A welfare analysis of subsidy regulation in the mobile telecommunications market*

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Abstract

In this paper, we analyze the impact of handset subsidies on demand for bundles of mobile telecommunications service and handsets, and evaluate the effects of subsidies and bundling regulations on social welfare using a counter-factual simulation analysis. By estimating a structural model that explicitly considers demand for bundles and the profit maximization of mobile operators and handset manufacturers separately, we find that mobile carriers indeed offer a discriminatory subsidy for handsets depending on a consumers' choice of service plans. Results of the simulation show that the ban of or putting a ceiling on handset subsidies reduces social welfare because, as the handset subsidy is regulated, consumers have to pay more for handsets or give up purchasing new products and service, and profits of providers are also reduced due to the decrease in demand. If the bundling of mobile carriers is prohibited, then price competition between handset manufactures occurs, but the social welfare will not improve because the competition will not reduce handset prices as much as the price with the current subsidy level. Thus, in this paper, we argue that the most effective way to improve social welfare is to let the market decide.

Key words: mobile telecommunications market, bundling, handset subsidy, regulation, social welfare

JEL Classification: L51, L96

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1. Introduction

In the telecommunications market, mobile carriers often sell a mobile communications plan and a handset as a bundle and offer a discount to consumers who sign up for a long-term contract. The discount is called a "handset subsidy" if it is provided as a reduced upfront price of the handset.[1] This type of subsidy is a prevalent marketing strategy of mobile carriers and it has been allowed in most countries, but not in a few, such as Belgium, Finland, and South Korea (Tallberg *et al*., 2007; OECD, 2013). After Finland lifted its restriction in 2006, South Korea remains the only country that strictly regulates the handset subsidy in the form of price floor. The Korean Congress enacted a new law, the "Mobile Device Distribution Improvement Act", reinforcing the government's restriction of the handset subsidy in October 2014. Why does the Korean government regulate this market? The Korean government argues that undesirable effects may arise from competition with handset subsidies. One concern is that the subsidy may be used as an instrument for predation. That is, market-dominant firms may offer "excessive" discounts for the bundled goods to deter a new entrant or to kill rivals in the market. In fact, there were some cases where consumers could purchase "minus-phones" for which the subsidies exceeded the retail price. However, there are only three big firms in the market and a new entrant has to get a license to enter. Furthermore, the service prices are strictly monitored by the regulatory authority. Thus, the concern about predatory pricing is not supported. Another concern is that the mobile operators discriminate against consumers in terms of the plan they subscribe to and the length of the contract. By offering a large subsidy, the operators may induce consumers to be "locked-in" with longer and more expensive contracts. However, price discrimination does not necessarily harm consumers, and subsidy competition can benefit rational consumers who have high utility for the handsets.

There is an extensive literature about bundling and price floor regulation but, on this specific issue, there have been few studies, written mostly by Korean researchers. As a theoretical study, Park and Ahn (2004) had the view that a subsidy is actually an instrument of discrimination between existing and new subscribers, but they showed that social welfare was higher when the subsidy existed. Cheong (2013) also showed theoretically that social welfare decreased when subsidies were prohibited by regulation. Among empirical studies, Choi and Kim (2011) estimated that the consumer surplus increased from 1,300 to 1,600 billion KRW when mobile handset manufacturers (manufacturers) decreased the handset price, instead of abolishing the subsidy. However, when the subsidy is banned, it is unknown whether the handset manufacturers will cut the handset price, because they would have no incentive to cut the price if the mobile carriers distribute the handsets in a bundle (Cheong, 2013). Kim and Kang (2012) considered that the consumer surplus may increase or decrease depending on the resources of the subsidy. In their research, the subsidy can increase social welfare, by up to 1,900 billion KRW, but if the entire resource of the subsidy comes from a high service rate, the consumer surplus will decrease to about 900 billion KRW. From Figure 1, we can see that the subsidy comes from both the mobile carriers and the handset manufacturers. Because at least part of the

[1] The use of the term "subsidy" may not be appropriate in that a subsidy is usually provided by a government or other institution to achieve a policy goal, whereas the handset discount is offered by mobile operators and recovered in the monthly payment for service. However, we will use the term because it is commonly used in academics and in practice.

subsidy comes from the manufacturers, the results of Kim and Kang (2012) imply that the consumer surplus is likely to increase due to the subsidy.

[Insert Figure 1]

As mentioned, mobile carriers sell bundled goods. However, the absence of appropriate data has limited the study of issues concerning both service and handsets. By using an individual-level data set that includes the choice of a handset and a service plan together, we try to estimate the demand for the bundled goods and measure the welfare effects of handset subsidies under various scenarios.

The main findings of the counterfactual analysis are as follows. First, prohibition of or putting a ceiling on the subsidy by regulation decreases social welfare, because, when regulating the handset subsidy, market share of outside options in which a consumer does not purchase a new product increases, and thereby profits of producers are also reduced. Second, if reduced service rates are required with a handset subsidy ceiling, the social welfare will also decrease because a cut in service rate just causes a monetary transfer from mobile carriers to consumers, which does not affect consumer demand. Thus, the change in social welfare is the same as the case with a handset subsidy ceiling. Finally, if the bundling of mobile carriers is prohibited, then the price competition between handset manufactures occurs, but the social welfare is not improved even if the competition leads to a cut in handset prices. Thus, the results of this paper show that given current market practices where mobile carriers sell service plans and handsets together, the most effective way to improve social welfare is letting the market compete, with subsidies.

The remainder of this paper is organized as follows. In Section 2, we introduce a brief history of subsidy regulation, focusing on recent developments in Korea. The empirical methods and the data are explained in Sections 3 and 4, respectively. In section 5, we report the estimation and simulation results and conclude in Section 6.

