# A Quantitative Analysis of the Effects of a Handset Subsidy on Consumer Welfare

Sung-Soo Han, Sung Ho Choi, Byeong-Kwan Kim, and Hyun Chung

**Observation of the effects of a handset subsidy on the mobile telecommunication industry has revealed two different aspects. The activation of various mobile services and the handset market, has led to the rapid acceleration of the related technological development, which is a desirable result, while rising prices and the overspending of related resources are undesirable. A great deal of research has been conducted to assess both desirable and undesirable factors using qualitative methods. However, quantitative studies into the effects of a handset subsidy are rare. In this study, we consider the positive and negative effects on consumer welfare of a change in demand and prices brought about by a handset subsidy. Then, we quantitatively compare the positive and negative effects and analyze their direct effects on consumer welfare.**

**Keywords: Subsidy, mobile handset, consumer welfare, quantitative analysis.**

## I. Introduction

The Korean mobile telecommunication industry has gone through various evolutionary phases, and three mobile telecommunication service providers are currently providing mobile services. Remarkably enough, the mobile telecommunication service industry is said to be competitive, although the number of service providers is small [1], [2]. In Korea, the mobile telecommunication services have a vertical business structure with mobile handsets being the strongest complementary goods of the services offered; therefore, the handset-manufacturing companies do not directly sell their handsets to the consumers; rather, the service providers purchase the handsets and sell them bundled with their mobile services [3]- [5].

A further significant characteristic of the current mobile telecommunication service market in Korea is that it has almost reached the saturation stage [6], [7]. This means that the majority of new subscribers are not new mobile users but users who are making a switch from other service providers. However, advanced mobile telecommunication services, such as Wi-bro and DMB, are preparing for imminent commercial service, and they may make inroads into the existing service market or create a new service market that is separate from the existing market in the near future [8], [9]. Many documents have referred to the great changes in the structure of the mobile telecommunication service market that will be brought about when the advanced services are launched.

In that situation, the ban on the handset subsidy, in force for a limited period of time only, will expire in 2006 in Korea. It was passed against the excessive handset subsidy of the mobile service providers in 2000. We cannot anticipate the direction in which the mobile telecommunication market will evolve once

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the ban expires [2], [10]. Some observers have suggested that the existence of a handset subsidy can only bring about great confusion in the mobile telecommunication market, as it did before. Others, however, insist that the subsidy will offer great benefits to service providers and consumers alike [10], [11].

For the objective evaluation of the effects of a handset subsidy, we need to estimate the variations in consumer welfare quantitatively. Up until now, most related studies have been devoted to qualitatively assessing the positive or negative effects of a handset subsidy, while quantitative studies are few and far between.

In this study, we quantitatively analyze the effects on consumer welfare of the handset subsidy by estimating the difference between the positive effect due to the rising demand of consumers and the negative effect arising from a price increase, which means the service rate.

## II. Estimation of Consumer Welfare

### 1. Consumer Welfare and Consumer Surplus

Consumer surplus is the total economic value of goods or services less the amount actually paid. The economic value means the maximum value that a consumer would be willing to pay to consume a given quantity of goods or services. By the summation of each consumer surplus, we can obtain the total consumer surplus using what is known as the Marshallian demand curve. It is under dispute as to whether consumer surplus is significant as a measure of consumer welfare [12], [13]. However, many scholars still use consumer surplus to estimate the social benefits arising from any variation in price or income [14], [15]. Robert D. Willig insisted that consumer surplus generally provides an effective approximate value for use as an appropriate estimation of social welfare [16]. In this study, we also use the consumer surplus for that purpose.

The existing methodologies for the estimation of consumer surplus can be classified into four categories. The first methodology uses the Marshallian demand curve. Hicks, however, stated that the surplus derived using the Marshallian demand curve is incorrect because any price reduction implies a relative increase in consumer income and thus the consumer is assumed to have a higher utility function than before [17]. Therefore, he insisted, a compensated demand curve should be used to obtain a correct estimation of consumer surplus. The two methodologies referred to above must involve an estimation of some parameters in order to determine the demand function. The estimated value of consumer surplus, therefore, has to be directly dependent upon the estimated parameters. A third alternative methodology is the non-parametric derivation method. Its methodology can provide an approximate surplus value by simple summation without any idea of the demand curve. Finally, Bresnahan proposed a utility function based on the theory of an index number to determine the consumer surplus [17]. These four methodologies all differ from each other, but the estimated results are known to be similar [18].

