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시장요인이 고려된 특성치 준거 기술측정†

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A Characteristic-Based Technology Measurement With Market Factor Considered†

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ABSTRACT

Technology measurement is related with how to construct indicators of technological change and relative ranking of technological sophistication. Many attempts have been made to understand the measurement of technology. However, technology measurement still remains little understood problem in spite of its importance.

This article is concerned with improving the measurement of technology by introducing market factors into the model. It illustrate a simple approach to the measurement of technology. This approach is based on the characteristic-space paradigm of technology. A relative ranking of technological sophistication for a product is measurable as a set of characteristics.

The main feature of the proposed approach is the combination of technical factors and market factors. Technical factors are reflected in the definition of technological sophistication. Market factors are embraced in the determination of the relative importance assigned to each technology defining characteristics. Thus, the weight is determined by technical factors and market factors, which differentiates the study from the past based on judgmental technique such as experts' opinion.

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** 현재 한국과학기술원 경영과학과 조교수로 재직중. 미국 Catholic대학에서 경제학으로 Ph.D(1985)를 취득했으며 세계은행에서(1980-1983)수출촉진정책에 관해 연구하였음. 관심분야는 공공정책의 평가, 기술과 경제성장, 그리고 복합기술과제의 관리 및 평가 등이다.

1. INTRODUCTION

Since the industrial revolution, a great part of the economic growth has been achieved by the utilization of natural resources with technological advance. However, the economic growth by exploiting natural resources seems to be getting harder and harder because of the limited availability of the natural resources. In modern economy, technology is viewed as a key driving force of the economic growth, as natural resources have been depleted. In addition, it is well recognized that the technology has significant impacts on the behavior of each actor in a certain economic system.

As the importance of technology increasing, the economic analysis has expanded its spheres by looking at the reality from the diverse aspects of technology. Particularly, technology measurement which is the focal point of this study occupies an established position in this new trends. As technical environments are getting more dynamic, technology measurement appears as an extremely useful tool from the practical perspective. Purposes of technology measurement are mainly to explore the key parameters of technology and to determine the best time to introduce a new technology. In addition, the identification of a gap between one's technological capability and the state of the art and the trend of technical progress is also quite important for choosing proper technology.

However, in spite of the agreement that technology measurement is an important element, we have scant knowledge about it and it remains as an little comprehended problem. To date, measuring the technology is dependent upon two categories of approach. One is the combination of measures such as the input, output, and precursors. The other consists of measures based on the characteristics of technology. Even though all measures developed have their weaknesses, they are likely to be worthy of different purposes rather than being mutually exclusive - given the limited present understanding of technology and technological change.

The purpose of this study is to illustrate a simple approach to the measurement of the level of a particular technology. The problem is how to construct indicator of technological change and relative ranking of technological sophistication.

We will approach this problem based on the idea that a relative ranking of technological sophistication for a product is measurable through a set of characteristics. The indicator developed here attempts to measure the level of technology in a particular product area where technological change has taken place under the form of incremental innovation.

It also provides the result of empirical study. In the application, the main focus is placed on product technology in which technology is embodied in the product to reflect characteristics of technology and market. The reasons behind this focus are simple. First, the trend shows that paradigm of competition shifts from competition through price advantage to that through quality advantage. Also, consumers are so willing to pay for high quality goods or immediate and complete service that the firm may concentrate on the quality of his products. Second, consumers experience the product technology in the market, not process technology. Considering the consumers' sovereignty, focusing on the product technology seems to be adequate. The product analyzed here is the personal computer.

However, the methodology can be extended to other products which can be described by the characteristics.

2. TECHNOLOGY AND ITS MEASUREMENT

2. 1 The Problem of Heterogeneity

Generally, technology is defined to be the human knowledge applied in production [14]. It consists of information on the way of transforming inputs into outputs. The definition of technology as the way of transformation stems mainly from the viewpoint of the neoclassical economic theory of production. One of the building blocks of this approach is the implicit assumption of homogeneity ; inputs and outputs of the production process are assumed to be homogeneous. However, there exists the tendency that the assumption of homogeneity leads to the failure in explaining adequately the real phenomena of the world. This is because most products are inherently heterogeneous.

