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Estimation of information value on the Internet: application of hedonic price model

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Abstract

This paper estimates the value of Internet information by using the hedonic price model (HPM). We specify a hedonic price function, and measure the consumer's willingness to pay for attributes to the Internet connection charge. We also identify a functional form for the HPM by using the Box–Cox transformation of the variables in our analysis. Our results indicate that the variation in the Internet connection charge is dependent upon the amount of information searching and e-shopping. We also find that the power functional form provides the best fit in describing the relationship between the Internet connection charge and the service characteristics. Based on the results of this paper, we expect that the economic value on Internet information will become larger than at present since Internet information usage is increasing. Thus, ISP or content providers seeking price discrimination can charge for information service instead of offering it for free if the firms segment their customers by the differential willingness to pay for each information.

Keywords: Hedonic price model; Information value; Internet

1. Introduction

The Internet has changed our lifestyle with a new concept of time, space and speed. It has also provided unlimited business opportunities for lots of potential customers comprised of individuals, companies and nations all over the world. In Korea, for example, the number of Internet users has increased rapidly in recent years, from about 3.1 million in late 1998 to more than 15 million in 2000. And, as Internet business continues to grow, almost all kinds of off-line businesses are entering cyber space.

In this study, we analyze the economic value of information obtained from Internet service by estimating the monetary value of the benefit that a consumer gets (where Internet services can be defined as the communication service, the information service, the market place service, and other services to subscribers via the public telephone network or data network). Specifically, we use the hedonic price model, known as the theory of characteristics value, which measures the value of each feature of the products in a real market. Many researchers use this

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model by using a questionnaire survey for consumers' real purchasing behaviors [1–3]. In this study, we thus use the questionnaire data from the real users of the Internet, who obtain information through the Internet. We first analyze the variables that explain the variations in the Internet connection charge. Second, we estimate the monetary value of information or the willingness to pay for Internet information usage. Note that our estimates can be regarded as consumers' surplus value given that most of the information on the Internet is now provided for free. Finally, we discuss some practical benefits of estimating the economic value of information.

2. Theoretical background

Hedonic price research is a well-established model to estimate implicit prices of multi-attribute items. Many researchers used the hedonic price model to measure consumers' valuations of attributes, which are part of a bundle of various characteristics they purchased [4–10]. The hedonic price model is also widely used in estimating the price changes of automobiles (see e.g., [11–14]). For example, Boulding and Purohit [13] applied the hedonic price model to investigate market valuation of antilock brakes and air bags.

The first application of the hedonic price model in the information technology (IT) area was in Chow's study [15], which estimated an annual quality-adjusted decline in mainframe computer prices between 1960 and 1965. Michaels [16] modeled the mainframe market with the product feature attributes of main memory size and secondary storage amounts. Berndt and Griliches [17] used the hedonic regression techniques to estimate the quality-adjusted change in prices for microcomputers. Rao and Lynch [18] estimated the value of attributes of computer workstations. Gandal [19] constructed a hedonic price index for spreadsheet software and found evidence of network externalities. Recently, Brynjolfsson and Kemerer [20] extended Gandal's research and provided a direct assessment of the role of network externalities and found the hedonic model to be a good predictor of actual market prices.

Since the hedonic price model decides the value of each attribute of a product or service, the sum of each value is the same as the price that consumers pay. Thus, we can estimate implicit prices of each attribute of Internet service by using the hedonic price model. Assuming that each individual understands the features of all kinds of Internet service and purchases the Internet service optimally, the hedonic price model can be the right method for estimating values of Internet service attributes. In other words, we assume Internet service is composed of a bundle of attributes as assumed for physical goods [21–23].

Consumers are assumed to have preferences over those attributes. There are maximum amounts that they are willing to spend, these are known as the consumer's bid or willingness to pay for any given combination they purchase. This bid depends upon the consumers' preferences as well as the bundle of characteristics. On the other hand, producers choose the bundle that maximizes their profits subject to the price of inputs, the production function, and the market price for each alternative bundle of characteristics. Thus, the producer's offer or willingness to accept the function indicates the minimum unit price the producer will accept for those services. The prices seen in the market are their tangency points since the market equilibrium is the tangency of these bid and offer functions [9,12,24].