In attempting to estimate the consumer surplus of the mobile telecommunication service using the above methodologies, we must necessarily confront certain problems. The most significant problem is the difficulty of gathering data. It is not easy to gather the appropriate data for analysis because the history of the mobile telecommunication service is very short. In particular, the Korean mobile service has only recently been generalized, having spread dramatically rather than progressively. In this study, we need to make certain assumptions, referred to later on, regarding the demand function of the mobile telecommunication service for our analysis.

### 2. Estimation Methodology of Consumer Surplus

As has already been noted, it is almost impossible to use the methodologies mentioned above because of the scarcity of available data. Our study accordingly modifies the methodology proposed by Alexander, Kern, and Neil, using only revenue and price elasticity to estimate the consumer surplus [18], [19]. Supposing that the revenue from the mobile telecommunication services is given by $q = q(p, w)$, where $q$ is the volume of total calls measured by the minute, $p$ is the price, and $w$ is a vector containing any other variables that might influence the revenue, such as the prices of other services and various price indices. We assume that this function has first and higher order derivatives. Then an inverse market demand function becomes

$$p = p\,(q, w). \tag{1}$$

Supposing that the price and revenue at a certain point in time are $p_0$ and $q_0$, respectively, and that the demand function is a quasi-linear demand curve, then it can only modify the function of price ($p$). Thus Taylor's theorem yields the following:

$$p(q) = p(q_0) + p'(q - q_0) + \delta(q). \tag{2}$$

Integrating this function from 0 to $q_0$ and subtracting the amount that the consumers actually paid ($p_0 \cdot q_0$) yields the consumer surplus ($CS$) as follows (see Fig. 1):

$$\begin{aligned} CS &= \int_0^{q_0} p(q)dq - p_0 \cdot q_0 \\ &= \int_0^{q_0} [p(q_0) + p'(q_0)(q - q_0) + \delta(q)]dq - p_0 \cdot q_0 \\ &= -\frac{p_0 q_0}{2\eta} + \int_0^{q_0} \delta(q)dq \end{aligned} \tag{3}$$

$$\eta = -\frac{1}{p(q_0)}\left(\frac{p_0}{q_0}\right). \quad (4)$$

Here, $\eta$ is the price elasticity of demand evaluated at $p_0$ and $\delta(q)$ is the residual term. When the second term in equation (3) is sufficiently small, the consumer surplus is approximately $-p_0q_0/2\eta$. Actually, when the demand function is linear, the consumer surplus is exactly this amount.

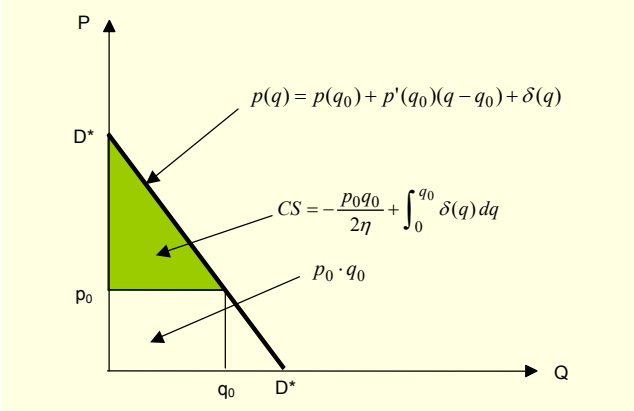


Fig. 1. Demand curve and consumer surplus.

## 3. Change in Consumer Surplus

As the price or other factors of the service change, the consumer surplus can also change at any time. The factors that have an influence on the change in consumer surplus can be classified as service price and non-price factors. Some of the more important factors are

i) change in the price of the service concerned;
ii) change in non-price factors such as
- the quality of the service,
- the price and quality of substitutes,
- the price and quality of complements,
- consumers' income,
- population, and
- tastes and preferences.

A change in the price of the service concerned will change the quantity of the service that consumers consume. This means that a change in the price brings about a change of revenue within the demand curve. A change in a non-price factor will, however, result in a movement of the demand curve. For instance, the maximum amount consumers would be willing to pay for a given quantity of the service increases when the price of complements decreases. This also means that a consumer would be willing to consume more at a given price. In this study, in order to analyze the change in consumer surplus resulting from a handset subsidy, one of the powerful complements, we estimate the difference in consumer surplus between the positive effect due to the increasing demand of consumers and the negative effect arising from the increasing price.

