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Collusion in a telecom market in which the entrant raises the price in return for a discount in interconnection charges by the incumbent

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Abstract

In 2003, the dominant former monopolist, which was subject to a stringent price regulation, and the new entrant in the local calls market of Korea made an agreement in which the entrant was to raise the price while the incumbent was to hand over market shares or transfer money using interconnection charge payment settlement as a channel. The antitrust authority and the court in Korea ruled the agreement to be collusive and imposed a heavy fine. The agreement has extraordinary features as a collusion agreement, as it specified that only one firm was to raise the price while the other firm was to transfer market shares or money. This paper develops a model of repeated Bertrand competition in a homogeneous market that captures the key elements of the local calls market in the early stage of deregulation to analyze the possibility of a collusion in which the unregulated firm raises the price while the regulated firm transfers market shares or money to the unregulated firm. The model assumes subscriber-based competition, the presence of switching costs, and asymmetry in the initial subscriber base and costs between the incumbent and the entrant. We found that there exists a subgame perfect equilibrium, in which the entrant raises the price above its optimal price against the regulated price of the incumbent in the mature stage of competition, and where the incumbent reciprocates by transferring money or market shares to the entrant.

1. Introduction

In June 2003, managers of KT and Hanaro Telecom (henceforth designated "Hanaro") met and made an agreement according to which Hanaro was to raise its monthly fixed fee in return for a transfer of market shares or money from KT in the local calls market of Korea[1]. KT was the dominant former monopolist with around 95% of the market share and was subject to a stringent price regulation by the ministry in charge of the telecom industry, while Hanaro was the new entrant in essentially a duopoly market. The Korea Fair Trade Commission (KFTC), the antitrust authority in Korea, and the court ruled that the agreement was collusive and imposed a heavy fine[2]. The agreement between the two firms is extraordinary as a collusion agreement in several respects. As far as we know, it is the only collusion agreement where only one of the participating firms was to raise the price while the other firm maintained its price. It is the only explicit collusion agreement in which a participating firm transferred market shares or money in return for a price increase of the other firm. It is also the only collusion case in which the incumbent former monopolist that was subject to price regulation colluded with the new entrant in the early stage of deregulation in a telecom market. This collusion case raises the possibility of a new form of collusion that has not yet been studied in the literature. The fundamental question we ask in this paper is whether and under what circumstances a collusion that takes this form can occur[3].

To investigate the possibility of a credible collusion that takes this form, we develop a model of duopoly competition between an incumbent former monopolist and a new entrant that captures the

[1] Details of the agreement are given in the next section.

[2] In Korea, the KFTC essentially plays the role of the prosecutor as well as that of the court in handling antitrust cases, determines whether a defendant violates the antitrust law, and often hands down economic penalties in the form of administrative fines on defendants. If a defendant disagrees with the rulings of the KFTC, it can bring the case to the court, asking the court to reconsider the case.

[3] The KFTC successfully proved that managers of KT and Hanaro met and made the agreement explicitly, and that Hanaro actually raised the price as specified in the agreement two months after the agreement was made. However, it did not offer a satisfactory explanation on how each of the two firms could increase its profit by carrying out the agreement, or why the agreement was incentive compatible for each of the two firms in its ruling.

key elements of the market for local calls in Korea around the time the agreement was made to explore the possibility of incentive compatible collusion, in which only the entrant raises the price while the incumbent reciprocates by paying money to the other firm[4]. The salient features of the model are subscription-based competition, switching costs of consumers, asymmetric cost structures of the firms, and asymmetric regulation that fixes the price of the incumbent. These features were important characteristics of the market for local calls in Korea in the early stage of competition after deregulation. These features may characterize the market for local calls in some other countries in the early stages of competition after deregulation, as well; furthermore, they may also be present in other telecom markets such as mobile telecom in some countries, at least during the period in which there is a transformation from a monopoly to a competitive market.

In some telecom markets, including local call telephone markets, consumers incur substantial switching costs in terms of time and effort when they change their operators. In most deregulated telecom markets, the incumbent former monopolist has 100% of the market share when the second firm enters. Further, in some telecom markets, including the market for local calls and the mobile telecom market, asymmetry usually exists in the cost functions of both the incumbent and the entrant. The incumbent has already completed much of its infrastructure when the entrant enters. In addition, much of the cost of investment in network facilities is sunk so that the marginal cost of the incumbent is significantly lower than the marginal cost of the entrant, which includes the cost of investing in building its network. All of these factors work against the entrant and in favor of the incumbent. Regulators in some countries, including Korea, have applied asymmetric regulation aimed at controlling the market power of the incumbent by preventing it from increasing prices for consumers and, at the same time, discouraging it from engaging in an aggressive price competition with entrants in the early stage of deregulation. Our model captures these features of partially deregulated telecom markets.

We have two results. The first is that, when the firms do not collude, the profit-maximizing strategy of the entrant consists of an introductory price that is substantially lower than the regulated price of the incumbent and a price that matches the regulated price of the incumbent in the mature stage. In our model, the entrant's strategy is affected by the asymmetry of costs, as well as the asymmetry of the initial subscriber base. Cost asymmetry, switching costs of consumers, and the asymmetry in the subscriber base all lead the entrant to charge a substantially lower price than the price of the incumbent and to raise it to the same level as the price of the incumbent. Our second and main result

[4] We believe that the part of the agreement on the market share was included as a mechanism to calculate the amount of money to be transferred from the incumbent to the entrant, as KT did not have a feasible way of transferring its subscribers to Hanaro. Discussions on the market share transfer are provided in the last section.

is that, under such circumstances, the entrant and the incumbent can form an incentive-compatible collusion in which the entrant raises the price above the level that maximizes its profit in the mature stage when it does not collude with the incumbent, while the incumbent reciprocates by transferring money to the entrant. In telecom markets, interconnection payment settlement can be used as a channel to transfer money, as the Hanaro–KT agreement specified.