2. Brief history of handset subsidy regulation in Korea

The first mobile telecommunications service in Korea was introduced in 1984 by Korea Mobile Telecom, which was a state monopoly and is now SK Telecom. By 1997, four other carriers had earned a license and there were five mobile carriers, two cellular carriers, and three PCS carriers until 2001. When there were five carriers and the market was growing, they fiercely competed with handset subsidies to attract consumers. As a result, the financial performance of mobile carriers worsened. Thus, the Korean government regulated “excessive” subsidies to improve the financial performance of mobile carriers and to keep the market structure with five carriers (Kim *et al*., 2004).

In 2002, the Korean telecommunications market was restructured from five to three mobile carriers by mergers, and the government enacted a clause prohibiting handset subsidies offered by mobile carriers in *the Telecommunications Business Act* in 2003. This clause also aimed to reduce the trade deficit from the consumption of handsets because the major parts of handsets were being imported then. The prohibition of

subsidies was lifted from the Act in March 2008, because it was a sunset regulation. However, in 2010 the Korean government reintroduced the regulation implicitly through the *Marketing Guideline* (MGL) in which the subsidy was capped at 270,000 KRW. Nevertheless, mobile carriers continuously violated the MGL and the government imposed fines on the carriers.

The Mobile Device Distribution Improvement (MDDI) Act reinforced subsidy regulation by the Korea Communications Commission, the regulatory authority for the telecommunications and media sector in Korea; it was empowered to set a subsidy cap every 6 months. The MDDI Act also prohibited discrimination based on rate plan type, age, and region, and required mobile carriers to disclose factory prices, sales prices, and subsidies by each handset model through their websites.

3. Empirical strategies

3.1. Demand estimation and consumer surplus

To estimate demand for bundled good in the mobile telecommunications market, we set up a discrete choice model similar to Thomadsen (2005). Each consumer chooses a bundled good that maximizes his utility among the alternatives, $j \in \{1,2,\dots,J\}$ and the outside option of not purchasing. Thus, there are $J+1$ options. A bundle j is the combination of a mobile service plan r and a handset h, i.e. $j = r \times h$ where $r \in \{1,2,\cdots,R\}$ and$h \in \{1,2,\cdots,H\}$. Formally a utility function of consumer i is as follows:

$$U_{ij} = \alpha P_j + \boldsymbol{X}_j'\beta + \varepsilon_{ij} \equiv V_j + \varepsilon_{ij} \tag{1}$$

where U_{ij} is the utility of consumer i who purchases the bundled good j, P_j and $\boldsymbol{X}_j$ denote the price and the vector of characteristics of the bundled good, respectively. The last term ε_{ij} is an error term that follows the type I extreme value distribution. The characteristics of bundled goods are distinguished into those of the mobile service and the mobile handset. The service attributes include the allowance for voice calls, SMS, and data. For the estimation, we converted each type of allowance into a monetary value by the price per call, SMS, and data and added them up because there are strong correlations among the allowances.[2] For the characteristics of handsets, we considered display size, definition and pixels of the display, capacity of the battery, weight, Digital Multimedia Broadcasting (DMB) function, pixels of the camera, and brand dummies. The price of the bundled good$j$, is the sum of the monthly fixed rate for a plan r, SR_r, and the list price of a handset h, P_h, from which a discount D_j is subtracted: that is, $P_j = SR_r + P_h - D_j$. A discount for the bundled good is composed of the discount in service rates DSR_r and the handset subsidy HS_h: that is, $D_j = DSR_r + HS_h$.

If the consumer does not subscribe newly to a service plane (i.e., he chooses the outside option), then his utility is as follows:

[2] The correlation coefficients between the service allowances are from 0.58 to 0.97.

$$U_{i0} = M_i'\delta + \varepsilon_{i0} \tag{2}$$

where M_i is a vector including age and gender.

Due to the assumption about the error term, we can write the probability of a consumer *i* choosing the bundle *j* in logit form (MacFadden, 1974).

$$P_{ij} = \frac{e^{V_j(\cdot)}}{e^{V_{i0}} + \sum_{j=1}^{J} e^{V_j(\cdot)}} \tag{3}$$

The coefficients of the utility function (1) and (2) can be estimated by the maximum likelihood. Based on the estimates, the aggregate choice probability of a good *j* is calculated as follows:

$$\hat{s}_j = \frac{1}{N}\sum_{i=1}^{N} \hat{P}_{ij} \tag{4}$$

The market shares of the bundled goods can be aggregated into the share of a service plan and a handset, as follows:

$$\hat{s}_r = \sum_{h=1}^{H} \hat{s}_{rh} \text{ and } \hat{s}_h = \sum_{r=1}^{R} \hat{s}_{rh} \tag{5}$$

The main purpose of this paper is to evaluate the welfare effects of the changes in regulation. For this, we follow the method of Small and Rosen (1981) to evaluate the consumer surplus.

$$\Delta E(CS_i) = \frac{1}{\alpha}\left[\ln\left(\sum_{j=0}^{J} e^{V_{ij}^{1}(\cdot)}\right) - \ln\left(\sum_{j=0}^{J} e^{V_{ij}^{0}(\cdot)}\right)\right] \tag{6}$$

where V_{ij}^{0} and V_{ij}^{1} denote the expected valuation or the inclusive value of a consumer about the bundles before and after the regulation change, respectively.

3.2. Supply side and producer surplus

As can be seen in Figure 1, the Korean telecommunications market has a vertically related structure. Upstream, the handset manufacturers provide their products to the downstream firms, such as mobile carriers, and downstream, the mobile carriers sell these mobile handsets with their service plans as bundled goods.