Let P_{hi} denote an optional i-th Internet service price. Also S_i indicates a characteristics variable for the attribute of Internet service, and Z_i a dummy variable for the Internet environments such as substitute goods, contract duration, register of Internet circles or communities, competition, etc. In addition, X_i denotes the usage level of Internet information service. Then, by using the hedonic price model, we have the hedonic price function of Eq. (1):

$$P_{\mathrm{h}i} = f(S_i, Z_i, X_i) \tag{1}$$

By differentiating $f(S_i, Z_i, X_i)$ with respect to X_i, we can have $\partial P_{\mathrm{h}i}/\partial X_i$, i.e., a change in price of Internet service with one increasing unit of Internet service usage. We name $\partial P_{\mathrm{h}i}/\partial X_i$ a marginal implicit price of Internet service which is eventually the same as the consumer's willingness to pay ($W_{\mathrm{x}i}$) for using the extra unit of Internet service. In general, Eq. (1) has a nonlinear shape since the marginal implicit price changes nonlinearly due to the characteristics

and usages of Internet service such as S_i, Z_i and X_i. This nonlinearity assumption is consistent with that of Rosen [9] who argues that the equation of goods' prices is not necessarily linear.

3. Analysis

In general, consumers or Internet users have four ways of connecting to the Internet. The first is through the telephone line, which connects to the ISP or Internet service provider. The second is by using the LAN network in universities, companies, organizations, etc., and the third is via the private line of super-high speed Internet service enterprises such as ADSL. Finally, the wireless Internet provided from mobile communication companies is the fourth way to use the Internet service.

In this study, we limit our research attention to the Internet users at home who pay a monthly bill to super-high speed Internet service enterprises because most home users in Korea connect to the Internet through a private line such as optical cable or ADSL.

If a consumer gets information from the Internet for free, s/he in fact benefits as much as the amount of his/her willingness to pay for the information s/he gets. This willingness to pay must be the same as economic, monetary value for Internet information usage. Hence, based on the monetary amount of willingness to pay, which we obtain from the survey, we measure the marginal implicit price for the usage of Internet service within the hedonic price model that we estimate.

Although there are lots of information services on the Internet, we limit the scope of study to information from the World Wide Web in order to improve the reliability of responses from the subjects. Such information services can be information of education, news, health, investment, game, online shopping, e-banking, e-mail, and so on [25,26].

3.1. Data collection

It is difficult to measure the exact degree or condition of the consumer's usage of Internet information service. In order to obtain a 'good' measure, in this study we directly ask the subjects about information regarding the actual condition of their Internet use such as monthly bill amount[1] and service options. And in the survey we focus our questions on the value of each information service unit instead of the value of information service as a whole.

The questionnaire for measuring the price of Internet service is made up of four parts: first, the monthly connection charge for using Internet service; second, the variables that affect the monthly payment such as options of speed, term of contract, discounting member, etc.; third, the demographic variables such as sex, age, education, income, etc.; and fourth, the actual usages of information services on the Internet such as periods of usage (Table 1).

We used the method of quasi-experimental design for improving accuracy in collecting the data. In early December of 2001, we distributed the questionnaire to 160 students, randomly chosen from two universities in Seoul, and made them record the actual at-home condition of the information service on the Internet for 1 week after they had received the questionnaire.

We obtained 154 valid answers per variable. The ratio of male to female is 55.8:44.2. The usage-year mean of the Internet is about 3 years and 90% of respondents used the Internet for less than 5 years.

3.2. Hedonic price model

The basic hedonic price function is as follows:

$$P_{\mathrm{h}i} = f(S, Z, X) \tag{2}$$

where $P_{\mathrm{h}i}$ is the Internet connection charge (as Internet service price); S is the characteristics variable of Internet service; Z is the dummy variable of Internet service and X is the usage level variable of Internet information service.