As a paper on competition, this paper is the first one to study collusion in a partially deregulated, homogeneous market between the incumbent former monopolist that is subject to price regulation and the new entrant that does not depend on information asymmetry. It is also the first one that analyzes the possibility of collusion, in which the entrant raises the price that will lead to a decrease in its profit in order to allow the incumbent to increase its profit, with the objective of sharing the increased profit of the incumbent. As a paper on switching costs, our paper is the first one to study competition and collusion between a dominant incumbent firm and an entrant in markets characterized by asymmetry of costs and subscriber-based competition, in addition to consumer switching costs. Padilla (1995) and Anderson et al. (2004) studied collusion in an infinitely repeated duopoly model. However, their model is different from ours in that it is stochastic and has symmetric firms and changing consumers. While they focused on the effects of switching costs on the price levels of two firms in a symmetric situation in Markov perfect equilibria, we focus on the collusion between the incumbent and the entrant that arises as a result of the asymmetry of the starting positions of the two firms. Chen (1997) has some features that our model has, including a common reservation price of consumers and a uniform distribution of switching costs. However, it differs from our model in that it has two periods, symmetric firms, and no possibility of collusion. Klemperer (1989) studied a two-period model of competition in a differentiated market. His model does not consider the possibility of collusion or the effects of asymmetry of cost structure. Klemperer (1987) studied the possibility of entry deterrence by an incumbent monopolist facing a potential entrant that takes advantage of switching costs of consumers. However, it does not consider collusion or the role of asymmetry in investment costs in competition in markets where switching costs are important. Although there is a large array of literature on competition, regulation, and collusion in telecom markets, there is no study that has examined collusion in telecom markets focusing on switching costs and the asymmetric positions of the incumbent and the entrant[5]. Barnes and Poudou (2009) analyzed the effect of cost-based access price regulation on the sustainability of tacit collusion. However, they focused on access price regulation and did not consider collusion between a regulated incumbent and unregulated new entrant

[5] There is a large amount of empirical literature on switching costs in various telecom markets [e.g., Park (2010)]. While most of these papers focus on estimating switching costs, none of them studied the link between switching costs and collusion.

and did not consider the effect of switching costs.

The paper is organized as follows: in the next section, we summarize the important facts about the Hanaro–KT collusion case and summarize the main issues arising from the case on collusion. In section 3, we develop two models to analyze competition and collusion in a market that captures the key elements of the collusion case and solve the games for subgame perfect Nash equilibria. Section 4 draws conclusions.

2. Market situations, the collusion case, and the effects of the agreement

Prior to the 1990s, the telecom industry in Korea was run as a state-owned enterprise monopoly. The Korean government began introducing competition into various telecom markets in the early 1990s. First, it introduced competition into the international call markets, then going on to introduce competition in the domestic long-distance market and the mobile telephone market. It opened the local calls market for competition last. Hanaro entered the market in 1997 and, after building a network infrastructure, began providing services in 1999. Hanaro entered the market for high-speed access to internet as well, competing with KT in the two markets[6]. The competition between Hanaro and KT had several asymmetric elements. As the new entrant into the telecom industry, Hanaro had to build its network of local loops from the ground up. On the other hand, KT had essentially completed its PSTN long before Hanaro's entry. The asymmetry in the investment in the network facilities of the two firms led to a large gap in the marginal costs of providing local call services. Hanaro's marginal cost of service included investment costs in the early stage of competition, while KT's marginal cost was far below Hanaro's. KT also enjoyed the first mover advantage in the subscriber base. Hanaro started with a zero market share, while KT started competition with 100% of the consumers as its subscribers. This asymmetry in the subscriber base worked against Hanaro, as switching costs of consumers was significant in this market; indeed, few subscribers of KT were willing to switch to Hanaro if both firms charged the same price.

The Ministry of Information and Communications, the ministry in charge of the telecom industry at the time, applied an asymmetric regulation to help Hanaro overcome the asymmetry in the subscriber base and the adverse effects of switching costs by prohibiting KT from lowering its price while allowing Hanaro to charge a price that was substantially lower than KT's[7]. It should also be noted that

[6] Several firms entered the market for access to internet, but none of them other than Hanaro entered the market for local calls.

[7] The Ministry of Information and Communications was abolished in 2008, and the functions it performed in

KT was under a price regulation that prohibited it from raising its price for local services as well. Thus, the ministry effectively fixed KT's price for local call services during the period relevant to the collusion case. KT's monthly fee had been fixed at KRW 4,000 since 1998. Hanaro initially charged the same monthly fee of KRW 4,000 when it started selling services in April 1999. In April 2001, one year after Hanaro's entry, the ministry raised KT's monthly fee to KRW 5,200, making Hanaro's service cheaper than KT's by KRW 1,200. The ministry maintained KT's price at KRW 5,200 for a long period of time—well after KFTC handed down the verdict in the collusion case[8]. Hanaro lowered its monthly fee again to KRW 3,500 in July 2002, widening the gap between the prices of the two firms to KRW 1,700[9]. In August 2003, shortly after Hanaro made the agreement with KT, it raised its price by KRW 1,000 to KRW 4,500, as specified in the agreement. From 1999 to 2006, the prices that consumers paid for land-to-land and land-to-mobile calls that depended on the frequency and duration of the calls were essentially the same between the two firms, as were the prices for the interconnection services during the period between Hanaro's entry and the time the agreement was made.

At the time Hanaro entered the local calls market, all existing consumers in the market were subscribers of KT. The total number of subscribers was stagnant as the market entered a saturated stage. As a result, competition between the two firms occurred mostly in existing markets that had been previously monopolized by KT[10]. Hanaro adopted a cream-skimming strategy of focusing on building its network in geographic markets that had a high density of consumers, mainly areas that had many apartment complexes and commercial buildings. It sold internet access and local call services to consumers separately as well as in bundles. For some reason, few chose to purchase bundled services, instead opting to purchase the two services separately. Hanaro penetrated the local call market quite effectively, initially partly as a result of the asymmetric regulation of the government

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the telecom industry were taken up by the Korea Communications Commission.

