A Study on the Valuation of Call Quality in Korean Mobile Communication Industry

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ABSTRACT

The purpose of this paper is to test whether prices of mobile communication service reflect their varying degrees of call quality, controlling for other service attributes. As, in fact, service is intangible goods difficult to measure its value, this paper makes use of econometric model, hedonic price analysis. Hedonic price analysis, has ever been applied in public or environmental economics, is employed and produces estimates of the prices (or the contributions toward the total price) for each characteristic. This paper applies hedonic technique to the value measurement of a service property for the use of Korean mobile communication. This paper uses actual transaction prices of mobile communication service to determine whether or not the market functions in pricing call quality of mobile communication service.

Finally, this show that the willingness to pay of consumer increases as call quality increases and so market makes prices on call qualities. Thus, major concern in this paper is about value measurement of service quality, and also suggest of the possibility to determine call quality value (or price) of mobile communication service.

I. INTRODUCTION

Service quality is perceived as a subjective concept rather than objective one. That is, service quality perceived by customer is not easily measured because of the obscurity of this intangible quality compared to tangible quality in other products. But, now on, as real application of service quality is limited due to only searching for the factors that affect service quality and looking for any relationships between them, we apply Hedonic price model for value measurement of service quality. Also, we evaluate service quality variable's economic return based on consumer's real payment value and try to give efficient information for a company's resource allocation decision[cronin, 1992].

Recently, the Korean mobile communication service has nearly doubled in its size by years, since it introduced cellular communication service in 1984. Reasons for this sharp rise in the number of subscribers include price reductions for vehicle phone terminals from 2 to 1 million won in Apr. 1988 and its expanded convenience of use of the mobile phone service to 70 cities nationwide. Digital cellular service was launched in 1996, and competition in that area has become intensive with PCS (Personal Communication Service) commencing in Oct. 1997.

The actual number of subscribers of mobile phones in Korea was 2,658 in the first year of introduction, and has reached 53% penetration rate with 23 million subscribers as of the end of Dec 1999. It means 53 out of 100 persons are using the service, which indicates mobile phone market has entered an era of extreme popularity.

The following TABLE 1 is the status of the Korean mobile communication service subscribers by year.

This rapid distribution of the mobile communication service in Korea actually has induced intense market competition and also has

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TABLE 1. The status of the Korean mobile communication service subscribers by year (Unit: 1,000 persons)

Years	1987	1989	1991	1993	1995	1997	1998	1999	2000.2
Subscribers	10	39	166	471	1,641	6,910	13,982	23,442	25,428
Penetration rate(%): by 100persons	0.025	0.094	0.384	1.071	3.725	15.65	31.74	53.20	57.71

lead subscription level to the saturation point. The five current mobile phone service providers have been building strategies to switch subscribers from other service to their own service, as well as signing up present non-subscribers and maintaining their existing subscribers. In this intense competition, a strong customer retention strategy is solely needed.

The following FIGURE 1 is the Penetration ratio trend of subscribers in mobile communication service. Here you can see that it is a service industry with its penetration ratio rapidly developing and recently surpassed the normal telephone subscription rate.

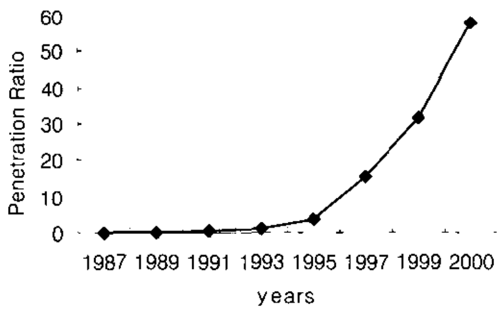

FIG. 1 Penetration ratio trend of subscribers in mobile communication service

Thus, this paper aims at not only understanding the quality properties of the mobile communication service keeping pace with the changing conditions of the market, but measuring the value of specific quality properties through correlation among these properties at the market.

Ⅱ. Value Estimation in Call Quality

2.1 How to measure elasticity in the log-linear model

Consider the following model, known as the exponential regression model:

$$Y(i) = \beta_1 X_i^{\beta 2} e^{ui} \quad (1)$$

Which may be expressed alternatively as

$$\text{In}Y_i = \text{In}\beta_1 + \beta_2 \text{In}X_i + \mu_i \quad (2)$$

If we write (2) as

$$\text{In}Y_i = \alpha + \beta_2 \text{In}X_i + \mu_i \quad (3)$$

where $\alpha = \text{In}\beta_1$, this model is linear in the parameters α and β_2, linear in the logarithms of the variables Y and X, and can be estimated by OLS regression. Because of this linearity, such models are called log-log, double-log, or log-linear models.