Although we have Eq. (2), the important thing is to decide the form of the function. Researchers often

[1] In the earlier stage of the ISP market in Korea, most of ISP offers promotions of free subscription. All of the subjects in our study got benefits of free subscription. Also, the monthly charges used in our study include fees such as modem rental, discount with long term contract, etc. Thus, the monthly bill of Internet connection charge contains all of the fees in Internet service.

Table 1
Variable descriptive statistics

Variable		Definition	Means (unit)	S.D.
P_{hi}		Monthly Internet connection charge	33 711.04 (Won, Korea currency)	8251.47
X	E-MAIL	Electronic mailing services	2.15 (times per day)	1.35
	E-SHOP	Purchase from the Internet	1.41 (per week)	1.88
	SEARCH	Search of information	3.12 (per day)	2.32
	E-BANK	Internet banking services	0.96 (per week)	2.56
	NEWS	News, broadcasts, entertainments	4.08 (per day)	3.65
	HEALTH	Health care information	0.32 (per week)	0.83
	INTUSE	Internet usage	5.68 (seven-point scale)	1.31
	CHAT	Chatting	2.78 (seven-point scale)	1.75
	GAME	Internet game	3.47 (seven-point scale)	2.17
S	YRCONTRACT	Term of contract	1.14 (years)	1.06
	HOUSE	Type of residence	APT (46.8%), others (53.2%)	–
	FAMILY	Number of family using Internet	2.49	1.14
	SPEED	Transmission speed	1 Mbps (20.8%)	
			1.5 Mbps (59.7%)	–
			8 Mbps (19.5%)	
	YRINT	Term of Internet usage	2.88 (years)	1.57
Z	DCONTRACT	Contract with service provider	Yes (33.8%), no (66.2%)	–
	CIRCLE	Register of Internet community	Yes (14.3%), no (85.7%)	–
	HOMEPAGE	Managing homepage	Yes (51.9%), no (48.1%)	–

use functions that are linear, quadratic, log–log, semi-log, exponential, Box–Cox and so on. Until now, however, there has been no definite rule for choosing a function type in the hedonic price model. Researchers used several functional forms for the hedonic price function on the basis of goodness of fit. In recent studies [8,27,28], nonlinear functions such as semi-log, log–log, and Box–Cox functions [29] are popularly used. In fact, as long as the chosen function is consistent with the economic theory, no specific function is required for the model [30].

In this study, we use the non-linear function of the Box–Cox as shown below, which also appeared in Goodman [4]:

$$P[\lambda] = (P^{\lambda} - 1)/\lambda \quad \text{for} \quad \lambda \neq 0$$
$$= \log P \quad \text{for} \quad \lambda = 0 \tag{3}$$

where λ is the parameter of the functional form since the function becomes linear if $\lambda = 1$ and semi-log if λ approaches 0.

Then, the price equation of Internet service that we estimate is as follows:

$$(P^{\lambda} - 1)/\lambda = \beta_0 + \sum \beta_i S_i + \sum \beta_j Z_j + \sum \beta_k X_k \tag{4}$$

In our analysis, λ is estimated by maximum likelihood estimates (MLE) in the Box–Cox regression of SAS program. The results of grid search are shown in Table 2. The regression under $\lambda = -0.3$ produces the best results for the Internet connection charge.

Table 2
Search of parameter λ for Box–Cox transformation

λ	Log likelihood	λ	Log likelihood
−3.0	−1396.67	0.3	−1355.44
−2.7	−1388.34	0.6	−1358.89
−2.4	−1380.74	0.9	−1363.92
−2.1	−1373.93	1.2	−1370.62
−1.8	−1367.94	1.5	−1379.04
−1.5	−1362.86	1.8	−1389.22
−1.2	−1358.74	2.1	−1401.15
−0.9	−1355.66	2.4	−1414.80
−0.6	−1353.70	2.7	−1430.12
−0.3	−1352.94	3.0	−1447.00
0.0	−1353.49		

3.3. Result of estimation

After going through the model specification using the Box–Cox regression [31], we finally estimated the Internet service price equation as shown below:

$$\{P_{hi}^{-0.3} - 1\}/-0.3 = 3.17 + 0.0061\text{SPEED} - 0.0042\text{CIRCLE} + 0.00075\text{E-SHOP} + 0.00064\text{SEARCH} - 0.0021\text{HEALTH} \quad (4)$$