[8] Thus, KT's monthly fee was fixed at this level before the agreement was made and had been maintained at this level for a long period of time that extended well beyond the period during which the KFTC investigated the case and handed down a ruling.

[9] KT and Hanaro sold several different packages of services that depended on the amounts of money subscribers had to deposit, the length of contracts, the number of lines, and bundling with internet services. The prices that we give here are the prices of the package offered by both firms that were also chosen by a predominant majority of subscribers at the time. The agreement between the two firms was also based upon the price of this package. In addition to paying a higher monthly fixed fee, KT's subscribers were also required to deposit a larger amount of money to use this package, compared to Hanaro's subscribers.

[10] New markets, which kept emerging as new areas that had not yet been inhabited, were developed in which the positions of the two firms were more symmetric. However, the proportion of these new markets was small. We will ignore the new markets in this paper and will instead focus on existing ones.

that allowed Hanaro to maintain a sizable gap between KT's price and its price. However, Hanaro's market share stalled after reaching about 4–5% of the market share, even though it built a network whose size was several times bigger than its subscriber base despite the continued asymmetric regulation. In early 2003, Hanaro fell into financial difficulties as a result of spending large amounts of money in expanding its network and stagnant revenues. In June 2003, 10 months after KT became a fully private firm after the completion of its privatization, the managers of KT and Hanaro met and made a detailed agreement on Hanaro's price, market share adjustment, and money transfer using an interconnection charge settlement as a vehicle.

According to the agreement, Hanaro was to raise the monthly fixed fee by KRW 1,000 and KT was to hand over market shares to Hanaro so that Hanaro's market share would increase at the rate of 0.1% point each month in the following five years or pay money if Hanaro's market share failed to increase as specified in the agreement. At the time, there were roughly 24 million subscribers in the market for access to the local loop in Korea; KT had around 95% of the market share. The agreement on the market share transfer was tantamount to handing over roughly 24,000 subscribers per month over the next 60 months. In case Hanaro failed to increase its subscribers at the rate of 0.1% point per month, the agreement specified that KT would pay Hanaro KRW 67.6 million per 0.1% of the market share it failed to hand over per month[11]. The agreement also specified that KT would transfer the money it owed Hanaro every three months by adjusting interconnection charge payments.

Hanaro raised its monthly fee by KRW 1,000 to KRW 4,500 in late August 2013. Hanaro's market share did not increase, actually falling slightly in the following two months. In November 2003, Hanaro demanded payment from KT in the form of reduction in its interconnection charge payments to KT, as specified in the agreement. It appears that KT management initially tried to meet the demand and adjust the interconnection payment according to the agreement. However, it soon gave up its efforts to transfer money to Hanaro when confronted by the opposition of managers working for the unit in charge of the interconnection payment settlement. KT subsequently notified Hanaro that it would not pay the money, and indeed did not pay any money in connection with the agreement. What happened between November 2003 and 2006, when the KFTC began its investigation, is unclear. The KFTC and the court ruled later that the agreement was a collusive one and that the two firms maintained collusion based on the agreement for a substantial period of time[12].

[11] For instance, if Hanaro's market share did not increase at all in the first five months after the agreement was implemented and increased by 0.1% in the sixth month, KT would owe Hanaro KRW 6.76 million x (5 + 4 + 3 + 2 + 1) = KRW 101.4 million by the end of the sixth month.

[12] This case has gone through a long and complex legal process. After the initial ruling by the KFTC, which imposed the largest administrative fine ever imposed for collusion at that time, a higher court and the Supreme

What are the effects of the agreement on the price, the profits of the two firms, and the consumers? Hanaro's higher collusive price has the effect of reducing its demand and increasing KT's demand. It is also possible that the price increase would lead some subscribers of Hanaro whose reservation price for having access to the local loop was low to stop purchasing the service altogether. The subscribers of Hanaro who remain with Hanaro even after the price increase will pay more by the amount equal to the increase in Hanaro's price. The subscribers of Hanaro who switch to KT after the price increase will also pay a higher price each month, in addition to switching costs. The price increase also has effects on Hanaro's revenue, which will increase by the number of subscribers who will remain as its subscribers multiplied by the increase in its price, and decreased by the number of subscribers it loses multiplied by the average revenue from those subscribers. The average revenue of a subscriber consists of the price before the price hike and the average revenue from their use of land-to-land, land-to-mobile, and various interconnection services. KT's profit will increase as a result of an increase in Hanaro's price by the number of increased subscribers multiplied by the average revenue from a subscriber that consists of its regulated price and the revenues from selling land-to-land, land-to-mobile, and various interconnection services to those consumers[13].

3. The model and the equilibrium

In this section, we develop two models of competition and collusion between an incumbent and the entrant in a partially liberalized duopoly market characterized by switching costs, cost asymmetry, and regulation of the price of the incumbent. We first consider a model in which firms compete without colluding. Since the incumbent's price is fixed and the incumbent does not collude with the entrant, the competition between the two firms becomes a single agent optimization by the entrant, who tries to maximize the present value of its profit stream by choosing a price in each of an infinite number of periods. After obtaining the unique equilibrium of the basic model, we slightly modify the basic model by allowing the entrant and the incumbent to form a collusion in which they use the price of the entrant and a transfer

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Court each ruled that, while there was collusion, the amount of the fine was excessive. They sent the case back to the KFTC, which ruled again that there was collusion, but reduced the amount of the fine. KT challenged the ruling and brought the case again to the court. However, both a higher court and the Supreme Court upheld the new ruling of the KFTC, thus ending the long legal battle.