## 4. Assumptions of Demand Curve

To evaluate the change in consumer surplus due to a handset subsidy, we need to make two assumptions. Our study assumes that the demand curve for the mobile telecommunication service is a simple linear function in order to enhance the accessibility of our analysis. Because the goal of our study is to verify whether a handset subsidy will have a positive or a negative effect on consumer surplus rather than to estimate the accurate volume of net surplus change, we regard this as an excusable assumption for our study. On the practical side, because the history of the mobile telecommunication service is so short, it is not easy to gather the appropriate data for estimating the accurate demand function. We have to consider another assumption that is plausible in terms of general demand functions. After an improvement in a non-price factor, it is more natural for consumers to increase their consumption of goods or services at a low price than at a high price. This is because the potential consumer base is generally larger at a relatively low price than at a relatively high price. When a change in demand is independent of the equilibrium price, it is the same at any price and the demand curve is shifted in parallel. When the change in demand is extremely dependent on the price, there can be no change in the demand at the high price that drives the quantity demanded to zero, and the change in demand increases as the price goes down. In that case, the demand curve would rotate around a single interception point on the price axis [20]. This means that the demand curve would make a skewed shift to the right rather than a parallel shift, and we can infer from this that the actual demand function, if it is a simple linear one, will most likely lie somewhere between two extreme cases, a parallel shift and a rotation around a single

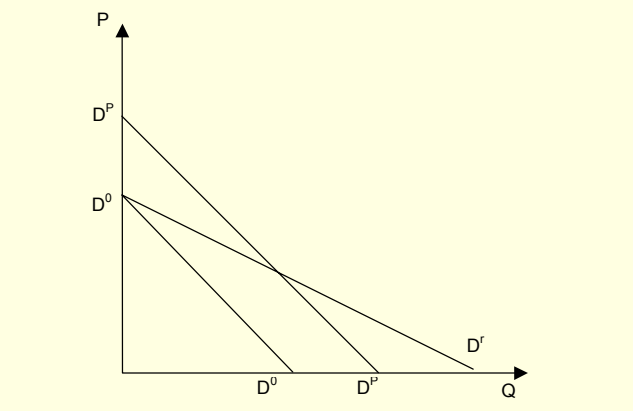


Fig. 2. Change in the demand curve in two cases.

interception point on the price axis [21]. However, since it is impossible to identify the actual demand function with the limited date available up to the times of our study, we consider two extreme cases: (1) a parallel shift, $D^pD^p$ and (2) a rotation around a single intercept point on the price axis $D^0D^r$, and we execute a scenario analysis (see Fig. 2).

## III. Effects of a Handset Subsidy

Although handset subsidies are granted in various countries, the effect on consumer surplus is not easy to estimate quantitatively because it is unusual to gather data for the subsidy-grant period and subsidy-prohibition period. In the case of Korea, a subsidy was granted at the beginning of the mobile telecommunication service, but it has been prohibited since 2000 because of overheated competition between service providers. In our study, using the unique history of the handset subsidy, we quantitatively analyze the effects of a handset subsidy on consumer surplus with the real data of two different periods, the subsidy-grant period and the subsidy-prohibition period.

The handset subsidy from the service providers influenced consumer surplus through various routes, but our study considers just two factors: increased service demand due to the substantial lowering of the cost of handsets, and the variation in price to compensate for the cost caused by the handset subsidy. We consider these two factors to be the most direct factors affecting the consumer surplus.

### 1. Variation of the Service Price

The handset subsidy, intended to create demand for the mobile telecommunication service, turns out to be represented at sales cost, and should finally translate into a responsible service price for consumers. This is because the revenues of service providers originate almost entirely from calls between users. However, raising the price for the supplementation of the handset subsidy is not manifested instantly, but continues slowly with some delay. To ascertain the variation in price, it is reasonable to consider the average for the prices within a given period of time, and our study estimates the variations in price and demand through the concept of an average within a given period of time for the purposes of analysis.

Because the notion of economies of scale comes into play in the mobile telecommunication service industry, a normal reduction in price naturally occurs as the number of subscribers increases. Therefore, using the concept of opportunity cost, we also consider the decrease in price reduction resulting from the handset subsidy as a decrease in consumer surplus.

To evaluate the net change in price, we make a comparison between the actual price during the subsidy-prohibition period and the estimated price, supposing that the handset subsidy continues during the subsidy-prohibition period, and then consider the difference between the two prices as the effect of price on consumer surplus.[1)]

### 2. Movement of the Demand Curve

As stated above, the grant of a handset subsidy —a powerful complement to the mobile telecommunication service— creates a demand for the service, as well as for the handsets, to increase through the immediate decrease in the handset price. Such increased demand results in a movement of the demand curve of the mobile telecommunication service.

However, the shift of the demand curve includes the effects of various other factors as well as that of the handset subsidy in the actual data. Change in other factors could arise from consumers' income, population, the price of substitutes, or service quality. In order to evaluate the net consumer surplus due to the handset subsidy, we need to remove the effects of the other factors, except that of the handset subsidy, from the total change in demand. The net change in consumer surplus could be evaluated using the following procedure. First, we find the estimated demand during the subsidy-prohibition period on the assumption that the handset subsidy will continue. Then the estimated demand is subtracted from the actual demand during the subsidy-prohibition period. To evaluate the estimated demand, our study will assess the trend of demand variation during the subsidy-grant period, and then apply this trend to the subsidy-prohibition period while considering the degree of market saturation during that period.