A manufacturer shares the costs of the handset subsidy with the carriers; thus, the profit function of the manufacturers is as follows:

$$\pi_m^U = \sum_{h \in f_m} (P_h - \varphi HS_h - mc_h) s_h M - F_m \tag{7}$$

where HS_h is the handset subsidy of a handset h, φ is the subsidy burden ratio, mc_h is the marginal cost, M is the potential market size for handsets, F_m is the fixed cost of the manufacturer m, and s_h is the market share of handset h. By rearranging the first-order conditions of profit maximization, we can calculate the marginal cost as a function of the prices, the ownership structure of products, and the parameters of demand function in vector notation (Nevo, 2001):

$$\boldsymbol{mc} = \boldsymbol{P} - \boldsymbol{\varphi HS} - \boldsymbol{b}(\boldsymbol{P}) \tag{8}$$

where $\boldsymbol{mc}$, $\boldsymbol{P}$, and $\boldsymbol{HS}$ are the vectors of marginal costs, handset prices and subsidies, respectively, and $\boldsymbol{b}(\boldsymbol{P})$ is the vector of markups. Following Berry *et al*. (1995), the markups are defined as $\boldsymbol{b}(\boldsymbol{P}) = \boldsymbol{\omega}^{-1}\boldsymbol{s}(\boldsymbol{P})$, where $\boldsymbol{\omega}$ is the $h \times h$ matrix of which element is $\frac{\partial s(P)_{-h}}{\partial P_h}$ if h and $-h$ are produced by the same firm and 0 otherwise. If we assume that the marginal cost in equation (8) is a constant, then we can calculate the change of the manufacturers' surplus caused by the regulation change as $\Delta\pi_m^U = \pi_m^{U_1} - \pi_m^{U_0}$.

The profit function of the carriers is similar to the mobile manufacturers, but the profits come from two different groups. One comes from new subscribers and the other comes from old subscribers who choose an outside option. Thus, we define P_0 as the average fee of old subscribers to calculate the mobile carriers' profits. Additionally, we assume that the marginal costs of mobile services are zero. This assumption is not seriously unrealistic, because most of the costs of the carriers are fixed costs, such as spectrum fees, network installation, and facilities. The actual price of a handset for the carriers is $\hat{P}_h = P_h - \varphi HS_h$. The carriers set SR_r for their service and offer their share of handset subsidy $(1-\varphi)HS_h$ and service rate discount DSR_r. Thus, the profit functions of mobile carriers are as follows:

$$\pi_k^D = \sum_{j \in f_k}(P_j - \hat{P}_h)s_j M + P_0 s_0 M - F_k \tag{9}$$

where $P_j = SR_r + P_h - D_j$, and F_k is the fixed cost of mobile carrier k. The surplus change of the carriers is similar to the surplus change of the manufacturers.

Finally, in equation (7), we define the burden ratio of the handset subsidy. For simplicity, we assume that the subsidy burden ratio is $\varphi = 1/2$.

3.3. Handset subsidy

To estimate the discrete choice model above, we should know the amount of the discount for each bundle. Unfortunately, we do not directly observe these subsidies in the data, but we can infer the subsidies from the information about the monthly installments for the handset of each consumer. As discussed earlier, mobile carriers offer a fixed amount of discount for the service, depending on the plans. Thus, the monthly fixed payment of consumer would be composed of that

$$\text{Monthly Fixed Fee} = \underbrace{\text{monthly installment}}_{=\text{Handset price}-\text{subsidy}} + \text{service rates} - \text{discounts of service rates}$$

However, retailers usually advertise this discount program as a handset subsidy to consumers (KISDI, 2011); thus consumers are likely to consider the sum of the handset subsidy and service rate discounts as a discount on the handset and to report the monthly installment by subtracting the handset subsidy and the rate discount from the handset price as follows:

$$\text{Monthly Fixed Fee} = \underbrace{\text{monthly installment}}_{=\text{Handset price}-\text{subsidy}-\text{discounts of service rates}} + \text{service rates}$$

In fact, we found some records that support our presumption in the data. If consumers exactly recognized the discount programs offered by mobile carriers, they had to report their service rates lower than the list rates, but many respondents reported the service rates as the same as or more than the list rates. Thus, the handset subsidy has to be calculated as follows:

$$\text{subsidy} = \text{list price of hadnset} - \text{monthly installment} - \text{discounts of service rates}$$

When estimating the demand model, we use estimated value of the subsidies instead of observed subsidies for two reasons.[3] First, consumers can get a different amount of subsidy even when they choose the same handset and the same plan due to discriminatory practices of carriers. This creates too many alternatives in the choice set of a consumer. Thus, to reduce the alternatives, we assign the same amount of subsidy for a specific combination of a handset and a service plan. Second, there are some combinations that were not chosen by any respondent in the sample, so we cannot determine a subsidy for those combinations. To estimate a discrete choice model of demand, we need to "fill out" the subsidy information for each combination of handsets and service plans.

To fill out the subsidy information, first, we estimate the average amount of subsidy, depending on the carriers and handsets, as follows:

$$HS_i = \sum_{k=1}^{3} D_k + \sum_{h=1}^{H} D_h \tag{10}$$

where HS_i is a calculated handset subsidy of individual i, D_k is a dummy for the carrier k, and D_h is a dummy for the handset h. This estimation is based on market practices. The mobile carriers use a strategy, the so called "policy of strategic mobile handset," which gives more subsidies to consumers who purchase a particular handset, so as to sell off the old handsets in inventory or to advertise the latest handsets for raising their market share. As the next step, to assign a handset subsidy depending on the service plan, we consider

[3] There are some papers that have used estimated values as proxy variables (e.g. Boskin, 1974; Hoffman and Duncan, 1988; Montmarquette *et al*., 2002; Luttmer, 2005). Boskin (1974) who estimated the occupational choice model, and Hoffman and Duncan (1988) who estimated the marriage decision model of female used the predicted wage rates as proxy variables, and Montmarquette *et al*. (2002) who estimated the major choice model used predicted future wage rates as proxy variables.