[13] The average revenue from subscribers Hanaro loses as a result of charging a higher price may be different from the average revenue from all of its subscribers. Similarly, the average revenue from additional subscribers of KT may be different from the average revenue from its existing subscribers.

of money from the incumbent to the entrant to increase their profits. In the modified model, we focus on a simple trigger strategy equilibrium, in which both firms choose the collusive actions in each period as long as they choose them in each of the preceding periods, but revert to the unique equilibrium of the basic model once a firm deviates from the action it is supposed to choose in collusion.

Basic model: a model of competition

Suppose that each consumer in a geographic market purchases up to one unit of a homogeneous, non-storable service in each period. Consumers are continuously distributed with a mass of unit 1. Each consumer has the same reservation price for the service, $v > 0$. Consumers are the same in each period, and their reservation price does not change over time. A consumer has to become a subscriber of a firm in order to purchase the service. There are two firms, the incumbent and the entrant, that sell a homogeneous service. The incumbent was selling 1 unit to every consumer in each period at a price set by the regulator before the entrant entered. Both firms have the same technology that is represented by a cost function $c(q) = 0$, if $q \leq x$, where x is the capacity that it built before the start of the period t, and $c(q) = c(q - x)$, if $q > x$ in each period[14]. The incumbent has already invested in a capacity of 1 so that its cost is 0 for all outputs in each period. The entrant has the cost function just described. Each consumer incurs a switching cost every time he or she switches from one firm to another. The switching cost of a consumer varies across consumers and is distributed over the interval $S = [0, S_H]$ according to a uniform distribution. For each consumer, the switching cost is constant over time and does not depend on the number of switches he or she made previously. Thus, each consumer is uniquely identified by a number $s \in S$, which is his or her switching cost. The incumbent is subject to regulation that fixes its price at p_0 in all periods. At the start of period 1, the entrant enters and chooses q_1, as well as a price p_1, to maximize the present value of its profit stream, which requires an investment of $x = q_1$ in its network facilities. In each of the subsequent periods, it chooses a price and produces a quantity of service that meets the demand at the chosen price. The entrant cannot commit to its future prices and cannot price discriminate between existing and new subscribers.

[14] This cost function reflects the fact that an operator in the local calls market must build a capacity that can produce a quantity of service it wants to sell in each period.

Meanwhile, the incumbent does not choose any action[15]. Consumers have a rational expectation about future prices and switch to a different firm whenever it can reduce the present value of the money it pays for the stream of services it consumes in the present and future periods. Both firms as well as the consumers discount the future with the same discount factor given by δ, $0 < \delta < 1$.

We focus on the pricing strategies of the entrant that take the form of choosing a price p_1 in period 1 and a price p_2 that is higher than p_1 in each period $t \geq 2$[16]. This is not restrictive, since the entrant has no reason to postpone choosing the price that maximizes the present value of its future profit once it establishes a subscriber base by choosing a low price in $t = 1$. Thus, the entrant's pricing strategy will take the form of charging a price $p_1 < p_0$ in $t = 1$ and a price $p_t = p_2$ in each $t \geq 2$, as its profit will be zero if $p_1 \geq p_0$ in $t = 1$. Given the regulated price of the incumbent p_0, a price path (p_1, p_2) of the entrant determines the demand of each firm in each period $t \geq 1$.

After observing p_1, some of the subscribers of the incumbent who can gain by switching to the entrant will switch in the first period. Let $S(p_1, p_2^E)$ denote the set of the consumers who will switch to the entrant in period 1 when the entrant chooses a price path (p_1, p_2) and when consumers expect the entrant to choose p_2^E in $t = 2$[17]. Who will switch in period 1? Consumers whose switching costs are smaller than the present value of the gain from switching in $t = 1$ will switch. If $p_2^E \leq p_0$, the consumers whose switching cost is smaller than $(p_0 - p_1) + \frac{\delta}{(1-\delta)}(p_0 - p_2^E)$ will switch to the entrant and stay with the entrant in subsequent periods. If $p_2^E > p_0$, consumers whose switching cost is smaller than $(p_0 - p_1) -$

[15] We can alternatively model the competition by allowing the incumbent to choose an amount of money it pays the entrant. In the equilibrium of this model of competition, the incumbent will always choose to transfer 0 to the entrant, leading to the same outcome in the equilibrium of the model in which the incumbent chooses no action. However, the incumbent will choose a positive amount of money in equilibrium in the model when it colludes with the entrant.

[16] Although we did not attempt to prove it, we believe that this property is implied by the optimality of the price path of the entrant.

[17] A consumer is identified by his or her switching cost here.

$\frac{\delta}{(1-\delta)}(p_2^E - p_0) = (p_0 - p_1) + \frac{\delta}{(1-\delta)}(p_0 - p_2^E)$ and larger than $\frac{1}{(1-\delta)}(p_2^E - p_0)$ will switch in $t = 1$ and stay with the entrant. Consumers whose switching cost is smaller than both $(p_0 - p_1)$ and $\frac{1}{(1-\delta)}(p_2^E - p_0)$ will switch to the entrant in $t = 1$ and switch back to the incumbent in $t = 2$. Given the regulated price p_0 of the incumbent and a price p_1 that the entrant chooses in $t = 1$, the set of the subscribers of the entrant who will switch back to the incumbent in $t = 2$ when $p_2 > p_0$ is equal to $[0, \frac{1}{(1-\delta)}(p_2^E - p_0)]$, while the set of subscribers of the entrant who will stay in its network is $[\frac{1}{(1-\delta)}(p_2^E - p_0), (p_0 - p_1) - \frac{\delta}{(1-\delta)}(p_2^E - p_0)]$, as long as $\frac{1}{(1-\delta)}(p_2^E - p_0) < (p_0 - p_1) - \frac{\delta}{(1-\delta)}(p_2^E - p_0)$. If this inequality is reversed, all of the subscribers the entrant acquired in the first period will switch back to the incumbent in period 2. We will exclude this uninteresting case from consideration and focus on the p_0, p_1, and p_2 that satisfy $\frac{1}{(1-\delta)}(p_2^E - p_0) > (p_0 - p_1) - \frac{\delta}{(1-\delta)}(p_2^E - p_0)$.