If the assumptions of the classical linear regression model are fulfilled, the parameters of (3) can be estimated by the OLS method by letting

$$Y_i^* = \alpha + \beta_2 X_i^* + \upsilon_i \quad (4)$$

where $Y_i^* = \text{In}Y_i$ and $X_i^* = \text{In}X_i$

The OLS estimators $\hat{\alpha}$ and $\hat{\beta}_2$ obtained will be best linear unbiased estimators of α and β_2, respectively. One attractive feature of the log-log model, which has made it popular in applied work, is that the slope coefficient β_2 measures the elasticity, of Y with respect to X, that is, the percentage change in Y for a given (small) percentage change in X.[1)]

1) The elasticity coefficient, in calculus notation, is defined as $(dY/Y)/(dX/X) = [(dY/dX)(X/Y)]$. Readers familiar with differential calculus will readily see that B_2 is in fact the elasticity coefficient. *A technical note* :

Thus, if Y represents the quantity off commodity demanded and X its unit price, β_2 measures the price elasticity of demand, a parameter of considerable economic interest. Two special features of the log-linear model may be noted: The model assumes that the elasticity coefficient between Y and X, β_2, remains constant throughout, hence the alternative name constant elasticity model.[2)]

In other words, the change in InY per unit change in $\ln X$(i.e., the elasticity, β_2) remains the same no matter at which InX we measure the elasticity. Another feature of the model is that although α and β_2 are unbiased estimates as and β_2 β_1 (the parameter entering the original model) when estimated as β_2 = antilog(α) is itself a biased estimator. In most practical problems, however, the intercept term is of secondary importance, and one need not worry about obtaining its unbiased estimate.

In the two-variable model, the simplest way to decide whether the log-linear model fits the data is to plot the scattergram of $\ln Y_i$ against $\ln X_i$ and see if the scatter points lie approximately on a straight line.

The calculus-minded reader will note that $d(\ln X)/dX = 1/X$ or $d(\ln X) = dX/X$. that is, for infinitesimally small changes(note the differential operator d) change in InX is equal to the relative or proportional change in X. In practice, though, if the change in X is small, this relationship can be written as change in INX = relative change in X, where ≒ means approximately Thus, for small changes,$(\ln X_t - \ln X_{t-1}) ≒ (X_t - X_{t-1}) / X_{t-1}$ = relative change in X Incidentally, the reader should note these terms, which will occur frequently:(1) absolute change (2) relative or proportional change, and (3) percentage change, or percent growth rate. Thus (Xt-Xt-1) represents absolute change, or the growth rate. Xt and Xt-1 are respectively, the current and previous values of the variable X.

2) A constant elasticity model will give a constant total revenue change for a given percentage change in price regardless of the absolute level of price. Readers should contrast this result with the elasticity conditions implied by a simple linear demand function. $Y_i = B_1 + B_2X_i + u_i$. However, a simple linear function gives a constant quantity change per unit change in price. Contrast this with what the log-linear model implies for a given dollar change in price.

The elasticity E of a variable Y (e.g., quantity demanded) with respect to another variable X (e.g., price) is defined as

$$\begin{aligned} E &= \%\ \text{change in Y} \ / \ \%\ \text{change in X} \\ &= (Y/Y)*100 \ / \ (X/X)*100 \\ &= (Y/X) * (X/Y) \\ &= (\text{slope}) * (X/Y) \end{aligned} \qquad (5)$$

where △ denotes a (small) change. If △ is sufficiently small, we can replace $\Delta Y/\Delta X$ by the calculus derivative notation, dY/dX [Gujarati, 1995].

2.2 Application of Hedonic model in Mobile Communication Service

The Hedonic model is based on the work of Rosen(1974). Each mobile communication service is comprised of a set of characteristics, such as A/S, added service, call quality etc. When consumers pay the bill for using communication service, what they pay is a bundle of characteristics. Consumers are assumed to have preferences over those attributes. There are maximum amounts they are willing to pay for any given combination they use. Their payments depend on income and preferences as well as the bundle of characteristics.

Providers choose the bundle that maximizes their profits subject to the prices of inputs, their production function, number of units provided and market prices for each alternative bundle of characteristics. Thus the provider's offer function indicates the minimum unit price the provider will accept for the mobile communication service provided. Market equilibrium is the tangency of these bid and offer functions. The prices seen in the market are these tangency points: the price consumers bid or are willing to pay for each characteristic is equal to the amount providers offer or are willing to accept for each characteristic. Earlier hedonic pricing model had been mainly used on assumption for the willingness to pay for environmental goods like atmosphere and water quality, which go together with transaction of housing and property land.