the incentives of the carriers. The mobile carriers should provide a larger subsidy to induce consumers to more expensive plans; thus, there will be a larger subsidy for more expensive plans. On the other hand, the carriers have little incentive to offer a high subsidy to heavy users who are likely to be less elastic to the costs or concerned about an extra charge fee (Miravete, 2003; Narayanan *et al*., 2007). Therefore, the marginal contribution of the service rate will be reduced. Thus, we estimate the handset subsidy conditional on the service rates using the average subsidy as follows:

$$HS_{hk} = \sum_{h=1}^{H}\sum_{k=1}^{3}\left(\beta_1^{hk} D_h D_k SR_r + \beta_2^{hk} D_h D_k SR_r^2\right) \quad (11)$$

where HS_{hk} is a estimated average handset subsidy of carrier k and handset h. By the incentive of mobile carriers, I expect that the coefficients are $\hat{\beta}_1^{hk} > 0$, and $\hat{\beta}_2^{hk} < 0$: that is, concavity of the subsidy schedule.

4. Data and variables

The data used in this paper came from the various sources. For information on bundled good purchases, we used the KISDI Media Panel (Media-panel) provided by the *Korea Information Society Development Institute*. The data set includes annual information, such as which mobile handset is used and which service plans are subscribed to. The first wave of the survey was from 2010 and the 3rd survey was completed in 2012. However, we only used the 3rd survey because only the 3rd survey provided relevant information, such as the ownership of handsets, for this paper. The characteristics of service plans were obtained from the websites of the mobile carriers (see Table 1).[4] The information on the characteristics of handset came from a website, www.cetizen.com, an online community of users in Korea.

[Insert Table 1]

There exist various bundled goods in the mobile telecommunication market, so it is difficult to consider all bundles in the estimation. In this paper, to reduce the choice set, we focused on 3G smartphone users who took a large share in the sample, and, in particular, those who newly subscribed to a plan in 2011. Although the Korean telecommunications market is now transitioning from 3G to LTE, 3G users had the largest share in the market in 2011 and the carriers' business conduct are essentially indifferent between 3G and LTE; thus, we can fully draw implication for the current market. We selected the respondents whose service plan was identified and the size of the sample shrank to 3,215 (1,103 new subscribers).

In the data set, the handset brand is identified only in a larger category such as iPhone, not iPhone 3 versus iPhone 4. We can assume that the market share of recently released models is higher, so we calculated the weighted average characteristics of the handsets using the release date of each model. For instance, three models in the Galaxy S series were released by SKT. We gave a weight of '3'to the latest model, '2' to the

[4] The websites of SKT, KT and LGU+ are www.tworld.co.kr, www.olleh.com, and www.uplus.co.kr, respectively.

second newest, and '1' to the oldest model[5], and if the models were released in the same month, then we gave them equal weight.

In the choice set of consumers, we distinguished the handsets by the carriers. For example, Apple's iPhone 3 was released by KT in 2009, but was not released by the other carriers. Thus, we should exclude some alternatives, such as iPhone 3 by SKT. In our sample, SKT and KT released 13 models and LGU+ released seven models of handsets. Thus, the selectable bundled products were $j = 198$, because there are 78 ($h = 13, r = 6$) for SKT and KT, and 42 ($h = 7, r = 6$) for LGU+.[6]

By assuming that all consumers make a 2-year contract with the mobile carriers, we define the price variable in a monthly unit. That is, we converted the handset prices to a monthly unit by dividing the price by 24 months. The service allowance is the sum of its monetary value multiplied by 1.8 per second, 20 per unit, and 0.025 per 0.5 KB for calls, SMS, and data, respectively. If the data allowance is unlimited, then we used 3,000 MB for the amount of the allowance.

Descriptive statistics are reported in Tables 2 and 3. The statistics were calculated by pooling the carriers; the service rates of 3G smart phones are categorized into six types in which their fixed rates were from 35,000 to 95,000, and the service fee of the outside option was, on average, 37,676 KRW. The reason why the service rates in Table 2 differ from those in Table 1 is because the fixed rates were cut by 1,000 KRW after September 2011. Because the survey was done before then, we applied the rates in Table 2 when estimating the demand function.[7]

[Insert Table 2]

[Insert Table 3]

Table 3 shows the distribution of the estimated subsidy depending on the service plans and the handsets. We can find that there is concavity along with the service rate and that the subsidy for the 65,000 plans is the highest. This might seem to be a puzzling result, but it might be a kind of price discrimination against heavy users or because the amount of discount on the service rate was large enough to cover most of the handset price, so a large subsidy was unnecessary. The result is also consistent with some reports showing that SKT in 2011 provided higher handset subsidies for the 55,000 plan than for the 95,000 plan. If we take an average of the subsidies across the manufacturers, we find that each firm offers different amount of subsidies.

5. Results

5.1. Demand estimation

[5] If there are four products, then we gave 4, 3, 2, and 1 as the weight to each product.

[6] There are mobile handsets by Blackberry and Nokia in the categories, but there were no consumers who chose these products in the data.

[7] The media panel usually surveyed the questionnaires from June to August in each year.

Table 4 shows the estimation results of demand for bundled goods using the conditional logit model. As expected, higher prices decreased utility to consumers and more allowances had a positive effect on utility. In terms of characteristics of the mobile handset, display, definition, pixels, battery life, DMB function, and the camera gave positive utility to consumers, but weight gave negative utility. In the case of outside utility, we find that as consumers were older, they wanted to choose the outside option.

5.2. Scenario analysis

In this subsection, we performed scenario analyses and evaluated the welfare effects of the policy changes. The predicted market share from estimation results is considered as the share under imperfect regulation of the handset subsidy because, despite the regulation by MGL in 2011, the carriers frequently violated the MGL. We consider four scenarios, described below (see also Fig. 2).