Thus, consumers whose switching cost is smaller than $(p_0 - p_1) - \frac{\delta}{(1-\delta)}(p_2^E - p_0)$ will switch in $t = 1$. Let us denote this by $\bar{s}(p_1, p_2^E)$. Then, consumers whose switching cost lies in $[0, \bar{s}(p_1, p_2^E)]$ switch in $t = 1$. This implies that $\bar{s}(p_1, p_2^E)/S_H$ will be the demand for the entrant and that $(S_H - \bar{s}(p_1, p_2^E))/S_H$ will be the demand for the incumbent in $t = 1$. In $t \geq 2$, demand for the entrant depends on p_2 as well as the subscriber base it acquired in period 1, $\bar{s}(p_1, p_2^E)/S_H$. If $p_2 > p_0$, the demand for the entrant shrinks from that in the first period by $(p_2^E - p_0)$, while the demand for the incumbent increases by the same magnitude in each $t \geq 2$. If $p_2 \leq p_0$, the demand for each of the two firms in each $t \geq 2$ is the same as the demand in the first period as long as $p_1 < p_2$, since none of the subscribers of either firm will have an incentive to switch to the other.

We summarize the properties of the demand for the entrant in each period we discussed in the above by the following lemma 1.

Lemma 1

Suppose the entrant chooses (p_1, p_2) in the basic model. Then, (1) the demand for the entrant in $t = 1$ is equal to $\bar{s}(p_1, p_2^E)/S_H = \{(p_0 - p_1) - \frac{\delta}{(1-\delta)}(p_2^E - p_0)\}/S_H$, and (2) the demand for

the entrant in each period $t \geq 2$ is equal to $\{\overline{s}(p_1, p_2^E) - \frac{1}{(1-\delta)}(p_2 - p_0)\}/S_H$ if $p_2 \geq p_0$, and $\overline{s}(p_1, p_2^E)/S_H$ if $p_2 \leq p_0$.

Lemma 1 implies that the entrant will never charge a price lower than p_0 in the second period when it maximizes the profit, as there is no reason to charge a price lower than p_0 in $t \geq 2$ when it can charge p_0 without affecting demand. Following proposition 1 establishes the optimal price path of the entrant when it competes with the incumbent without colluding.

Proposition 1

Assume $p_0 > (1 - \delta)c$ and $(1 - 2\delta)\, p_0 + (1 - \delta)\, c > 0$. The optimization problem of the entrant in the basic model has a unique solution (p_1^*, p_2^*), where $p_2^* = p_0$, and $p_1^* = \frac{1}{2}\{\frac{(1-2\delta)}{(1-\delta)}p_0 + c\}$.

<pf>

We first show that $p_2^* = p_0$ by showing that $p_2^* \geq p_0$ and $p_2^* \leq p_0$. $p_2^* \geq p_0$ by lemma 1 and the rational expectations as we observed in the above. Thus, $p_2^* < p_0$ cannot occur, and $p_2^* \geq p_0$ must hold in equilibrium. To show $p_2^* \leq p_0$, consider the profit maximization of the entrant s.t. $p_2 \geq p_0$. The demand for the entrant in the second and each of the subsequent periods is equal to $\{\overline{s}(p_1, p_2^E) - \frac{1}{(1-\delta)}(p_2 - p_0)\}/S_H = \{(p_0 - p_1) - \frac{\delta}{(1-\delta)}(p_2 - p_0) - \frac{1}{(1-\delta)}(p_2 - p_0)\}/S_H = \{(p_0 - p_1) - \frac{(1+\delta)}{(1-\delta)}(p_2 - p_0)\}/S_H$ if $p_2 \geq p_0$ and is equal to $\overline{s}(p_1, p_2^E)$ if $p_2 < p_0$ by lemma 1. The present value of the profit stream of the entrant evaluated in $t = 2$ when $p_2 \geq p_0$ is $\frac{1}{(1-\delta)}\{(p_0 - p_1) - \frac{(1+\delta)}{(1-\delta)}(p_2 - p_0)\}p_2/S_H$. The cost of the entrant in $t \geq 2$ is zero, as p_2 is higher than p_1 so that the demand in each $t \geq 2$ is smaller than the demand in the first period. The right-hand side derivative of this quadratic function with respect to p_2 evaluated at p_0 is equal to $-p_1 - \frac{2\delta}{(1-\delta)}p_0 < 0$. Consequently, maximizing $\frac{1}{(1-\delta)}\{(p_0 - p_1) - \frac{(1+\delta)}{(1-\delta)}(p_2 - p_0)\}p_2/S_H$, s.t. $p_2 \geq p_0$ has the solution at $p_2 = p_0$. Thus, $p^* > p_0$ cannot occur in equilibrium,

and $p^* \leq p_0$ must hold. This completes the proof that $p_2^* = p_0$ when the entrant chooses an optimal pricing path, since $p_2^* = p_0$, $\bar{s}(p_1, p_2^E) = \bar{s}(p_1, p_0) = (p_0 - p_1)$. The optimization problem of the entrant in $t = 1$ becomes maximizing $(p_0 - p_1)(p_1 - c) + \frac{\delta}{(1-\delta)}(p_0 - p_1)p_0$ with respect to p_1. The first-order condition leads to $p_1^* = \frac{1}{2}\{\frac{(1-2\delta)}{(1-\delta)}p_0 + c\}$. Because the profit function is quadratic, p_1^* is the solution if $\frac{(1-2\delta)}{(1-\delta)}p_0 + c < p_0$, which is satisfied by the assumption that $p_0 > (1 - \delta)c$. ■