Attempts have been made to overcome the problem of products' heterogeneity for empirical research. Since the seminal works of Lancaster(1967) and Rosen(1974), the tradition has been founded that characteristics, rather than goods, are arguments of behavioral relations. Their major contributions are briefly summarized as the introduction of the idea that goods are consumed for the characteristics they possess and the characteristics, not goods themselves, are utility-generating.

2. 2 Definition of Technology and Measurement

Based on the preceding discussion, it is necessary to construct the operational definition of technology which captures the notion of heterogeneity. Two assumptions are employed to define the technology meaningful for empirical research. The first assumption is the characteristics description of the product. That is, product is regarded as a combination of characteristics valuable to users. This assumption enables us not to take into account the physical and marketable aspects of the product. By doing so, two benefits are drawn : the construction of object-specific measures and no consideration of factors external to technology. The second assumption is the full embodiment of technology in the product.

Combining the two, we can catch the point that technology is carried into the product through the diverse characteristics. In other words, technological change in a product at a given time period consists of changes in the level of each characteristic and in the appearance of new characteristics.

Under these assumptions, the value of the goods embodying a certain technology stems from the characteristics contained in that good. Thus, technology is defined to be the quality level of the product. Qualities can be specified in terms of diverse characteristics.

They can be considered as a composite of a number of different characteristics [1] [16]. Therefore, technology measurement is concerned with measuring the quality level of the product.

3. MARKET FACTOR WEIGHED INDEX FOR TECHNOLOGY MEASUREMENT

3. 1 Model Specification

We have adopted in Section 2 Adelman and Griliches's view of quality which was regarding it as a composite of a number of different characteristics.

The attention should be paid to the word "composite". This may imply that all characteristics are not equally important to define the level of quality. The economic value of each characteristic is so different that the relative importance will not be equal. Hence, the quality of the product embodying a certain technology is assumed to be a function of both the defining characteristics of their quantitative levels and the relative importance of those characteristics.

Thus, the determination of the weights of different characteristics is a critical factor to progress our discussion. In previous studies, relative weights assigned to different characteristics were drawn from judgmental technique such as interviews with designers, experts, users, and so on.

According to the characteristics approach to consumer demand, the price consumers are willing to pay reflects the value they set on each characteristic. The relative importance is determined with the aid of this value. Conventionally, this value is obtained by the regression equation that determines functional relationships between prices of product and characteristics. This regression approach is commonly known as the hedonic price method. The value of characteristics is often referred to as the implicit price in the context of the hedonic price method.

Quite simply, the approach consists of fitting regression relationships on cross sections of various models of the form :

$$P_j = f(X_{1j} \cdots, X_{nj})$$

where P_j is the price of the jth model, and $x_{1j}, x_{2j}, \cdots, x_{nj}$ are levels of characteristics 1, 2,$\cdots$,n contained in the jth model.

This equation is referred to as the hedonic price function and interpreted as a function that disaggregates the price of the good into the implicit prices and the quantities of the characteristics. And it provides estimates of prices for the characteristics. From the theory of the hedonic approach, each coefficient is interpreted as an implicit price and represents the marginal value of consumers. Since the prices must be estimated, rather than directly observed, they are usually termed implicit prices [20].

The weights are determined by the following equation :

$$w_i = a_i / \sum a_i$$

where a_i is the ith coefficient of the regression equation. Note that the weights are also normalized so that their values sum up to one.

The index of relative rankings among the various products is then set by

$$Q_j = w_1 X_{1j} / \overline{X}_1 + \cdots + w_n X_{nj} / \overline{X}_n$$

where $\overline{X}_i$ is a reference value of the ith characteristic. As mentioned before, the relative importance given to each characteristic is determined by the hedonic price method.

If $X_n < \overline{X}_n$ and the values of w_n sum to 1, then the value of technological sophistication index will also lie between 0 and 1.

One explanation is given to the variable $\overline{X}_i$. This variable is used to describe the products in a normalized and adimensional characteristics space. Product's technological level is assumed not to be connected with the absolute value of the key characteristics. Instead, it is related with the characteristics value in the normalized space.