### 3. Net Change of Consumer Surplus

Figures 3 and 4 illustrate the movement of the demand curve and the variation in price due to the handset subsidy in the case of a parallel shift and a rotation respectively. As shown in the figures, the net changes in consumer surplus (*NW*) are determined as follows:

- In the case of a parallel shift,

  $NW_p$ = □ $P^R$⑧⑤$P^E$ – □ $D^R$⑤⑥$D^E$

  $D^0$: demand curve just before subsidy prohibition

  $D^R$: actual average demand curve after subsidy prohibition

  $D^E$: estimated average demand curve after subsidy prohibition, supposing that the subsidy is continued

1) Besides, when the change in demand or price is caused by other factors, it should be proper to consider and get rid of all of the changes caused by other factors, including the development of related technologies and changes in the various regulations, with the exception of the handset subsidy. In our study, we conceive them as random factors smoothed into the analysis time horizon.

• In the case of a rotation:

$NW_r$ = □ $P^R$⑧⑤$P^E$-△$a^0$⑤⑥.

$P^0$: price just before subsidy prohibition

$P^R$: actual average price after subsidy prohibition

$P^E$: estimated average price after subsidy prohibition, supposing that the subsidy is continued

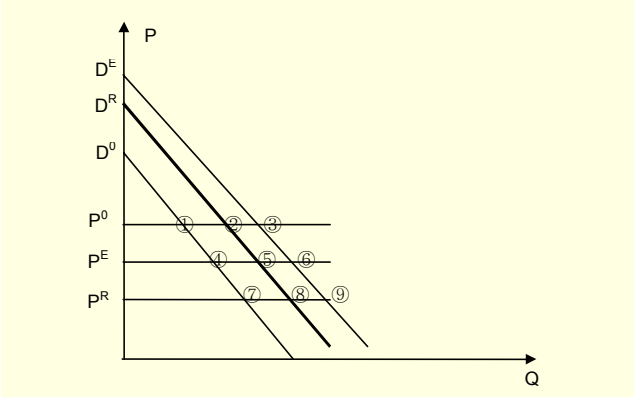


Fig. 3. Net change in a parallel shift.

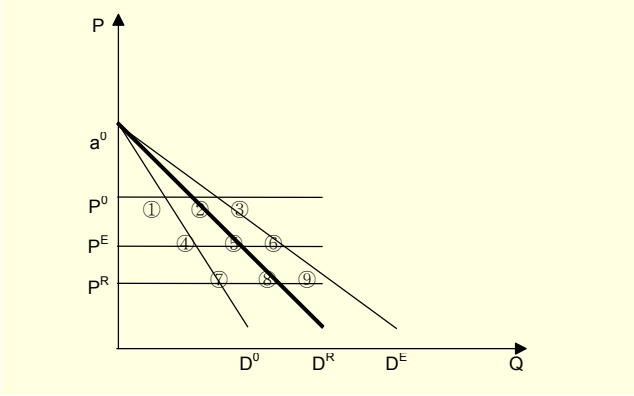


Fig. 4. Net change in a rotation.

## IV. Case Study

In this section, we evaluate the effect of the handset subsidy on consumer welfare by comparing the change in consumer surplus during the subsidy-grant period (June 1999–May 2000) and the subsidy-prohibition period (June 2000–December 2004) in the Korean mobile telecommunication market.

Our goal in this case study is to verify whether the prohibition of the handset subsidy will have a negative effect on consumer surplus through a quantitative evaluation of the effects on consumer surplus by estimating the change in net consumer surplus between the subsidy-grant and subsidy-prohibition periods. For the evaluation, we use the actual data for the prices, subscribers, and telephone traffic of the 3 service providers from May 1996 to December 2004.

### 1. Assessing the Price Index

Before estimating the change in consumer surplus, we should consider the price of the mobile telecommunication service. The current tariff system of the mobile telecommunication service, known as the two-layer tariff system, consists of a subscription fee, a basic charge, and a communication charge [22], [23]. The subscription fee is only paid once for subscription; however, the basic charge and communication charge are generally paid every month. The basic charge is levied to maintain the subscription state, while the communication charge is a variable cost that fluctuates according to the telephone traffic volume. Service providers are offering many kinds of tariff packages to satisfy diverse consumer demands. For evaluation, we need to assess a price index that is representative of these various tariff systems.