Lemma 1 and proposition 1 characterize the optimal pricing strategy of the entrant who chooses a price that is lower than the regulated price of the incumbent in the first period to establish a subscriber base. Consumers who switch from the incumbent to the entrant in the first period are those whose switching costs are lower than that of the consumers who remain as subscribers of the incumbent, despite paying a higher price. Since the switching cost of a consumer is distributed along the interval $[0, s_H]$, there will be an $\bar{s}$, $0 < \bar{s} < s_H$, such that consumers whose switching cost is lower than $\bar{s}$ will switch to the entrant, if the entrant succeeds in attracting subscribers of the entrant to it in period 1. While the entrant's price in period 1 is lower than the price of the incumbent, consumers expect the entrant to charge a higher price that maximizes its profit in subsequent periods by taking advantage of the switching costs of the subscribers it attracted in the first period. Since it is optimal for the entrant to charge p_0 in each period $t \geq 2$, consumers rationally expect the entrant to charge p_0 in each period $t \geq 2$. Thus, a consumer switches to the entrant in period 1 if and only if its switching cost is less than the price differential in the first period. In the second period, the entrant raises the price to p_0. No consumers who switched to the entrant in period 1 will switch back to the incumbent in period 2, since they have to pay a positive switching cost in order to switch back to the incumbent, while they will pay the same price after switching back. None of the subscribers of the incumbent in period 1 will switch to the entrant either, as both firms charge the same price in each period $t \geq 2$, while they have to pay a switching cost larger than $\bar{s}$ to switch to the entrant[18].

[18] If the incumbent were not subject to price regulation, it could raise the price to a level that is higher than the entrant's price by $\bar{s}$ without losing any of its subscribers, since essentially all of its subscribers have switching

The subscriber base the entrant captures in the first period thus becomes its demand in each period $t \geq 1$. The present value of the profit of the entrant can be simplified as a function of its price in the first period, given the regulated price of the incumbent. It earns a revenue of $\bar{s}p_1/S_H$ in period 1, where $\bar{s}$ is the upper bound of the consumers who switch from the incumbent to the entrant in period 1, and earns a revenue of $\bar{s}p_0/S_H$ in each subsequent period. The cost it pays to generate this revenue stream is $c\bar{s}$, which it pays in period 1.

The optimal price path of the entrant given in lemma 1 and proposition 1 leads to the subscriber base of the entrant $\bar{s}^* = \frac{1}{2}\left\{\frac{1}{(1-\delta)}p_0 - c\right\}$ that it captures in period 1 and retains in subsequent periods. The price that the entrant chooses in period 1 and the resulting subscriber base it captures both depend on its marginal cost of building capacities, the regulated price of the incumbent, and the discount factor. A higher regulated price leads to a higher price of the entrant and a larger subscriber base, while a higher marginal cost of building capacities leads to a higher price but a smaller subscriber base. Naturally, the profit of the entrant is an increasing function of the regulated price of the incumbent and a decreasing function of its marginal cost. As the consumers and the entrant discount the future more and more, the entrant chooses a higher price in period 1 and builds a smaller subscriber base. This conforms to the intuition. A higher discount factor means a lower value of δ that leads to a lower present value of the subscriber base in future periods.

A model of collusion

Suppose that in the basic model we studied above, the entrant chose $p_1^* = \frac{1}{2}\{\frac{(1-2\delta)}{(1-\delta)}p_0 + c\}$ and built a subscriber base $[0, \bar{s}^*]$ in period as in proposition 1, where $\bar{s}^* = (p_0 - p_1)$; suppose further that, before the start of the second period, the entrant and the incumbent decided to collude. Thus, this collusion was unexpected in period 1 in the sense that both firms as well as consumers believed that the entrant would choose the optimal price path in the basic model[19]. Suppose that the entrant and the incumbent agree on a simple collusion scheme, in

costs that are higher than $\bar{s}$ and would increase the price by at least $\bar{s}$.

[19] If the entrant knows in the first period that it will collude with the regulated incumbent in the second period, it will choose a different price and a different subscriber base in the first period. The entrant has an incentive to choose a lower price in period 1 to expand its subscriber base compared to when it is not aware of the possibility of collusion, as it expects to receive a higher average revenue in period 2 from each subscriber it captures in

which the entrant will charge a price $p_t > p_0$ in each period $t \geq 2$, and in return the incumbent will pay the entrant an amount of money m_t at the end of each period with the following properties:

(1) $p_t = p_2^K > p_0$ in each $t \geq 2$, as long as the entrant chose p_2^K and the incumbent paid the entrant M in $t = 2$ and in each subsequent period up to $(t - 1)$, but $p_t = p_0$ in t and in each of the subsequent periods once the actions chosen by the entrant and the incumbent deviate from (p_2^K, M) in period $(t - 1)$.

(2) $m_t = M$ in each $t \geq 2$, as long as the entrant chose p_2^K in $t = 2$ and in each subsequent period up to $(t - 1)$ and the incumbent paid the entrant M in each period before t, but $m_t = 0$ once a defection from (p_2^K, M) occurs in a period in all subsequent periods.

As the entrant charges $p_2 > p_0$, some of its subscribers whose switching cost lies in $[0, \frac{1}{(1-\delta)}(p_2 - p_0)]$ will switch back to the incumbent, while the remaining subscribers whose switching cost lies in $[\frac{1}{(1-\delta)}(p_2 - p_0), \overline{s}^*]$ will remain as subscribers of the entrant. As a result, its demand in each period $t \geq 2$ will decrease by $\frac{1}{(1-\delta)}(p_2 - p_0)\}/S_H$, and the incumbent's demand will increase by the same magnitude. The change in the entrant's profit in each period $t \geq 2$ is $[\{(p_0 - p_1) - \frac{1}{(1-\delta)}(p_2 - p_0)\}p_2 - (p_0 - p_1)p_0]/S_H$. This is negative and monotonically decreasing for all $p_2 > p_0$. The change in the profit of the incumbent is $\frac{1}{(1-\delta)}(p_2 - p_0)p_0$, which is positive and an increasing linear function of p_2. The sum of the changes in the profits of the two firms is $(p_2 - p_0)\{(p_0 - p_1) - \frac{1}{(1-\delta)}(p_2 - p_0)\}$ and is positive, as long as p_2 does not exceed p_0 by too much and satisfies $(p_0 - p_1) > \frac{1}{(1-\delta)}(p_2 - p_0)$.