Normalization is a general statistical practice when different sets of data are to be used in forming an index. But the question remains as to which method of normalization is best.

Nondimensionalization can be accomplished by referencing all values to the (commercially achieved) maximum value of each characteristic.

3. 2 Some Remarks on the Model

The measure proposed in this paper is based on a combination of different methods. The critical point is the characteristics description of product. If there are a number of models or variants of a generic product available to consumers at different prices, the equilibrium demand for each model should be explained by its particular combination of characteristics, together with a set of implicit utility weight factors that can be determined by statistical regression techniques. The overall utility of the product is a sum of products-of-characteristic measures times the appropriate weight factors.

Innovations can be mainly classified into incremental innovation and radical innovation by the degree of the technological change.

However, the measure proposed pays attention only to the incremental improvement. Incrementation exists if two products that appear at different times can be characterized by the same set of parameters. It also requires that subsequent development can begin where prior development ends. That is, a given state of technology, once achieved, does not have to be reachieved.

The requirements that products be describable by a characteristic set and that incrementation exists define both the phenomena to which the analysis applies and the class that is excluded. Basic research and invention are excluded from the scope of analysis ; the output of such activity is unique, unpredictable, and unspecifiable.

The trial of fixing the relative contribution to the quality level by the hedonic price method is caused by the customers' sensitive responses to changes both in price and in the supply of characteristics, as a new model is introduced or a model is altered. If a product can be considered a bundle of characteristics, then the quality of the product increases by increasing the number of characteristics included and/or raising the level of each characteristic. Following this definition, the quality contribution to each price can be determined by regressing the prices of the goods with respect to their defining characteristics.

Although the hedonic approach raises a number of conceptual problems, it seems to be generally agreed that there is a legitimate application for the technique in selected products where there has been a steady flow of minor improvements rather than a dramatic innovation.

4. APPLICATION TO KOREAN PC MARKET

4. 1. General Description

The process of measurement must be simple and practical from the perspective of users. Furthermore, the output of the measurement will be objective and quantitative rather than qualitative. The measurement will be carried out with the above-proposed measure and it requires information about

- the key characteristics used to define the technology,

- the weights assigned to each characteristic,
- the reference values selected for each characteristic,
- the equation employed to identify the technological sophistication

Personal computers are selected for case study. Attempt to construct the technological sophistication index of a personal computer is a challenge because it has exhibited exceedingly rapid quality change. Differences in quality are distinctive features of the market for personal computers.

The index of relative rankings is specified as follows.

$$Q_j = w_1 X_{1j} / \overline{X}_1 + \cdots + w_n X_{nj} / \overline{X}_n$$

The next step is to disaggregate a computer into a number of key characteristics. Disaggregation is based on the identification of characteristics pertinent to a computer. Thus, analysis should be carried out to identify characteristics which are evaluated to be significant by consumers or producers. This evaluation is the foundation of breaking down the product as the mix of representative characteristics. The selected characteristics should be those that completely represent the quality level of the product.

However, caution should be placed on choosing the key characteristics since a biased result may be brought about if the inadequacy exists in the process of selection. Hence, the identification of the proper characteristics are critical.

Computer speed, the size of random access memory(RAM), and the size of hard disk drive (HDD) are taken to be key characteristics.

Then, the index is shortened as follows

$$Q_j = w_1 X_{1j} / \overline{X}_1 + w_2 X_{2j} / \overline{X}_2 + w_3 X_{3j} / \overline{X}_3$$

where X_{1j}, X_{2j} and X_{3j} denote the clock speed, RAM size, and HDD size of the product, respectively, and $\overline{X}_i (i=1, 2, 3)$ is the reference value of the characteristic.

The reference value is used when normalizing the data. Normalization is based on the maximum amount of some characteristics contained in the data set. The maximum quantity of any single characteristic which can be technologically achievable will seldom be observed in products that are marketed. Thus, the values with the bar represent the highest characteristic values attained by examples of the product assumed to embody a certain technology.

4. 2. Database for Empirical Analysis

Based on the key characteristics, data has been collected for 50 models from 22 firms;19 domestic (5 big firms and 14 mid-small firms) and 3 foreign companies which are shown in TABLE 1.