Our study assesses the price indices during the two periods (the subsidy-prohibition period and the subsidy-grant period) based

Table 1. Changes in price (in US$ ).

| | Basic | Normal | Discounted | Night |
|---|---|---|---|---|
| **Company A** | **(/month)** | **(/10s)** | | |
| 06/1999 – 03/2000 | 18.0 | 0.026 | 0.018 | 0.013 |
| 04/2000 – 05/2000 | 16.0 | 0.022 | 0.016 | 0.011 |
| 06/2000 – 12/2001 | 16.0 | 0.022 | 0.016 | 0.011 |
| 01/2002 – 12/2002 | 15.0 | 0.021 | 0.014 | 0.010 |
| 01/2003 – 08/2004 | 14.0 | 0.020 | 0.013 | 0.010 |
| 09/2004 – 12/2004 | 13.0 | 0.020 | 0.013 | 0.010 |
| **Company B** | **Basic** | **Normal** | **Discounted** | **Night** |
| 06/1999 – 03/2000 | 16.5 | 0.019 | 0.015 | 0.010 |
| 04/2000 – 05/2000 | 16.0 | 0.018 | 0.015 | 0.010 |
| 06/2000 – 12/2001 | 16.0 | 0.018 | 0.015 | 0.010 |
| 01/2002 – 12/2002 | 15.0 | 0.018 | 0.015 | 0.010 |
| 01/2003 – 08/2004 | 14.0 | 0.018 | 0.014 | 0.010 |
| 09/2004 – 12/2004 | 13.0 | 0.018 | 0.014 | 0.010 |
| **Company C** | **Basic** | **Normal** | **Discounted** | **Night** |
| 06/1999 – 03/2000 | 16.0 | 0.020 | 0.013 | 0.012 |
| 04/2000 – 05/2000 | 15.5 | 0.019 | 0.013 | 0.012 |
| 06/2000 – 11/2001 | 15.5 | 0.019 | 0.013 | 0.012 |
| 12/2001 – 12/2002 | 14.8 | 0.018 | 0.013 | 0.010 |
| 01/2003 – 08/2004 | 13.0 | 0.018 | 0.013 | 0.010 |
| 09/2004 – 12/2004 | 12.0 | 0.018 | 0.013 | 0.010 |

Basic: Basic charge
Normal: Normal communication rate
Discounted: Discounted communication rate
Night: Midnight discounted communication rate

* Source: Modified from KISDI (2004)

Table 2. Calculating the price indices (in US$ /min.).

| | Periodic PI | Company PI |
|---|---|---|
| **Company A** | | |
| 06/1999 – 03/2000 | 0.2448 | |
| 04/2000 – 05/2000 | 0.2131 | 0.2395 |
| 06/2000 – 12/2001 | 0.2131 | |
| 01/2002 – 12/2002 | 0.1994 | |
| 01/2003 – 08/2004 | 0.1880 | |
| 09/2004 – 12/2004 | 0.1818 | 0.1987 |
| **Company B** | | |
| 06/1999 – 03/2000 | 0.2030 | |
| 04/2000 – 05/2000 | 0.1963 | 0.2019 |
| 06/2000 – 12/2001 | 0.1963 | |
| 01/2002 – 12/2002 | 0.1901 | |
| 01/2003 – 08/2004 | 0.1823 | |
| 09/2004 – 12/2004 | 0.1761 | 0.1884 |
| **Company C** | | |
| 06/1999 – 03/2000 | 0.2023 | |
| 04/2000 – 05/2000 | 0.1956 | 0.2012 |
| 06/2000 – 11/2001 | 0.1956 | |
| 12/2001 – 12/2002 | 0.1858 | |
| 01/2003 – 08/2004 | 0.1746 | |
| 09/2004 – 12/2004 | 0.1683 | 0.1836 |

PI: Price Index

Table 3. Integrated price indices in each period (in US$/min.).

| Period | Integrated index | Difference |
|---|---|---|
| Subsidy-grant | 0.225 | |
| Subsidy-prohibition | 0.193 | 0.032 |

on the data for the changes in the standard price in Table 1 [10]. The price indices are standardized on the basis of 160 minutes (Normal/Discounted/Night: 60%; 25%; 15%). We calculate the integrated price indices by the following procedures. First, we calculate the periodic price index in each period using the data in Table 1, and then we calculate the price index of each company using the weighted average of the periodic price indices based on the length of each period, as shown in Table 2. The integrated price indices are finally calculated by the weighted average of the price index of each company based on its market share [20]. Table 3 shows the results of calculating the integrated price indices.