However, one convenient measurement method whose usefulness is credited as an effort to overcome this difficulty is Hedonic analysis technique, also called the indirect measurement method. This study has determined the property used by consumers to identify quality of mobile communication service through the questionnaire. It then formulated a regression equation with the quality property as the independent variable and payment intention as the dependent variable in order to obtain the value per immeasurable influential factors in market products (service). From this method, the important properties can be discovered and the enterprise can focus their efforts when producing their products (service).

For example, the property of call quality in mobile communication service is not separately graded in the market. That is, additional payment is not specifically made for the service property called call quality. The utility of hedonic economic value analysis lies in calculating the value which customers are willing to pay for this property called call quality. The price used in the hedonic equation is the actual price paid for Mobile Communication Service, or what is referred to as the transaction price.

In addition to these attributes, a set of dummy variables is used. The equation to be estimated can be written in the following form:

$$\ln P = a+BjXj+CkWk+ZmQn+e \qquad (6)$$

Where P = the price at which the consumer actually paid
X = a vector of characteristics of Service Quality;
W = a vector of dummy variables
Q = a vector of the population characteristics
e = error term.

The equation is estimated in semi-logarithmic functional form. In addition, this form allows for the fact that as the amount of a characteristic increases, all else held constant, the marginal valuation of the service quality ought to increase. It is also important to note that the choice of this particular functional form may affect the statistical results.

Once the Hedonic equation has been estimated, the coefficients on each variable can be used to derive the price elasticity for each characteristic. If the coefficients differ significantly from zero and if the price of mobile communication service increases as the amount of the characteristics increases, the market works, However, if the coefficients are not statistically significant, the null hypothesis that the market does not work in handling the characteristics cannot be rejected [Asher, 1992].

Ⅲ. Analysis Results

3.1 Estimation

This study drew up a questionnaire addressing mobile communication service. The number of observations used in the final analysis, 480, is substantially less than the 724 in the original data set. Some observations were eliminated due to nonresponse or missing data.

Usable data were analysis samples of mobile communication subscribers in the metropolitan area (Seoul and Kyunggi Province) gathered between Nov. and Dec. 1999. Gender distribution was 65.4% male and 34.6% female. The age group most represented was 20 to 29 years olds, accounting for 61.4%.

The measurement of call quality used in this study is the Likert scale index.

The index takes on values of 1 through 7, where 7 indicates that the call quality has much better than average rating, 4 an average rating, and 1 a much worse than average rating.

In practical work of communication industry, call quality is divided by wideness of call area, good connection in call area, clearness of call quality. Thus, the elasticity of three variables on call quality is respectively calculated. One percent increases in call quality, which is reflected by an increase in the call index, results in an increase in the price of mobile communication service. This result has the proper sign and is consistent with the hypothesis; the higher call quality, the more consumers are willing to pay for the service all else held constant.

This study tries to isolate the economic value analysis of call quality level of mobile communication service. The call quality factor was selected because it was identified as the most significant quality factor for customer satisfaction and what a consumer considers the most is call quality [maekyung.1999.10]. Especially, as the age group goes up, elder people group answered call quality was the crucial factor when deciding what mobile communication service to choose.

Here is actual survey analysis (in TABLE 2) for various-weighted service quality factors in these order, including in subscribers of all the mobile communication providers.

TABLE. 2 Weight of call quality by actual survey analysis

Service quality factor	Results of index measure
Call Quality	6.12
Additional Service	4.39
Convenience of change	4.86
Convenience of charge payment	5.28
Employee Reliability	5.19
A/S	5.69

According to Rosen (1994)'s study, marginal price in linear function becomes a constant number so it is not desirable in practical. So, mainly used functions in many studied are log-log type function, log-linear type function and non-ruling specific function type called Box-Cox type function etc.

But in this study, log-linear function was selected because of easiness of result interpretation.