TABLE 1 : Data on Technical Specification for Personal Computer

NO.	MODEL	CPU	SPEED	RAM	HDD	PRICE
1	PHANTOMi386X /40	386DX	40	4	120	960,000
2	HB 386	386DX	40	4	120	880,000
3	NEWTEC VESA36	386DX	40	2	245	990,000
4	SW ELITE	386DX	33	4	130	890,000
5	UNION 386DX1	386DX	40	4	120	890,000
6	ADTEC ZECCA50	486SX	25	4	170	1,397,000
7	PHANTOMi48625	486SX	25	4	120	1,100,000
8	GS GDM425L	486SX	25	4	210	1,460,000
9	HP Vectra486 /2VL	486SX	25	4	120	990,000
10	IBM PS /VPSI425SX	486SX	25	4	120	1,120,000
11	NEWTECSCS146SX2	486SX	25	4	245	1,140,000
12	NOVA	486SX	25	4	130	980,000
13	OPTIMA 120G	486SX	25	4	210	1,180,000
14	QNIX OMNI486 /SX25	486SX	25	4	200	1,580,000
15	SB 486H /T10G	486SX	25	4	170	1,180,000
16	UNION 486SX2	486SX	25	4	250	1,190,000
17	XTER EX486SX25	486SX	25	4	120	1,078,000
18	PHANTOM VL 486DX /33	486DX	33	4	250	1,520,000
19	CC pcLPv 433DX	486DX	33	4	170	1,630,000
20	DW CPC-25001 X50	486DX	50	4	170	1,720,000
21	HD Solomon POWER 433DX	486DX	33	4	200	1,850,000
22	HP Vectra 486 /33VL	486DX	33	4	240	1,290,000
23	NEWTEC SCSI486V33	486DX	33	4	340	1,650,000
24	OPTIMA 200G	486DX	33	4	250	1,590,000
25	QNIX OMNI 486 /33	486DX	33	4	200	2,041,000

TABLE 1 Continued

NO.	MODEL	CPU	SPEED	RAM	HDD	PRICE
26	SAEKDONG 486DX-33	486DX	33	4	250	1,900,000
27	SS SPC7500P-VW234H	486DX	50	4	340	2,100,000
28	UNION 486DX1	486DX	33	4	250	1,610,000
29	ADTEC POPORA 77	486DX2	50	4	250	1,732,500
30	DEC pcLPv450D2	486DX2	50	4	245	2,130,000
31	DW CPC-2900 X50	486DX2	50	4	340	2,470,000
32	GS GDM450L	486DX2	50	4	340	2,060,000
33	HB486S	486DX2	50	4	120	1,450,000
34	HD Solomon 450 DX2	486DX2	50	4	170	1,690,000
35	HJ GREEN MAX	486DX2	50	4	200	1,510,000
36	KY KDT VESA 486V50	486DX2	50	8	250	1,790,000
37	NEWTEC SCSI486V50	486DX2	50	4	340	1,790,000
38	OPTIMA 250G	486DX2	50	4	250	1,720,000
39	SAM MI JX30	486DX2	50	4	245	1,775,000
40	SB Popular 486P/T45V	486DX2	50	4	420	1,880,000
41	SR N4541VG	486DX2	50	4	170	1,820,000
42	DEC pcLPv 466D2	486DX2	66	4	245	2,340,000
43	HB486H	486DX2	66	4	120	1,550,000
44	IBM PS/VP 486DX2	486DX2	66	4	245	2,090,000
45	NEWTEC SCSI486V66	486DX	66	4	340	1,980,000
46	SAEKDONG 486DX2-66	486DX2	66	4	250	2,180,000
47	SB Popular 486P/T55V	486DX2	66	4	420	2,280,000
48	SW ATLAS VL DX-66	486DX2	66	4	250	1,750,000
49	UNION 486DX2-66	486DX	66	8	250	2,110,000
50	XTER EX486DX2-66	486DX	66	8	500	2,233,000

SOURCE : Catelogues and Magazine

The reference values, as stated above, are the highest characteristic ones obtained by examples of the technologies included in the set. Therefore, each value of the reference is obtained by scanning all characteristic columns for the highest values ;

$$\overline{X}_1=66,\ \overline{X}_2=8,\ \text{and}\ \overline{X}_3=500$$

These higher values are placed in the denominators of the index equations. Hence,

$$Q_j = w_1X_{1j}/66+w_2X_{2j}/8+w_3X_{3j}/500$$

In this approach, the characteristic values in the numerator change over time and across products, and the highest characteristic value of technology in the denominator remains fixed for a given data set.