## 2. Estimating the Effect on the Price Index

In this section, we estimate the net change in the price index, one of the factors considered in our study. It can be estimated by the difference between the actual average price index ($\overline{P^R}$) and the estimated average price index ($\overline{P^E}$) during the subsidy-prohibition period. The estimated average price index ($\overline{P^E}$) is the price index when we suppose that the handset subsidy is granted during the subsidy-prohibition period.

In the early stage, because of the consistent addition of subscribers and the effect of economies of scale, the price reduction increases dramatically. However, the price reduction gradually decreases according to the decreasing addition of subscribers and reaches the absolute price index that can compensate for the pure cost.

Our study defines the price reduction $Y(t)$ at time $t$ as the difference between the price index in $t$, $P(t)$ and the price index in $t$-$1$, $P(t$-$1)$. The price reduction $Y(t)$ is calculated by considering the increasing rate of subscribers, and then the average price reduction $\overline{Y}$ is calculated through the average of the price reduction $Y(t)$ in a given period. Examining the data for the increase in the number of subscribers, we identify the increase rate as slowing down from 1999 [20]. Next, we calculate $Y^E(t)$, the estimated price reduction. $Y^E(t)$ is supposed to be followed as equation (5).

$$Y^E(t) = k*LN(t+1) \quad (5)$$

The time $t$ is the time point which begins at 0 by the monthly unit. The time point 0 refers to January 1996, the launch date of the mobile telecommunication service in Korea. Based on the historical data for the price change, we can estimate parameter $k$ of the function as the following equation (6).

$$Y^E(t) = 0.7542*LN(t+1) \quad (6)$$

Then, the estimated average price index $\overline{P^E}$ in the subsidy-prohibition period could be calculated by subtracting the estimated average price reduction $\overline{Y^E}$ from the price index $P^R(53)$ just before subsidy prohibition began in June 2000. See equation (7).

$$\overline{P^E} = P^R(53) - \overline{Y^E} = 0.225 - 0.003 = 0.222 \ (\$/\min.) \quad (7)$$

In equation (8), the net average price reduction due to subsidy prohibition $\overline{D^E}$ during the subsidy-prohibition period is estimated as the difference between the estimated average price index $\overline{P^E}$ and the actual average price index $\overline{P^R}$.

$$\overline{D_P^E} = \overline{P^E} - \overline{P^R} = 0.222 - 0.194 = 0.028 \ (\$/\min.) \quad (8)$$

The net average price reduction due to subsidy prohibition $\overline{D_P^E}$ during the subsidy-prohibition period represents the degree to which the customers' additional burden caused by the handset subsidy is eliminated. That is to say, if the handset

subsidy is continued, service providers have to decrease the price reduction for the supplementation of the cost from the grant of the handset subsidy. Such a decrease in price reduction could be transferred to customer surplus.

## 3. Estimating the Effect on the Demand Curve

In this section, we estimate the net change of demand, another factor considered in our study. It can be estimated by calculating the difference between the actual average yearly traffic increase $\overline{\Delta Q_A^R}$ and the estimated average yearly traffic increase $\overline{\Delta Q_B^E}$ in the subsidy-prohibition period. The estimated average yearly traffic increase $\overline{\Delta Q_B^E}$ represents the average yearly traffic increase on the assumption that the handset subsidy is granted in the subsidy-prohibition period.

To estimate the effect of the demand curve shift, we have to calculate the actual average yearly traffic increase ($\overline{\Delta Q_A^R}$, $\overline{\Delta Q_B^R}$) in the subsidy-grant period and the subsidy-prohibition period. See equations (9), (10), and Table 4.

$$\Delta Q(t) = Q(t) - Q(t-1) \tag{9}$$

$$\overline{\Delta Q_J^R} = \sum_{t \in J} w(t) \cdot \Delta Q(t) \tag{10}$$

$J = A$ (subsidy-grant period), or
$B$ (subsidy-prohibition period)
$w(t)$ = the time weight of traffic increase in time $t$
$Q(t)$ = the traffic volume in time $t$

To evaluate the estimated average yearly traffic increase $\overline{\Delta Q_B^E}$, we have to consider the actual average yearly traffic increase $\overline{\Delta Q_A^R}$ and the suppression rate of traffic increase $\overline{S_B}$, which is the measurement of the slowdown in the traffic increase trend by decreasing the basis for new subscriptions according to the penetration-to-saturation status of the mobile telecommunication market. The suppression rate of the traffic increase $\overline{S_B}$ is considered for a more accurate estimation. As seen in equations (11) and (12), we calculate the estimated average yearly traffic increase $\overline{\Delta Q_B^E}$ in the subsidy-prohibition period by the weighted average of each estimated yearly traffic increase $\Delta Q^E(t)$, which is found by subtracting the suppression portion of the traffic increase at time $t$ in the subsidy-prohibition period from the previous estimated yearly traffic increase $\Delta Q^E(t-1)$.

