4 - \gamma - \gamma^2\} - \{12 - 2\gamma[2\gamma - 1]\}\Delta)}{2(k(8 - 3\gamma^2) - 1)} \\
P_1^V - P_2^V \leq 0 &\text{ if } \Delta \geq \frac{k(8 + \gamma(4 - \gamma - \gamma^2)) - (1 + \gamma)}{2[k(2 - \gamma)(3 + 2\gamma) - 1]} \equiv Y(k, \gamma) \text{ and } k > \frac{1}{6 + \gamma - 2\gamma^2} \\
\text{and } P_1^L - P_2^L &= c_1 - c_2 + \frac{1 + \gamma - (3 - \gamma)\Delta}{4 - 2\gamma} \\
P_1^L - P_2^L \leq 0 &\text{ if } \Delta \geq \frac{1 + \gamma}{3 - \gamma} \equiv Z(\gamma).
\end{aligned}$$

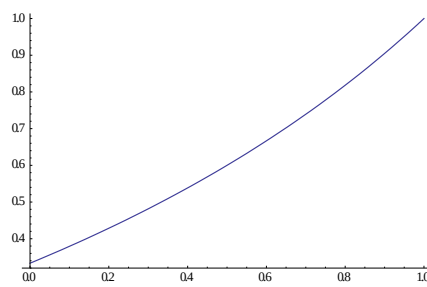
These price differences are illustrated in [Figure 3-3](#) and [Figure 3-4](#).

Figure 3-3: Price difference under vertical integration



Note: Taking $Y(k, \gamma)$ on height, k on widths, and γ on lengths, we can see that $\Delta \geq 1 \geq Y(k, \gamma)$ for any $k \in [1, 3]$ and $\gamma \in (0, 1]$ by 0.1.

Figure 3-4: Price difference under legal unbundling



Note: Taking $Z(\gamma)$ on height and γ on horizontal axis, we can see that $\Delta \geq 1 \geq Z(\gamma)$ for any $\gamma \in (0, 1]$ by 0.1.

Conclusion

The thesis is constructed by three chapters, each of which is interested in the industries where a dominant firm exists in context of vertical relationship. Here, I summarize the results obtained in each chapter. Afterward, I propose some plans for future research.

Chapter 1 estimated the economic effect of the NKK and Kawasaki Steel merger applied by conventional event study with using stock return data. As long as focusing on the merging industry, the event study shows that the merger is for anti-competitive. However, taking the customer firms for the merging industry into account, the merger might not be for anti-competitive. Our results for the customer firms as follows: while relatively more significant positive abnormal returns are observed in steel-processing industry, there were fewer significant observations in other three customer industries. These significant abnormal returns among customer firms are mixed: positive and negative. Following the hypothesis that relating the signs of abnormal returns for each firm concerned and the effect of merger, then we can propose that the merger was expected to achieve efficiency improvements. Even though we employed another estimation model which introduced dummy variable, the result of testing abnormal returns was maintained.

Chapter 2 analyses the effect of policies for fair competition in liberalized electricity market where the ownership of cost efficient nuclear power plants matters; specifically, we compared the NOME law and public ownership. Recent other work showed that the NOME law would bring larger total output. We first set up a model assuming simple as much as previous study, and then compared the effect of the NOME law and public ownership. As a result, we found that public ownership outperforms the NOME law in terms of total output of electricity. Thus far, contrary to previous study, it appears public ownership is superior to the NOME law. Next, we arranged the model in more realistic assumption: capacity constraint and fixed costs with respect to nuclear power plants. Then, we found that depending on the condition on fixed cost, the NOME law does outperform public ownership; the result changed contrary to what obtained under simple assumption. Whereas the public ownership seems to be a policy for fair competition, the policy embraces the average cost principle; the public firm upstream does not sell nuclear-generated power at marginal cost. Thus, the effect of public ownership on electricity downstream market would not be superior to the effect under the NOME law according with the size of fixed cost of nuclear power plants. The NOME law is not merely proposed political compromise that the incumbent firm resists accepting public ownership but has greater economic significance.

In Chapter 3, we study vertical structures with upstream monopolist by comparing vertical integration with legal unbundling. In case of the essential input price is regulated exogenously, if the essential input price is low enough, the integrated monopolist raises the downstream rival's cost and

the rival is to be active in the market. In case of the essential input price is unregulated and set by the monopolist endogenously, whenever the integrated monopolist has incentive to raise the rival's cost, that is when the rival is never efficient than the downstream affiliate, it sets the essential input price lower to raise the rival's cost higher. At the event, the rival will be foreclosed from the downstream market. However, if the downstream goods are differentiated in some degree, the integrated monopolist does not raise the rival's cost even when the rival is less efficient. Under legal unbundling where the downstream parent firm still maximizes joint profit as well as vertical integration but the upstream monopolist considers only its own profit, the upstream monopolist does not have incentive to raise the rival's cost regardless of that the essential input price is regulated or unregulated. Finally, we find that total downstream output and consumer surplus under vertical integration are larger than legal unbundling. This result comes from what the effect of overcoming double marginalization problem is larger than potential effect of raising rival's cost.

Next, for future research, I provide some plans for each chapter as follow. It is said that event studies are useful from the point of view of competition policy. To compare the result in Chapter 1, it would be good to employ other models of event study, for example GARCH model, Markov switching model, among other things. Because the study in Chapter 1 pays attention to mainly financial terms, we are not able to suppose specific contents brought by the merger. To complement this study, it is recommended to investigate what happened after the merger in real terms.

The problem studied in Chapter 2 specifically is from France and can be from Japan because in these countries nuclear power has been used as cost efficient generation and has been continued to take over to the incumbent. Taking a look other regions, hydro power is cost efficient in Scandinavia countries. In addition, photovoltaic power and wind power are increasing widely. Therefore, this study is expected to consider other powers but nuclear power and thermal power. Prospect of nuclear power should be taken into account carefully.

Finally, in Chapter 3, when the vertically integrated firm raises the downstream rival's cost, margin squeeze does not happen simultaneously, and vice versa. If the downstream goods are imperfect substitute, there are some degrees of range in which neither sabotage nor margin squeeze happen. The problem remaining is that to examine how and whether the regulator can choose the essential input price accurately to drop in the safe harbor range. If the downstream goods are perfect substitute, such a safe harbor input price would be determined in unique. Thus, it might be hard for the regulator to choose the unique input price. This problem can be analyzed under which conditions of perfect or imperfect information about the cost of upstream monopolist.

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