4. 3. Determination of Weights

The remaining task of filling in the full information for the measurement is the determination of the relative importance of each characteristic. For this purpose hedonic price method is employed and relative values are evaluated based on the characteristic coefficients obtained from a hedonic price regression.

Most commonly used hedonic function has one of the three forms : linear, semi-log, or log-log [4][5]. Based on the reasonable consideration, any form can be taken in empirical study. Ohta (1975) stated that "There are three criteria for choosing a specific functional form of a regression equation : (1) choosing the most simple convenient form to obtain the estimates of interesting parameters, (2) choosing the form which yields the best fit, and (3) choosing the form which is based on assumptions that are shown to be plausible in the actual world."

Combining the first and the second criteria, the functional form in this study is derived as follows

$$\log P=a_0+a_1\log SPEED+a_2\log RAM+a_3\log HDD+\text{disturbance}$$

The log-log form is the well-used form for the price regression equation, and it yields the best fit under the given set of data.

It may be necessary to interpret the meaning of intercept carefully. If the product is a collection of characteristics, then all the characteristics should be included in the equation. In this case, the price could be entirely explained by the variables without an aid of an intercept. But some products have basic characteristics, for example, FDD and keyboard, that do not significantly differentiate them yet but they incur production costs. Furthermore, the price of a good could include costs other than those incurred to produce the given characteristics. Hence, the above equation contains an intercept.

The result of the hedonic price regression is summarized in TABLE 2.

TABLE 2 : Result of the Hedonic Price Regession

	Coefficients	Standard Error	t Statistic	P-value
Intercept	4.633797	0.16383	28.28412	5.23E-32
x1	0.331654	0.079526	4.170361	0.000124
x2	0.171056	0.130176	1.314039	0.194952
x3	0.39403	0.07208	5.466553	1.53E-06

Regression of prices on characteristics gives the average price of a given product with a given set of characteristics. Since a model with a positive residual in a regression of prices on characteristics is considered relatively inefficient in the sense that it yields fewer characteristics than an average product, one would expect it to be estimated low, other things being equal. Similarly, since a product with a negative residual yields more characteristics than the average product priced at that level, one would expect it to be estimated as relatively attractive to consumers.

TABLE 3 contains the residuals of each product.

Using this result, the weights assigned to each characteristic are

$$w_1=0.37,\ w_2=0.19,\ \text{and}\ w_3=0.44$$

Now, we have the complete form :

$$Q_j = 0.37 \times X_{1j}/66 + 0.19 \times X_{2j}/8 + 0.44 \times X_{3j}/500$$

4. 4. Calculation of Index and Results

The index for personal computers are calculated by means of the above equation. Results of this computations are presented in TABLE 4.