Lemma 2

The combined profit of the two firms will be larger than the sum of the profits of the two

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period 1 when it colludes with the incumbent in $t \geq 2$. However, consumers can also expect that the price in later periods depends on the subscriber base of the entrant and the link between the price in period 1 and the price in later periods.

firms in the equilibrium of the basic model when the entrant chooses $p_2 \in (p_0,\ p_0 + (1-\delta)\overline{s}^*)$, where $\overline{s}^* = (p_0 - p_1)$ is the subscriber base of the entrant in the first period. The combined profit is maximized when $p_2 = p_0 + \frac{1}{2}(1-\delta)\overline{s}^*$.

The proof is straightforward, as the combined profit of the two firms in each $t \geq 2$ is given by a quadratic function whose derivative is equal to zero at $p_2 = p_0 + \frac{1}{2}(1-\delta)\overline{s}^*$. When the entrant charges $p_0 + \frac{1}{2}(1-\delta)\overline{s}^*$, which maximizes the combined profit of the two firms in each $t \geq 2$ after establishing a subscriber base [0, s¯*] in $t = 1$, its subscriber base will shrink by $\frac{1}{2}\overline{s}^*$. As a consequence, its revenue and profit will both decrease by $\frac{1}{2}\overline{s}^* p_0 - \frac{1}{4}(1-\delta)\overline{s}^{*2}$. At the same time, the number of subscribers of the incumbent will increase by $\frac{1}{2}\overline{s}^*$, allowing the incumbent's profit to increase by $\frac{1}{2}\overline{s}^* p_0$ in each period $t \geq 2$. The net effect of the price increase of the entrant to $p_0 + \frac{1}{2}(1-\delta)\overline{s}^*$ on the combined profit of the two firms when it charges is positive and equal to $\frac{1}{4}(1-\delta)\overline{s}^{*2}$.

Lemma 2 shows that any price of the entrant belonging to $(p_0,\ p_0 + (1-\delta)\overline{s}^*)$ will increase the sum of the profits of the two firms. Thus, there arises the possibility that the two firms may collude to increase their profits. For the two firms to successfully collude and maximize the combined profits, they must agree on a sharing rule that distributes the increase in the combined profit in such a way that each firm finds it in its interest to adhere to the collusive scheme. Suppose that they agree to divide the increase in the combined profit by α and (1 – α), where α is the proportion of the increase in the combined profit that will accrue to the entrant. Then, $m_t = \frac{1}{2}\overline{s}^* p_0 - \frac{1}{4}(1-\delta)\overline{s}^{*2} + \alpha\frac{1}{4}(1-\delta)\overline{s}^{*2}$ for each $t \geq 2$. As long as $0 < \alpha < 1$, the individual rationality constraints are satisfied for both firms. However, for the entrant and the incumbent to have an incentive to carry out the agreement, neither of them should be able to profitably deviate from the agreement. The following proposition 2 establishes a condition for the incentive compatibility constraints.

Proposition 2

Suppose that the entrant chose p_1^*, the optimal price for the first period in the basic model in

period 1, and captured a subscriber base [0, $\overline{s}^*$], given by proposition 1 in period 1. Suppose further that the entrant and the incumbent make an agreement that specifies that (1) the entrant will choose $p_2^K = p_0 + \frac{1}{2}(1-\delta)\overline{s}^*$ in the beginning of $t = 2$ and choose p_2^K in each $t \geq 3$, as long as the incumbent pays it $m_t = M = \frac{1}{2}\overline{s}^* p_0 - \frac{1}{4}(1-\delta)\overline{s}^{*2} + \alpha\frac{1}{4}(1-\delta)\overline{s}^{*2}$ in the second and all previous periods up to $(t-1)$; (2) the incumbent will pay the entrant M in the second and all previous periods up to $(t-1)$, as long as the entrant chooses p_2^K in the second and all previous periods; and (3) the entrant and the incumbent choose p_0^* and $m_t = 0$ respectively in t and all subsequent periods if one or both of them deviates from (1) or (2). Then, the agreement is a subgame perfect Nash equilibrium for any α such that $0 < \alpha < 1 - \frac{4p_0(1-\delta)}{\{p_0-(1-\delta)c\}}$.

<pf>

The action that maximizes the short-run profit of the entrant in a period $t \geq 2$ when it deviates from the collusion agreement is to choose p_0, which leads to an increase in profit equal to $\frac{1}{2}\overline{s}^* p_0 - \frac{1}{4}(1-\delta)\overline{s}^{*2}$. In other words, the best that the entrant can do in deviating from the agreement is to save the loss of revenue that it would incur by choosing p_2^K instead of p_0. However, since the agreement specifies that the incumbent give the entrant an amount that is equal to this loss plus $\alpha\frac{1}{4}(1-\delta)\overline{s}^{*2}$ as long as the collusion is maintained, the increase in the entrant's profit in the defecting period is smaller than the profit it foregoes in that period alone, and will be smaller than the sum of the present value of the profits it foregoes in the defecting period and all subsequent periods. Thus, the incentive compatibility constraint of the entrant will be automatically satisfied. On the incumbent's side, the best it can do when defecting from the collusion agreement is to keep all of the increase in its profits that comes as a result of the entrant's choosing p_2^K to itself and gives the entrant nothing. Therefore, the largest amount it can gain by defecting is equal to the amount it promises to give the entrant in the defecting period, which is $\frac{1}{2}\overline{s}^* p_0 - \frac{1}{4}(1-\delta)\overline{s}^{*2} + \alpha\frac{1}{4}(1-\delta)\overline{s}^{*2}$. By choosing $m_t = 0$, it foregoes a future profit of $(1-\alpha)\frac{1}{4}(1-\delta)\overline{s}^{*2}$ in each future period, whose present value assessed in the defecting period is equal to $(1-\alpha)\frac{1}{4}\delta\overline{s}^{*2}$. For the incumbent not to have an incentive to deviate from the collusion agreement, we must have