For this, the following econometric model was developed:

$$\ln P = \beta_0 + \beta_1 F_1 + \beta_2 F_2 + \beta_3 F_3 + \beta_4 F_4 + \beta_5 F_5 + \beta_6 F_6 + \beta_7 F + \beta_8 F_8 + \beta_9 F_9 + \varepsilon_1 \quad (7)$$

P: monthly charge (ln form), F1: age variable [AGE], F2: continuous use variable(dummy)[CONTIN], F3: educational level variable[EDU], F4: gender variable(dummy)[GENDER], F5: necessity variable [NECESSITY], F6: perceived call quality variable [PER], F7: use minute variable[USEMIN], F8: use period variable[USEMON], F9: vocation variable [VOCA]

TABLE. 3. Results of Correlation analysis among the variables

	VOCA	PER1	GENDER	USEMIN	USEMON	EDU	CONTIN	AGE
VOCA	1.000	-0.005	-0.064	-0.061	-0.0125	-0.169	0.029	-0.104
PER1	-0.005	1.000	0.002	-0.083	0.116	-0.034	-0.281	0.074
GENDER	-0.064	0.002	1.000	0.014	-0.023	0.212	0.095	0.039
USEMIN	-0.061	-0.083	0.014	1.000	0.066	0.115	0.030	0.129
USEMON	-0.125	0.116	-0.023	0.066	1.000	0.064	-0.085	0.165
EDU	-0.169	-0.034	0.212	0.115	0.064	1.000	0.096	0.159
CONTIN	0.029	-0.281	0.095	0.030	-0.085	0.096	1.000	-0.135
AGE	-0.104	0.071	0.039	0.129	0.165	0.159	-0.135	1.000

Variable	Beta Tolerance	VIF
AGE	0.62100	1.610
CONTIN	0.88900	1.125
EDU	0.97862	1.101
GENDER	0.94824	1.055
PER1	0.9361	1.107
USEMIN	0.96461	1.037
USEMON	0.76220	1.312
VOCA	0.71485	1.399

$\beta 1$-$\beta 9$: regression coefficient to each variable, ϵt : error term, independent, with N(0, $\sigma 2$) distribution

And in the above equation, the multicollinearity analysis for the correlation degree between variables on the firstly measurable quality, 'wideness of call area' is needed. Thus, the following TABLE 3 presents correlation coefficients and beta tolerance, VIF for the multicollinearity analysis. In TABLE 3, because the result presenting the correlation degree is low, the equation is no problem for multicollinearity.

3.2 Payment for service quality Calculations

Note that these coefficients are not the price elasticity of demand. As the equation is estimated in semi-logarithmic functional form, the elasticity coefficient for each independent variable can be interpreted as an approximation of the percentage change in the dependent variable for a one unit change in the independent variable, everything else held constant. These present the percentage change in price for one percent increase in the relevant variable.

Thus the following equations are needed for inducing the elasticity of call quality.

$$\ln P = \alpha + \beta_1 X \tag{8}$$

$$\beta_1 = d(\ln P) / dX \tag{9}$$

The equation (8) is the semi-log form and the equation (9) presents the coefficient of β_1. And the elasticity for dependent (lnP) with respect to independent X is the equation (10)

$$\eta = (dP/dX) * (X/P) \tag{10}$$

Substituted (9) to (10), hence,

$$\eta = \beta_1 * X \tag{11}$$

In the equation (11), X is calculated by mean of X.

As a result of empirical analysis on 'wideness of call area' variable, by the above model, the following was determined.

In the semi-log model of TABLE 4, significance level 0.0000 is statistically significant and determinant coefficient R2 of 0.347 indicates that the independent variables of the regression model have an effect on payment of 34.7%.

TABLE. 4 Estimated equation on 'wideness of call area' variable [Dependent variable = ln(monthly charge)] (**) 1% significance level

variables	Estimate	t-value
age	-0.001890	-0.978
continuous use	-0.104372	-3.491**
educational level	0.027567	1.089
gender	0.145831	4.845**
necessity	-0.103174	-3.360**
use minute	0.002359	6.694**
use period	0.001655	1.369
vocation	-0.007687	-0.805
call quality	0.097302	9.986**
constant	10.245345	75.331**

As seen in TABLE 4, continuous use variable, gender variable, necessity variable, use minute variable and 'wideness of call area' variable had a significant relation with monthly charge fee (payment) with estimated value. But Note that this estimated value is not the elasticity coefficient.

Thus the elasticity(η) of call quality variable (wideness of call area) on the above estimated equation is 0.41158(=0.097302×4.23). The value 4.23 means X average. Since payment variable and independent variable (call quality: wideness of call area) are estimated in semi-log form, this indicates the elasticity of the dependent variable. This elasticity coefficient means when call quality level improves by 1%, users are willing to pay a monthly charge of 0.4115% more

The following content is the value estimation for 'wideness of call area' variable. That is, the average charge fee on the survey respondents is 46,760 won, and so, the additional payment value per one subscriber on the better 1% call quality scale(wideness of call quality) is 175won(0.41158 ×46,760). Finally, total payment value is calculated by total subscribers, and so, if the investment cost for 1% call quality (wideness of call quality) is calculated, the cost-benefit analysis can be performed. And other call quality can be performed by the above way.