TABLE 3 : Residuals of Each Product

Obs.	ACT.	PRED.	Resi.	Obs.	ACT.	PRED.	Resi.
1	5.982271	6.087372	−0.105100	26	6.278754	6.185264	0.093489
2	5.944483	6.087372	−0.142890	27	6.322219	6.297732	0.024488
3	5.995635	6,158023	−0.162390	28	6.206826	6.185264	0.021562
4	5.949390	6.073361	−0.123970	29	6.238673	6.245113	−0.006440
5	5.949390	6.087372	−0.137980	30	6.328380	6.241656	0.086723
6	6.145196	6.079279	0.065917	31	6.392697	6.297732	0.094965
7	6.041393	6.019675	0.021718	32	6.313867	6.297732	0.016136
8	6.164353	6.115439	0.048914	33	6.161368	6.119513	0.041855
9	5.995635	6.019675	−0.024040	34	6.227887	6.179117	0.048770
10	6.049218	6.019675	0.029543	35	6,178977	6.206928	−0.027950
11	6.056905	6.141818	−0.084910	36	6.252853	6.296606	−0.043750
12	5.991226	6.033392	−0.042150	37	6,252853	6.297732	−0.44880
13	6.071882	6.115439	−0.043560	38	6.235528	6.245113	−0.009580
14	6.198657	6.107090	0.091567	39	6.249198	6.241656	0.007542
15	6,071882	6.079279	−0.007400	40	6.274158	6.333892	−0.059730
16	6.0775547	6.145276	−0.069730	41	6.260071	6.179117	0.080955
17	6.032619	6.019675	0.012944	42	6.369216	6.281645	0.087571
18	6.181844	6.185264	−0.003420	43	6.190332	6.159502	0.030830
19	6.212188	6.119268	0.092920	44	6.320146	6.281654	0.038501
20	6.235528	6.179117	0.056412	45	6.296665	6.337721	−0.041060
21	6.267172	6.147079	0.120093	46	6.338456	6.285102	0.053354
22	6.110590	6.178279	−0.067690	47	6.357935	6.373881	−0.015950
23	6.217484	6.237883	−0.020400	48	6.243038	6.285102	−0.042060
24	6.201397	6.185264	0.016133	49	6.324282	6.336595	−0.012310
25	6.309843	6.147079	0.162764	50	6.348889	6.455210	−0.106320

NOTE : Actual and predicted data are converted by the log transformation of product price

TABLE 4 : Index of Technological Sophistication

MOTEL	INDEX	MODEL	INDEX
PHANTOM i386DX/40	0.322368	SAEKDONG 486DX-33	0.527133
HB 386	0.322368	SS SPC7500P-VW234H	0.742888
NEWTEC VESA386	0.407368	UNION 486DX1	0.527133
SW ELITE	0.292855	ADTEC POPORA 77	0.681688
UNION 386EX1	0.322368	DEC pcLPv450D2	0.678288
ADTEC ZECCA 50	0.380236	DW CPC-2900 X50	0.695926
PHANTOM i486E/25	0.346236	GS GDM450L	0.695926
GS GDM425L	0.407436	HB486S	0.546326
HP Vectra 486/25L	0.346236	HD Solomon 450DX2	0.580326
IBM PS/VP S1425SX	0.346236	HJ GREEB MAX	0.600726
NEWTEC SCSI486SX2	0.431236	KY KDT VESA 486 V50	0.634726
NOVA	0.353036	NEWTEC SCSI486V50	0.695926
OPTIMA 120G	0.407436	OPTIMA 250G	0.634726
QNIX OMNI 486/SX25	0.400636	SAM MI JX30	0.631326
SB 486H/T10G	0.380236	SB Popular 486 P/T45V	0.750326
UNION 486SX2	0.434636	SR M4541VG	0.580326
XTER EX486SX25	0.346236	DEC pcLPv 466D2	0.826600
PHANTOM VL486DX/33	0.527133	HB486H	0.741600
DEC pcLPv 433DX	0.472733	IBM PS/VP 486DX2	0.826600
DW CPC-25001 X50	0.627288	NEWTEC SCSI486V66	0.891200
HD Solomon 433DX	0.493133	SAEKDONG 486DX2-66	0.830000
HP Vectra 486/33VL	0.520333	SB Popular 486 P/T55V	0.945600
NEWTEC SCSI486V33	0.588333	SW ATLAS VL DX-66	0.830000
OPTIMA 200G	0.527133	UNION 486DX2-66	0.830000
QNIX OMNI 486/33	0.493133	XTER EX486DX2-66	1.000000

In the case of products with 386DX, 486DX2-50, and 486DX2-66 chip, model 3, model 40, and model 50 has the highest index value, respectively. They have the largest negative residuals, respectively among all the products from each category in the data set. Therefore, they are the most attractive ones in the context of hedonic regression. Thus, purchase of these products is the reasonable decision-making.

All products with 386DX chip has the negative residuals, which reflects the relatively high performance with respect to the price.

Model 16 has the highest index with a larger negative residual among all products with 486SX chip. It seems reasonable for consumers to consider the purchase of this product.