$\frac{1}{2}\overline{s}^{*}p_0 - \frac{1}{4}(1-\delta)\overline{s}^{*2} + \alpha\frac{1}{4}(1-\delta)\overline{s}^{*2} < (1-\alpha)\frac{1}{4}\delta\overline{s}^{*2}$. After substituting $\frac{1}{2}\{\frac{1}{(1-\delta)}p_0 - c\}$ for $\overline{s}^{*}$ and rearranging, we have the desired result. ■

Lemma 2 and proposition 2 establish our main result that the entrant and the incumbent can use a simple trigger strategy combination to maximize their combined profit and share the increase in the combined profit by taking advantage of the switching costs of consumers. Subscribers of the entrant whose switching costs are too high to justify switching to the incumbent pay a higher price, despite the higher price that the entrant chooses in the collusion. Subscribers of the entrant whose switching costs are low switch to the incumbent and pay the same price that they would pay when the two firms do not collude. However, they pay switching costs. Consequently, the subscribers of the entrant are worse off as a result of the collusion, while the subscribers of the incumbent are not affected by the collusion. Thus, the collusion affects only those consumers whose switching costs are low.

4. Conclusion

In this paper, we studied the behavior of the firms in the early stage of competition in a newly deregulated market characterized by subscriber-based competition and switching costs. We showed that when the incumbent firm is subject to price regulation, the entrant will choose a familiar strategy of charging a low introductory price in the early stage of competition and raising it to maximize its profit from the locked-in subscribers in the mature stage. We also showed that the two firms can use a simple trigger strategy combination to form a collusion in which the entrant raises the price while the incumbent transfers an amount of money that more than compensates for the loss of profit the entrant suffers as a result of raising its price. Our main result depends on subscriber-based competition, asymmetry in the subscriber base between the incumbent and the entrant, and switching costs of consumers that vary with consumers. Our result on the optimal response of the entrant against the regulated price of the incumbent in the second period, summarized in proposition 1, seems to depend on the assumption of a uniform distribution of switching costs. When the distribution of switching costs takes a more general form, the entrant may choose a price p_1 that is higher than the regulated price of the incumbent. When F is the distribution function of s, the profit of the entrant in each $t \geq 2$ when it chooses a price $p_2 > p_0$ is given by $(F(p_0 - p_1) - F(\frac{1}{(1-\delta)}(p_2 -$

$p_0))p_2$ for $p_2 > p_0$. It is possible that this function of p_2 attains an interior maximum at a point belonging to $(\frac{1}{(1-\delta)}(p_2 - p_0), (p_0 - p_1))$, depending on the shape of F[20]. Even when the entrant chooses a price p_1 that is higher than the regulated price of the incumbent p_0 when it competes with the incumbent without colluding in more general cases, we expect that the collusion of the form supported by a simple trigger strategy that we discussed in this paper will continue to exist for a wide range of distribution functions F.

We did not analyze the possibility of collusion in which the incumbent transfers market shares to the entrant instead of paying money—although such a scheme was included in the agreement between Hanaro and KT, as it seems that the incumbent in the local calls market does not have a feasible instrument with which it can transfer market shares to the entrant to produce a market share distribution. Given the regulated price of the incumbent, a price chosen by the entrant induces a market share distribution through the decisions made by the consumers on their operators. The part of the agreement on market shares implicitly assumes that a price increase by the entrant will lead to an outcome in which its market share is smaller than what the agreement specifies. Thus, the incumbent should choose an action that will increase the market share of the entrant and decrease its market share by the same magnitude. Such a transfer of market share can be achieved only through a transfer of subscribers. The problem is that there is no feasible way one can think of by which the incumbent can transfer its subscribers to the entrant when its price is fixed. Even if there is some way for the incumbent to control the number of subscribers to some degree, it will be extremely difficult to ensure that the market share distribution changes by a certain proportion each month. We believe that the part of the agreement on the market share distribution was included as a mechanism to calculate the amount of money to be transferred from the incumbent to the entrant.

Our results have policy implications. Antitrust authorities need to pay attention to the possibility of collusion between a regulated incumbent dominant firm and a new entrant in telecom markets in which only the incumbent raises the price. This form of collusion may also be used by firms even when the dominant incumbent firm is not subject to price regulation, as the colluding firms decide to raise the price of the entrant only in order not to

[20] The entrant will never choose a $p_1 < p_0$ regardless of F, as the demand for the entrant will remain constant at $(p_0 - p_1)$ for all p_2 belonging to $(p_1, p_0]$.

arouse suspicion of collusion. Our analysis of the basic model also makes it clear that the regulated price of the incumbent affects the price path of the entrant, market share distribution, and the welfare of consumers in a profound way even if the entrant does not collude with the incumbent in a profound way, suggesting that the regulator should consider the short-term effect on consumer welfare as well as the longer-term effect on competition when choosing a regulated price.

What do our results suggest about the collusion case that occurred in the local calls market in Korea in 2003? Our model and analyses show that it is possible for the incumbent and a new entrant in telecom markets to collude in the mature stage of competition in a way described by the agreement made between Hanaro and KT in 2003. However, our results do not imply that the alleged collusion between the two firms was, in fact, a collusion that our model analyzed. The main reason for our reservation is based upon the fact that Hanaro's increase in price, although specified in the agreement and executed according to the agreement, was the first meaningful price increase since it entered the market, and that Hanaro did not lower its price back to the level it had maintained before the agreement—even after it became clear that KT would not transfer money or market shares. Thus, further investigation of the case, including an examination of various policies the Ministry of Information and Communications pursued, is necessary to determine whether the Hanaro–KT agreement was a collusive one.

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