Table 3 shows the results from the regression analysis with OLS estimates. We used the backward elimination procedure in choosing the variables shown in Eq. (4). As a result, many variables in Table 1 are excluded in Eq. (4). The value of F statistics, 10.42, is statistically significant with a P-value of 0.000. This confirms the statistical significance of this regression model. The value of R^2 is 0.298, which means that the price change of Internet service is explained by about 30% according to the independent variables of our model. Although an R^2 of 0.298 seems to be low, it is not disappointing since it only indicates that other variables exist to explain the change of the Internet connection charge. For example, the price change of the Internet service is often dependent upon the costs at firms. However such variables are not considered in our model.

By examining the variance inflation factor (VIF) and the condition index (CI), we find that both the VIF and CI of our regression results are lower than 10. In other words, our results are free from the multicollnearity problem. The Durbin–Watson (D–W) test also shows that our results have no autocorrelation problem since the value of D–W is close to 2. Hence, our analysis satisfies the assumption on the residual item in the regression model [32,33].

Table 3
Results of regression analysis ($\{P^{-0.3}-1\}/-0.3$)

Variable	Coefficient	t-value	VIF
CONSTANT	3.17000	666.96**	1.24
SPEED	0.00610	4.88**	1.13
CIRCLE	−0.00420	−1.97**	1.26
E-SHOP	0.00075	1.77*	1.05
SEARCH	0.00064	2.09**	1.14
HEALTH	−0.00210	−2.31**	1.09

df = 153, $R^2 = 0.298$, $F = 10.42$, Sig. $F = 0.000$, CI = 7.63.
Durbin–Watson = 2.033.
**(*) is significant at $P = 0.05$ ($P = 0.1$).

The estimated regression coefficients, for SPEED, E-SHOP, and SEARCH, are positive as expected. It means that an increasing level of Internet services use results in placing greater weight on the service charge. The negative sign of CIRCLE means that those who registered in the Internet communities (dummy variable = 0) are more willing to pay than those who do not join any community. However, for HEALTH, the sign is unexpectedly negative. This unexpected result might be caused by the fact that most of the subjects in our study seldom use the Internet information on health care since its mean is 0.32 per week. In fact, by examining the data, we find that the monthly bill of those who frequently use the health care information is mostly below 30,000 Won, lower than the mean. Differently said, the negative sign of HEALTH is caused by the subjects in our data who pay the small monthly connection charge. In sum, five independent variables of the transmission speed of superhighway Internet, joining of Internet circle or community, the amount of e-shopping and searching (retrieval), and the amount of health care information used are statistically significant for the price of Internet service.

Next, we investigate how much the Internet user is willing to pay for Internet information. As in Eq. (4), the hedonic price equation that we estimate has the dependent variable $\{P_{hi}^{-0.3} - 1\}/-0.3$ and the independent variable with the form of power function. Thus, we can measure the price elasticities in terms of independent variables.

For example, we can calculate the price elasticity of SEARCH on the Internet connection charge by differentiating both sides in terms of SEARCH, assuming all else are constant. Based on the formula calculating price elasticity [34], we have Eq. (5):

$$\begin{aligned}\varepsilon(\text{Elasticity}) &= \%\ \text{change in}\ P_{hi} / \%\ \text{change in SEARCH} \\ &= (\Delta P_{hi}/P_{hi}) \cdot 100/(\Delta\text{SEARCH}/\text{SEARCH}) \cdot 100 \\ &= (\Delta P_{hi}/\Delta\text{SEARCH}) \cdot (\text{SEARCH}/P_{hi}) \end{aligned} \quad (5)$$

where Δ denotes a small change. If Δ is sufficiently

small, we can replace $\Delta P_{hi}/\Delta$SEARCH by the calculus derivative notation, dP_{hi}/dSEARCH.