$$\Delta Q^E(t) = (1 - \overline{S_B}) \cdot \Delta Q^E(t-1) \tag{11}$$

$$\overline{\Delta Q_B^E} = \sum_{i \in B} w(t) \cdot \Delta Q^E(t) \tag{12}$$

The suppression rate of the traffic increase $\overline{S_B}$ (2.93%) applied in this study is calculated by assuming that 50% of the actual average yearly traffic decreasing rate (5.855%)[2] stems from the saturation factor. We can calculate the estimated average yearly traffic $\overline{Q_B^E}$ in the subsidy-prohibition period (2000-2004) by adding the estimated average yearly traffic increase $\overline{\Delta Q_B^E}$ to the actual traffic volume for 2000. See equation (13).

$$\begin{aligned}\overline{Q_B^E} &= Q(2000) + \overline{\Delta Q_B^E} = 40{,}159 + 7{,}692 \\ &= 47{,}851 \text{ (million minutes)}\end{aligned} \tag{13}$$

The average net change in yearly demand due to subsidy prohibition $\overline{D_D^E}$ during the subsidy-prohibition period is calculated by (14).

$$\begin{aligned}\overline{D_D^E} &= \overline{\Delta Q_B^E} - \overline{\Delta Q_B^R} \\ &= 7{,}692 - 7{,}633 = 59 \text{ (million minutes)}\end{aligned} \tag{14}$$

Table 4. Estimating the average yearly traffic increase (in million minutes).

| Year | $Q(t)$ | $\Delta Q(t)$ | $\overline{\Delta Q_J^R}$ | $\overline{\Delta Q_B^E}$ |
|---|---|---|---|---|
| 1996 | 4,107 | | | |
| 1997 | 6,566 | 2,459 | | |
| 1998 | 12,858 | 6,292 | | |
| 1999 | 26,967 | 14,109 | | |
| 2000 | 40,159 | 13,192 | 8,300 | |
| 2001 | 49,151 | 8,992 | | |
| 2002 | 59,490 | 10,339 | | |
| 2003 | 63,099 | 3,609 | | |
| 2004 | 67,450 | 4,351 | 7,633 | 7,692 |

## 4. Estimating the Net Change in Consumer Surplus

As previously mentioned, we have assumed that the demand curve is linear. The price elasticity of demand η is estimated at -3 based on the data for January 2003, which is not influenced by any other factor (except the variation in price[3]).

Based on the estimated data for the demand change and price reduction, Figs. 5 and 6 can be illustrated in the case of a parallel shift and a rotation. The net changes of consumer surplus $NW$ are estimated by the following:

2) The figure is from Choi (2005).
3) The data is from KISDI (2004).

• In the case of a parallel shift:

$$NW_p = \square P^R⑧⑤P^E - \square D^R⑤⑥D^E$$
$$= 1{,}326.047 - 1{,}410.691$$
$$= -\$84.604M$$

• In the case of a rotation:

$$NW_r = \square P^R⑧⑤P^E - \triangle a^0⑤⑥$$
$$= 1{,}323.953 - 690.038$$
$$= \$633.915M$$

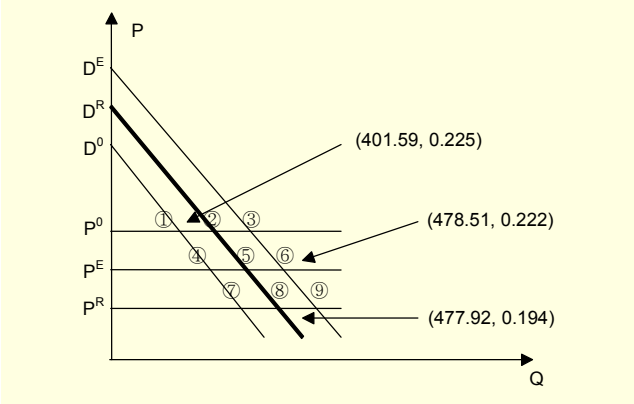


Fig. 5. Estimating the net change in a parallel shift.

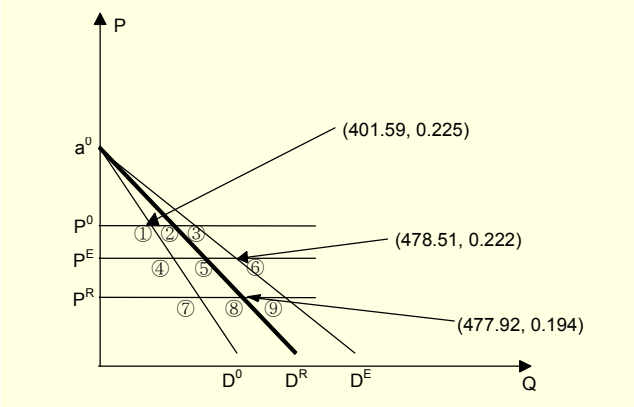


Fig. 6. Estimating the net change in a rotation.