Scenario #1. The government bans the handset subsidy. The carriers never violate the regulation to avoid extremely harsh punishment such as revocation of business license. The subsidy is assumed to be zero: that is, $HS_j = 0$ in the simulation.

Scenario #2. The government allows the handset subsidy, but with a ceiling up to 270,000 KRW in total. This scenario is very similar to the recent MDDI Act. To simulate this scenario, we restrict the handset subsidy at 11,250 KRW per month (= 270,000/24 months) if the handset subsidy exceeds the ceiling.

Scenario #3. The government allows the subsidy with a ceiling up to 270,000 KRW and additionally requires cuts in service rates by 1,000 KRW. To do this, we subtract 1,000 KRW from the fixed rates of every plan.

Scenario #4. The government bans the handset subsidy and prohibits bundling by mobile carriers. By this regulation, consumers can buy the handset from any manufacturer, and freely subscribes to mobile telecommunications services from any mobile carrier.

[Insert Figure 2]

The results of counterfactual analyses from scenario #1 to #3 are presented in Tables 5 and 6. In the case of mobile carriers, the simulated results show that if the handset subsidy is banned (scenario #1) or restricted (scenario #2), then the market share of relatively expensive service plans will decrease and the outside option, not purchasing, will increase, but the profits of the carriers in scenario #1 and #2 will increase, due to savings in marketing costs (See Appendix). These results imply that the handset subsidy makes it easier consumers for to subscribe to new products by reducing the purchasing cost and the consumers who subscribe to new products choose 55,000 or 65,000 plans to receive larger handset subsidies. The results of scenario #3 shows that the cut in service rates does not increase the market share of 3G service plans because it simply causes a monetary transfer from mobile carriers to consumers. Thus, while the cut in service rates can increase the consumer surplus, it decreases the profits of mobile carriers without changing market share. From these results, a question may arise. If the profits increase when a handset subsidy is banned or restricted, then why

do mobile carriers compete with a handset subsidy? It is because the subsidy competition is more flexible than service rates because service prices are heavily regulated. Another possible reason is that it is more profitable than competition via service rates because a price cut there affects all existing customers, while a handset subsidy is applied only to new subscribers.

[Insert Table 5]

[Insert Table 6]

In the case of the handset manufacturers, the average profits are also decreased because of the increase in the outside option if they do not decrease the handset price. According to the simulation results, if the subsidy is banned, all firms' market shares are decreased, but if the subsidy is restricted, only firm A's market share decreases. The results of scenario #2 show that the manufacturers have the incentive to offer the handset subsidy through negotiation with mobile carriers if a handset subsidy is allowed, and that the subsidy competition of manufacturers is more flexible than decreasing the handset price in terms of profits.

To see this, assume that there is no bundling in scenario #4. We so far assume that there is no price competition between manufacturers because where the distribution network is controlled by the mobile carriers and the manufacturers do not directly sell their product to consumer, they have no incentive to compete with price (Cheong, 2013). However, if the handset manufacturers sell the handset directly to consumers, they would have a bigger incentive to compete with price. To calculate the simulated handset price, we use the estimated results of the demand and price equation, equation (5), and equation (8), similar with Park and Rhee (2014). The simulation algorithm is as follows:

- First, calculate the reference price, which excludes subsidy using equation (8), i.e., $\boldsymbol{P} = \boldsymbol{mc} + \boldsymbol{b}(\boldsymbol{P})$.
- Second, calculate the new market share using reference price and equation (5), and update the markups to update the handset price, i.e., $\boldsymbol{P^{NEW}} = \boldsymbol{mc} + \boldsymbol{b^{NEW}}(\boldsymbol{P})$.
- Third, compare the new price with the reference price to check whether the price converges: i.e., $\left\|\boldsymbol{P^{NEW}} - \boldsymbol{P}\right\| < \varepsilon$. If the norm is greater than the tolerance level, then iterate the above process until it converges.
- Fourth, if the norm converges, then calculate the new market share using the new price.

Table 7 shows the simulated market share of the service plans and the manufacturers in scenario #4. According to the results, the change in market share of service plans and handsets is similar to that in scenario #1 and consumer surplus as well as firms' profits decrease. Why do the profits and consumer surplus decrease despite price competition? It is because, although the manufacturers reduce the handset price by competition, the new prices will be still higher than the prices with a subsidy (see Table 8) and thus the share of no purchases is increased.

[Insert Table 7]

[Insert Table 8]

To summarize the results of the scenarios, we calculated changes in social welfare by $\Delta SW = \Delta CS + \Delta PS$ and reported it in Table 9. Table 9 tells us that social welfare is worse off when any type of regulation is introduced. If handsets and services are sold separately, the handset prices will fall due to price competition between handset manufacturers, but social welfare will not be improved because when handset subsidies are offered, the handset price is still cheaper.

[Insert Table 9]

6. Conclusion

In this paper, we analyzed the welfare effects of subsidy regulation in the Korean telecommunications market. Previous studies related to this subject area only analyzed interactions between handset manufactures and consumers due to the absence of data, but this paper overcomes this limitation using a unique data set.

The main findings of this paper are as follows. First, mobile carriers offer discriminatory handset subsidies, depending on the consumer choices of service rates to attract consumers to more expensive service plans. Second, prohibition of or putting a ceiling on the subsidy by regulation decreases social welfare, because, when regulating the handset subsidy, the market share of the outside option in which consumers do not purchase a new product at all increases; thus, profits of producers are also reduced. Third, if reduced service rates are required with a handset subsidy ceiling, social welfare will also decrease because the cut in service rates is just a monetary transfer from mobile carriers to consumers, which does not affect consumer demand. Thus, the change in social welfare is the same as with the case of a handset subsidy ceiling. Finally, if the bundling of mobile carriers is prohibited, then price competition between handset manufactures does occur, but social welfare is not improved even if this competition does lead to a cut in handset prices. Thus, the results of this paper show that given current market practices, where mobile carriers sell the service plans with handsets together, the most effective way to improve social welfare is to let the market compete, with subsidies.