By differentiating both sides of Eq. (4) with respect to SEARCH:

$$dP_{hi}/d\text{SEARCH} = 0.00064/P_{hi}^{\lambda-1} \quad (6)$$

Then, by substituting Eq. (6) into Eq. (5), we get:

$$\varepsilon = (0.00064/P_{hi}^{\lambda}) \cdot \text{SEARCH} \quad (7)$$

In practice, however, the elasticity is often computed at the sample mean values of SEARCH and P_{hi}^{λ} to obtain a measure of average price elasticity. That is:

$$\bar{\varepsilon} = (0.00064/\overline{P_{hi}}^{\lambda}) \cdot \overline{\text{SEARCH}} \quad (8)$$

Thus, we get 0.046% for the average price elasticity. Note that this is not the price elasticity of demand. This is the percentage change in Internet connection charge for one percent increase in the independent variable. Therefore, on average, one percent increase in SEARCH results in 0.046% increase in the price paid for Internet usage, which is about 16 Won in Korean currency. In other words, the consumer's marginal willingness to pay for the extra effort of searching for the Internet information is on average of 0.046%. This result has the proper sign and is consistent with the hypothesis that the more SEARCH, the more consumers are willing to pay for the Internet connection charge, all else held constant. The other results of coefficient estimates and elasticities are shown in Table 4.

The results from E-SHOP also support the hypothesis. As E-SHOP increases, Internet connection charge increases, holding all else constant. Thus, consumers have the willingness to pay an additional 8 Won compared to the present Internet service charge for the sake of the benefit obtained from Internet information.

Since the willingness to pay is the same as the marginal implicit price on information, we now measure the economic value of information on the Internet from additional searches. Likewise, we can obtain the economic value of Internet information in terms of extra changes in the independent variables shown in Table 4.

Table 4
Consumers' average willingness to pay (WTP)

Variable	Coefficient	Elasticity (%)	WTP (won)
E-SHOP	0.00075	0.024	8
SEARCH	0.00064	0.046	16
HEALTH	−0.00210	−0.0153	−5

4. Conclusion

As consumers obtain information from Internet services, they often save on opportunity costs such as money, time, and effort in the collection of information. The consumers also benefit by using Internet service instead of telephone and mailing services. However, the value of information usage on the Internet is not properly reflected in the Internet service price since most of the information is available for free.

We estimate the consumer's willingness to pay for the Internet information usage by using the hedonic price model. We estimate the economic value of information through analysis of the survey questionnaire data. That is, by estimating the consumer's willingness to pay for the Internet information usage via regression analysis, we measure the coefficients of the variables related to the Internet connection charge.

We also estimate the price elasticity related to the information acquired from the Internet. For example, 0.046% and 0.024% are the average price elasticities for information searching and shopping on the Internet, respectively.

In sum, we have made a couple of contributions. First, by using the hedonic price model often used in the automobile industry, we identified a functional form for Internet information usage with the Box–Cox transformation. Second, we calculated the price elasticity of information usage on the Internet connection service charge. With the price elasticity, we derive the information value, which is the marginal implicit price on information acquired from the Internet.

Based on the results of this study, we expect that

the economic value on the Internet information will become larger than at present since Internet information usage is increasing. In other words, we find the possibility of raising the Internet information usage charge based on the price elasticities we obtain even though the service charge of ISP is in reality dropping rapidly. Thus, ISP or content providers seeking price discrimination can charge for information service instead of offering it for free if the firms segment their customers by the differential willingness to pay for each information.

Despite the contributions, our study has some limitations. First, the subjects of our survey are mostly university students residing in the Seoul Metropolitan area. This may cause a bias on the usage of specific information. Thus, in the future, wider range of subjects should be examined. Another is an identification problem of the functional form, which has often been argued in hedonic price studies. To solve the problem, it is necessary to pass through the two-step method suggested by Rosen [9] for which homogeneous multiple markets should exist. In our study, however, we only had the first step since the Internet connection service market is a national, single market in Korea. As a consequence, we were not able to analyze the welfare of all Internet users in accordance with the increase of Internet information usage. In addition, the welfare analysis from the two-step method is not our intention for this study.

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