In the case of products with 486DX chip, Model 27 has the highest index. However, this product has the positive residual. In spite of the highest technology index, the residual is positive so that careful consideration is needed when the consumer purchases.

One distinctive point is that the personal computer with 386 DX chip is superior to that with 486SX chip in the average. The main reason is the superiority of 386DX chip to 486 SX chip in clock speed. Most of the personal computers with 386DX chip contained in the data set have of 40 MHz, which means that the microprocessor runs the forty million commands per second. Thus, the superiority maybe stems from the prominent performance of the microprocessor.

TABLE 5 : Evolutionary Pattern of Technology according to the Upgrades of CPU

NO.	CPU	AVE. OF INDEX
1	386DX	0.431
2	486SX	0.422
3	486DX	0.510
4	486DX2-50	0.609
5	486DX2-66	0.742

One other noticeable point is the highest index of big fives' products. This is shown in TABLE 6. It can be inferred that large firms tend to work out the strategy of quality leadership. The foreign products exhibit the lowest degree, which may be the result of the high price policy. In other words, to compete in price, they lower the price of product by the relatively poor package of characteristics.

TABLE 6 : Index under the Level of Corporation

		AVE. OF INDEX
DOMESTIC	BIG FIVE	0.592
	MID-SMALL	0.531
FOREIGN		0.508

5. CONCLUDING REMARKS

The main purpose of this study is concerned with technology measurement. Hybrid measure of technology is employed in this study by incorporating several approaches. Thus, certain requirements have to be met to apply this approach. The procedure for measuring the level of technology defined in this study is far from complete.

Problems related with the assumptions employed should be reviewed first. We assumed that the product is regarded as a set of multifarious characteristics and that technology is fully embodied in the product. Therefore, the product must be multi-characteristic with easily quantifiable characteristics and all products under consideration should be described in terms of the same group of characteristics. This assumption is likely to raise the dispute of the conceptual applicability. The question whether the measures of technology and technological change based on product characteristics are a useful concept remains unsettled. In addition, this approach cannot be readily applied to the process technology which is difficult to disaggregate into characteristics.

As the technological efforts are directed to either the cost-reduction or the quality improvement, technology is not sometimes expected to be fully embodied in product. The process technology is aimed at reducing the cost and in this case technology is embodied in the process. So, the embodiment in product raises the problem similar to that of the assumption of characteristics description. In addition, the borderline between the product technology and the process technology is sometimes vague.

There exists the problem related with the determination of weights. In case of a multi-characteristic product, an important factor is the determination of the relative weight of individual characteristics influencing the level of the technology. Weights in this approach were derived from using the hedonic price method.

Relative weights of individual characteristics were obtained by means of prices per unit of characteristics, determined by regressing prices on characteristics. This idea stems from the fact that the coefficients in the price-characteristic relationship estimate both the user's assessment of an incremental unit of characteristic and the producer's cost of supplying that unit. By the way, careful attention should be paid to the interpretation of the implicit prices of the hedonic price method since it rests on the implicit assumption of a competitive market. If this is indeed the case, using the bedonic price method as a means of setting up characteristics' relative weights is justified in that the relative importance of diverse characteristics results from the equilibrium between producers and buyers. If the market is imperfect, the interpretation of the price-quality relationship becomes somewhat obscure. In this case, the way of obtaining the relative importance of individual characteristics should be revised. And, interpreting the implicit prices as the consumers' evaluation holds valid within the range of the competitive market.

Finally, one remaining limitation is the problem of selecting characteristics, which may be the most difficult aspect of applying the general approach. Statistical biases will be produced if the importance of unmeasured characteristics grows over time.

However, the salient feature of the proposed approach is the combination of the technical factors and the market factors. Technical factors were reflected in the definition of technological sophistication. This is the tradition of engineering approach to technology measurement. Meanwhile, market factors were embraced in the determination of the weights. In the past studies, the weight was determined by experts' opinion. This judgmental technique may lose its credibility and precision and, as a result, will be hard to be testified whether it is objectively valid or not. In this approach, the weight was determined by the hedonic regression approach, which differentiates this study from the past study.

The proposed approach is based on the test of validity on assumptions which will be the direction of further research.

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