## 5. Total Changes in Consumer Surplus Including the Actual Handset Subsidy

In order to add the consumer surplus from the actual handset subsidy to our results, we need the upper limit of the maximum handset subsidy that the service provider can offer in a year. It is determined based on the premise that the competitive structure of the existing service providers is supported. If any one of the service providers suffers continuous cumulative deficit due to the overburdened handset subsidy, the existing competition structure will collapse due to a breakdown of the service provider concerned.

Because the handsets intended for subsidy are mostly stored goods, their value is less than the price at which the service providers purchased them. Therefore, the consumer surplus from the actual handset subsidy has to be smaller than the amount of the handset subsidy which the service providers assert. In this study, we suppose that the consumer surplus from the actual handset subsidy is 70% of the amount of the handset subsidy that the service providers are able to grant.[4] Then the maximum average subsidy $HS_{max}$, which is granted for one year, is estimated by the following:

$$HS_{max} = 0.7 \times (\text{the number of service providers}) \times P_{min}$$
$$= 0.7 \times 3 \times 103.65$$
$$= 217.665\ (\$M)$$

In the above equation, the amount of $103.65 million is calculated from the minimum average yearly net profit ($P_{min}$) of the 3 existing service providers.[5] The total change in consumer surplus $TW$ is calculated by subtracting the maximum average subsidy $HS_{max}$ from the net change in consumer surplus in each case.

• In the case of a parallel shift:

$$TW_p = -84.604 - 217.665$$
$$= -302.269\ (\$M)$$

• In the case of a rotation:

$$TW_r = 639.915 - 217.665$$
$$= 422.250\ (\$M)$$

In the results of our case study, we were able to estimate a decrease in consumer surplus of $302.269M in the case of a parallel shift and the increase in consumer surplus of $422.250 in the case of a rotation. The results indicate that the hypothesis - that the prohibition of a handset subsidy will have a negative influence on consumer surplus - could not be true.

## V. Concluding Remarks

We developed a quantitative model for evaluating the effect on consumer welfare arising from the prohibition of a handset subsidy. To this end, our study used the concept of consumer surplus as the measurement of consumer welfare, and analyzed the factors which have a direct influence on consumer welfare.

In the results of our case study, when considering the two direct factors (the change in demand and the change in price due to subsidy prohibition), we were able to estimate a reduction in consumer surplus of $302.269M in the case of a

4) The figure was taken from the results of the survey of handsets for subsidy during the subsidy-grant period.

5) The required data was gathered from the yearly business report from 2000 to 2004.

parallel shift of the demand curve, and an increase of $422.250M in the case of a rotation. This suggests that it is not, in the current state, valid to state that the effect of subsidy prohibition on consumer welfare is absolutely negative. This is because the change in the actual consumer surplus is expected to be located between the results in the case of a parallel shift and those of a rotation.

When considering the indirect factors not accounted for in our study, the social benefits associated with a handset subsidy (such as market expansion, activation of mobile services and the handset market, and the acceleration of related technology development) are known to decrease gradually as the market reaches the point of saturation. On the other hand, the social disadvantages associated with a handset subsidy are likely to continue because of increasing overspending due to overheated competition, the decline in reserve energy for developing new services or technologies through new investment, the collapse of an effective competitive market structure, and so on. Because the negative effects of these indirect factors, which are not quantified in our study, are also expected to be greater than their positive effects as the market approaches saturation, the handset subsidy is not expected to positively influence the consumer surplus or the social benefits in the current Korean mobile telecommunication market.

We can conclude that the grant of a handset subsidy might be an effective policy which causes consumer surplus or the social benefit to increase at the introduction of new goods or services or during the growth period; however, it could lead not only to a reduction in social benefits but also to a decrease in the consumer surplus during the market-saturation period. Therefore, the policy for a handset subsidy should be determined according to a close examination of the market evolution stage and the changes in the technological situation.

Because of an insufficiency of the required data, we have had to make certain assumptions regarding the demand function. The range of our study is limited to consumer surplus under the direct effects of a handset subsidy in the current mobile telecommunication industry in Korea. Additional studies are therefore required to estimate the exact demand function with sufficient data and to evaluate the change of consumer surplus in the altered circumstances following the entrance of new mobile telecommunication services such as Wi-bro, DMB, and so forth.

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