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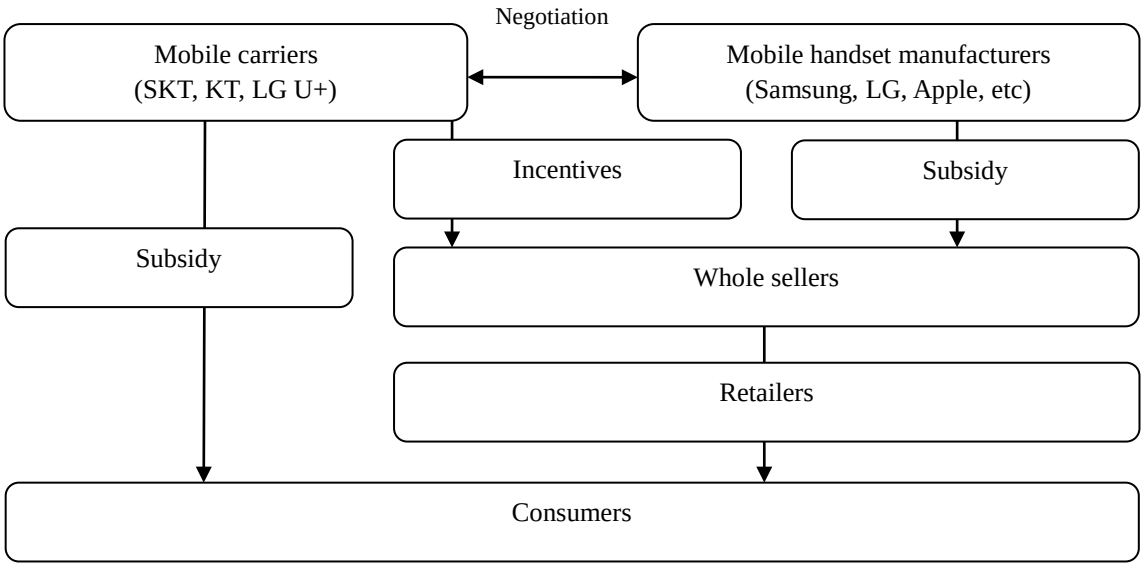
Figures and Tables

Figure 1. Korean telecommunications market structure



Source: KISDI (2011)

Table 1. 3G service plans for each mobile carrier and service allowance after September 2011

Mobile carriers	Service plans	Service rates (KRW)	Discounts (KRW)	Call (Minutes)	SMS (Unites)	Data (MB)
SK Telecom (Special discount)	All in one 34	34,000	11,000	150	150	100
	All in one 44	44,000	14,500	200	200	500
	All in one 54	54,000	17,500	300	200	Unlimited
	All in one 64	64,000	19,500	400	400	Unlimited
	All in one 79	79,000	22,500	600	600	Unlimited
	All in one 94	94,000	27,500	1,000	1,000	Unlimited
KT (Smart sponsor)	i-Slim	34,000	12,000	150	200	100
	i-Light	44,000	15,000	200	300	500
	i-Value	54,000	17,000	300	300	Unlimited
	i-Medium	64,000	19,750	400	400	Unlimited
	i-Special	78,000	22,500	600	600	Unlimited
	i-Premium	94,000	26,000	800	1,000	Unlimited
LG U+ (Super save)	OZ smart 34	34,000	13,000	150	150	1,000
	OZ smart 44	44,000	18,000	200	300	1,000
	OZ smart 54	54,000	21,000	300	300	Unlimited
	OZ smart 64	64,000	23,000	400	400	Unlimited
	OZ smart 74	74,000	25,000	600	600	Unlimited
	OZ smart 94	94,000	30,000	1,000	1,000	Unlimited

Notes: The name of the discounts program is in parenthesis. Calls, SMS, and data volumes are the basic services in accordance with each service plan.
Source: Each mobile carrier's website

Table 2. Descriptive statistics

Panel A. Characteristics of each service plan

Service plans	Sample share (%)	Service rates	Discounts	Service Allowance			
				Sum	Call	SMS	Data
3	5.35	35.00	11.82	34.49	16.20	3.39	14.89
		(0.00)	(0.76)	(18.64)	(0.00)	(0.49)	(18.84)
4	6.28	45.00	15.44	57.84	21.60	5.21	31.03
		(0.00)	(1.35)	(10.91)	(0.00)	(0.98)	(10.47)
5	19.47	55.00	18.05	191.21	32.40	5.21	153.60
		(0.00)	(1.55)	(0.98)	(0.00)	(0.98)	(0.00)
6	2.18	65.00	20.34	204.80	43.20	8.00	153.60
		(0.00)	(1.38)	(0.00)	(0.00)	(0.00)	(0.00)
7	0.65	78.55	23.03	230.40	64.80	12.00	153.60
		(1.89)	(1.02)	(0.00)	(0.00)	(0.00)	(0.00)
9	0.37	95.00	27.44	273.09	99.49	20.00	153.60
		(0.00)	(1.49)	(10.55)	(10.55)	(0.00)	(0.00)
Outside option	65.69	37.68					

Panel B. Characteristics of mobile handsets

Handset price	Display	Display definition	Pixel	Battery	Weight	DMB	Camera
29.03	3.79	350.64	226.89	1,502.88	131.41	0.65	5.68
(5.96)	(0.51)	(123.99)	(41.06)	(261.23)	(25.10)	(0.44)	(1.41)

Notes: Monetary units are 1,000 KRW. The standard deviation is in parentheses. The monetary values of call, SMS and data are translated by 1.8/s, 20/unit and 0.025/0.5KB, respectively. The service allowance is the sum of the monetary values of call, SMS, and data.