And the next variable of call quality is 'good connection in call area'. As above a result of empirical analysis on 'wideness of call area' variable, the following was determined.

In the semi-log model of TABLE 5, significance level 0.0000 is statistically significant and determinant coefficient R2 of 0.342 indicates that the independent variables of the regression model have an effect on payment of 34.2%.

As seen in TABLE 5, continuous use variable, gender variable, educational level, necessity variable, use minute variable, 'good connection in call area' variable had a significant relation with monthly charge fee (payment) with estimated value. But this estimated value is not the elasticity coefficient. Thus the elasticity(η) of call quality variable on the above estimated equation is 0.42575(=0.099244×4.29). The value 4.29 means mean of X. This elasticity coefficient indicates the elasticity of the dependent variable, since payment and independent variable, call quality (good connection in all area), are estimated in log forms. This means when call quality level improves by 1%, users are willing to pay a monthly charge of 0.42575% more.

And the final variable of call quality is 'clearness of call quality' and the coefficient of following equation was determined

In the semi-log model of TABLE 6, significance level 0.0000 is statistically significant and determinant coefficient R^2 of 0.293 indicates that the independent variables of the regression model have an effect on payment of 29.3%.

As seen in TABLE 6, continuous use variable, gender variable, necessity variable, use minute variable, 'clearness of call quality' variable had a significant relation with monthly charge fee

TABLE 5. Estimated equation on 'good connection in call area' variable [Dependent variable = ln (monthly charge)]
(**) 1% significance level, (*) 5% significance level

variables	Estimate	t-value
age	-0.001713	-0.884
continuous use	-0.122275	-4.130**
educational level	0.050938	1.995*
gender	0.152899	5.065*
necessity	-0.101126	-3.279**
use minute	0.002081	5.910**
use period	0.001705	1.407
vocation	-0.009044	-0.944
call quality	0.099244	9.794**
constant	10.160453	72.289**

(payment) with estimated value. But this estimated value is not the elasticity coefficient. Thus the elasticity(η) of call quality variable on the above estimated equation is 0.35394(=0.079183× 4.47). The value 4.47 means mean of X. This indicates the elasticity of the dependent variable, since payment and independent variable, call quality (clearness of call quality), are estimated in log forms. This elasticity coefficient means when

TABLE. 6 Estimated equation on 'clearness of call quality' variable [Dependent variable = ln(monthly charge)]
(**) 1% significance level, (*) 5% significance level

variables	Estimate	t-value
age	-0.001306	-0.649
continuous use	-0.147421	-4.850**
educational level	0.020951	0.795
gender	0.150286	4.800**
necessity	-0.126131	-3.971**
use minute	0.001892	5.174**
use period	0.001448	1.148
vocation	-0.003136	-0.316
call quality	0.079183	7.502**
constant	10.401507	74.520**

call quality level improves by 1%, users are willing to pay a monthly charge of 0.35394% more. Thus this means that the most important variables of three call quality variables is 'wideness of call area' variable.

Ⅳ. Conclusions

Service quality perceived by customer is not easily measured because of the obscurity of this intangible quality compared to tangible quality in other products. But, as real application of service quality is limited due to only searching for the factors that affect service quality and looking for any relationships between them., we applied Hedonic price model for value measurement of service quality.

We utilized actual transaction prices of mobile communication service to determine whether or not the market functions in pricing call quality of mobile communication service. This study finds that as call quality increase, the payment of consumer increases, all else held constant. The findings show that the market does work in pricing these characteristics. As the market is observed to work, the need to rely on consumer protection legislation to guarantee call quality is lessened. Thus this study shows that not only do consumers value these characteristics but also providers have an incentive to provide higher call quality.

The following TABLE 7 presents the summarized results for above analysis.

TABLE. 7 Summarized results for hedonic analysis

Models	R^2	β	X average	η
Wideness of call area	0.347	0.0973	4.23	0.4115
Good connection in call area	0.342	0.0992	4.29	0.4257
Clearness of call quality	0.293	0.0791	4.47	0.3539

If the total current subscribers is multiplied the above result, the entire payment increase can be estimated. If investment expense for the improvement of call quality level is calculated, it is then possible to analyze investment validity through cost-benefit analysis.

The major contribution of this study is a pilot study on value measurement of service quality. Hopefully further research can be carried out to determine the value measurement of other variables.

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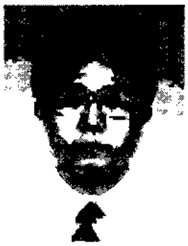

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