Sources: Korean Media Panel 3rd wave, websites of each mobile carrier, www.cetizen.com

Table 3. Estimated handset subsidy

	Service rates	Mean	S.D.	Min	Max
Panel A. Service plans	35	5.72	2.38	2.28	10.93
	45	6.62	2.75	2.64	12.65
	55	7.19	2.99	2.87	13.75
	65	7.45	3.1	2.98	14.23
	75~80	7.26	3.03	2.95	13.85
	95	6.25	2.6	2.51	11.94
Panel B. Handset manufacturers	A	7.54	3.74	2.28	14.23
	B	6.67	2.71	3.38	11.93
	C	5.73	1.41	3.33	7.73
	D	7.07	0.74	5.69	8.22
	E	4.32	0.54	3.36	5.18
	F	5.91	0.65	4.74	7.09
	G	3.73	0.34	3.17	4.12
	H	9.14	0.91	7.44	10.5

Note: The monetary units are 1,000 KRW.
Source: Korean Media Panel 3rd wave

Table 4. Estimation results of bundling choice model

Variables	Coefficients	t-statistics
Bundled price	-0.20	(-24.42)
Service allowance	0.02	(24.38)
Display	46.11	(6.31)
Squared display	-6.42	(-7.01)
Definition of display	0.05	(2.44)
Definition of display× Pixel	-0.0003	(-3.65)
Pixel	0.08	(4.76)
Battery	0.03	(11.76)
Weight	-0.11	(-11.57)
DMB	2.53	(6.98)
Camera	9.42	(6.71)
Squared camera	-0.77	(-7.75)
Outside utility for males	-0.11	(-1.35)
Outside utility for age 30~39	0.52	(3.44)
Outside utility for age 40~49	1.29	(8.72)
Outside utility for age 50~59	2.39	(14.53)
Outside utility for age 60+	4.22	(13.97)
Pseudo R^2	0.66	
Alternatives	199	
Sample observations	3,215	
Observations	639,785	

Notes: We let data = 3,000 MB if the data allowance is 'unlimited.' The dummy variables for the mobile carriers and the handset manufacturers are included in the model. The reference group for outside utility of age group is age 20~29.

Figure 2. Each scenario and market structures

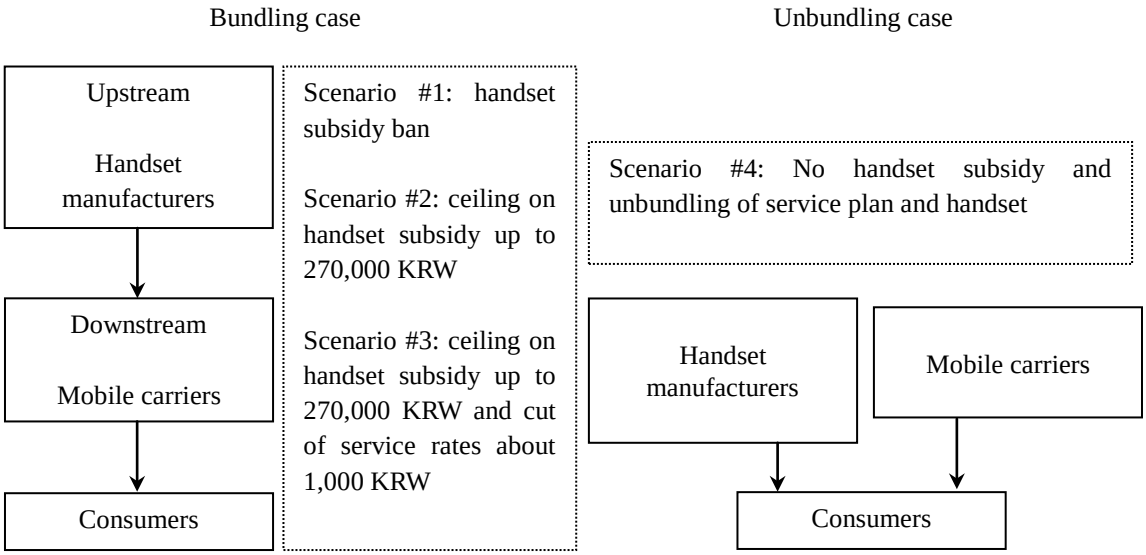


Table 5. Market share of the service plans and the profits of mobile carriers: Scenarios #1~3

Service plans	Market share (%)						
	Predicted (S0)	S1	ΔMS (%p) (S1-S0)	S2	ΔMS (%p) (S2-S0)	S3	ΔMS (%p) (S3-S0)
3	7.48	3.80	-3.68	7.50	0.02	7.50	0.02
4	4.09	1.71	-2.39	4.09	0.00	4.09	0.00
5	16.76	6.03	-10.73	16.69	-0.07	16.69	-0.07
6	4.92	1.68	-3.24	4.89	-0.03	4.89	-0.03
7	0.88	0.32	-0.56	0.87	-0.01	0.87	-0.01
9	0.18	0.08	-0.10	0.18	0.00	0.18	0.00
Outside	65.69	86.39	20.69	65.78	0.09	65.78	0.09
Sum	100.00	100.00		100.00		100.00	
$\Delta\pi^D$ (KRW)			1,690.69		7.31		-992.69

Notes: Scenario #1 is a ban on handset subsidies, Scenario #2 is a ceiling on handset subsidies, and Scenario #3 is a cut in service rates with a ceiling on handset subsidies. Changes in profits are calculated using the profit function of mobile carriers. The profit from the outside option is 37,676 KRW per user.

Table 6. Market share of the handsets and the profits of handset manufacturers: Scenarios #1~3

Handset manufacturers	Market share (%)						
	Predicted (S0)	S1	ΔMS (%p) (S1-S0)	S2	ΔMS (%p) (S2-S0)	S3	ΔMS (%p) (S3-S0)
A	23.86	8.13	-15.72	23.75	-0.11	23.75	-0.11
B	4.29	2.31	-1.99	4.30	0.01	4.30	0.01
C	3.42	1.93	-1.49	3.43	0.01	3.43	0.01
D	0.16	0.06	-0.10	0.16	0.00	0.16	0.00
E	0.22	0.14	-0.08	0.22	0.00	0.22	0.00
F	2.05	0.95	-1.10	2.06	0.00	2.06	0.00
G	0.03	0.02	-0.01	0.03	0.00	0.03	0.00
H	0.28	0.07	-0.21	0.28	0.00	0.28	0.00
Outside	65.69	86.39	20.69	65.78	0.09	65.78	0.09
Sum	100.00	100.00		100.00		100.00	
$\Delta\pi^U$ (KRW)			-832.10		-2.07		-2.07

Notes: Scenario #1 is a ban on handset subsidies, Scenario #2 is a ceiling on handset subsidies, and Scenario #3 is a cut in service rates with a ceiling on handset subsidies. Changes in profits are calculated using the profit function of handset manufacturers.

Table 7. Simulated results of Scenario #4

Service plans	Market share (%)		Handset manufacturers	Market share (%)	
	S4	ΔMS (%p)		S4	ΔMS (%p)
3	7.06	-0.42	A	17.97	-5.89
4	3.18	-0.91	B	3.19	-1.10
5	11.40	-5.36	C	2.57	-0.85
6	3.16	-1.76	D	0.09	-0.06
7	0.60	-0.28	E	0.17	-0.05
9	0.15	-0.03	F	1.39	-0.66
			G	0.03	0.00
			H	0.14	-0.14
Outside option	74.45	8.76		74.45	8.76
Sum	100.00			100.00	
$\Delta\pi^D$ (KRW)		1,243.07	$\Delta\pi^U$ (KRW)		-802.54

Notes: Scenario #4 is the unbundling case. ΔMS = ΔMarket share. Changes in profits are calculated using the profit function of mobile carriers and handset manufacturers. The mobile carriers' profit from the outside option is 37,676 KRW per user.

Table 8. Simulated new equilibrium handset prices in Scenario #4

Handset manufacturers	List price	Panel A. Without subsidy		Panel B. With subsidy		
		New price	Discount rate (%)	Old price	Discount rate (%)	$\hat{P}_h$
A	29,584.38	24,272.53	21.88	22,041.93	34.22	25,813.15
B	29,400.90	25,858.08	13.70	22,733.29	29.33	26,067.09
C	34,955.56	31,918.84	9.51	29,225.10	19.61	32,090.33
D	24,141.44	20,599.70	17.19	17,067.26	41.45	20,604.35
E	26,075.89	23,905.70	9.08	21,751.02	19.88	23,913.45
F	29,079.83	26,026.87	11.73	23,173.02	25.49	26,126.43
G	24,763.10	22,896.84	8.15	21,030.58	17.75	22,896.84
H	27,813.19	23,231.16	19.72	18,670.85	48.97	23,242.02

Notes: Discount rate $= (1 - \mathrm{P}'/\text{List price}) \times 100$. Handset price is monthly base. The monetary units are KRW. $\hat{P}_h = P_h - \varphi HS_h$ and $\varphi = 0.5$.

Table 9. Summary of the scenario analysis

Scenarios	Regulations			ΔCS (KRW)	ΔPS (KRW)		ΔSW (KRW)
	Handset subsidy	Service rates	Goods		Mobile carriers	Handset manufacturers	
# 1	Prohibition		Bundling	-1,591.15	1,690.69	-832.10	-732.56
# 2	Ceiling		Bundling	-8.01	7.31	-2.07	-2.77
# 3	Ceiling	Price cut	Bundling	991.99	-992.69	-2.07	-2.77
# 4			Unbundling	-749.43	1,243.07	-802.54	-308.90

Appendix

A.1. Decomposition of mobile carriers' profits

In this appendix, we decompose the mobile carriers' profit function into the profit, and cost, side. If we let superscript 1 be the result of any scenario, then we can decompose $\Delta\pi_k^D$ as follows:

$$\Delta\pi_k^D = \underbrace{\sum_{r\in f_k}(SR_r - DSR_r)(s_r^1 - s_r^0) + P_0(s_0^1 - s_0^0)}_{Change\ in\ sales} - \underbrace{\sum_{j\in f_k}(1-\varphi)HS_j\left(s_j^1 - s_j^0\right)}_{Change\ in\ marketing\ costs}$$

In the above equation, the first term on left side means a change in sales, and the others are in marketing costs. In the case of sales, the terms, $(SR_r - DSR_r)(s_r^1 - s_r^0)$ and $P_0(s_0^1 - s_0^0)$, mean the change of sales in 3G smartphone service rates, and the outside option, respectively. In the case of marketing costs, if $s_j^1 < s_j^0$, then it means a saving in marketing costs, because it positively appends to revenues of mobile carriers. The decomposition results are reported in Table A.1.

Table A.1. Decompositions of mobile carriers' profits

	Scenario 1			Scenario 2		
	New subscribers	outside option	Total	New subscribers	outside option	Total
Change in sales	-7,383.88	7797.10	413.22	-36.38	32.47	-3.90
Change in marketing costs	1,277.47	0.00	1,277.47	11.22	0.00	11.22
Change in profits			1,690.69			7.32
	Scenario 3			Scenario 4		
Change in sales	-378.60	-625.31	-1,003.90	-3,335.87	3,301.47	-34.40
Change in marketing costs	11.22	0.00	11.22	1,277.47	0.00	1,277.47
Change in profits			-992.68			1,243.07