Validation of a Marketable Quality and Profitability Model for Japanese Corporations

Valbona Barolli* and Heihachiro Fukuda**

**Graduate School of Engineering, Fukuoka Institute of Technology (FIT)*
3-30-1 Wajiro-higashi, Higashi-ku, Fukuoka 811-0295, Japan
E-mail: mdm04005@ws.ipc.fit.ac.jp
***Department of System Management, Fukuoka Institute of Technology (FIT)*
3-30-1 Wajiro-higashi, Higashi-ku, Fukuoka 811-0295, Japan
E-mail: fukuda@fit.ac.jp

Abstract

In this paper, we provide an evaluation method for both: the marketable quality and the profitability. We define the corporation rate of operation and profitability. Based on these definitions, we present a model to identify the profitability function considering the rate of operation at the break-even point. This function is considered as the marketable quality indicator from the viewpoint of a fair relationship between producers and consumers. Then, we apply the real values of some leading manufacturing corporations in Japan to our proposed model to analyze its accuracy. We presented a theoretical distribution of profitability by the proposed profitability function and the theoretical distribution of marketable quality indicator. We validated the proposed model and showed that the proposed model gives a good approximation of the economical trends of Japanese corporations. We verified that the fair relationship is a better considered relation than the unfair relationships.

1. Introduction

The corporation profitability is conceptually considered to be a function of two variables: qualitative and quantitative aspects.

The break-even point ratio expressed in the following equation is used as an indicator related to profitability to measure the degree of safety against a risk of loss.

Break-even point ratio = Sales at the break-even point / Sales
= Fixed costs / (Sales–variable costs)

This indicator is based on the profit graph presented by Knoeppel [1]. Another profitability indicator (relative annual profit) has been obtained from the rate of operation and the rate of operation at the break-even point [2].

Relative annual profit = Rate of operation / Rate of operation at the break-even point = Marginal profit / Fixed costs

As can be seen, this is an inverse number of the break-even point ratio. We consider the relative annual profit as a profitability indicator in this study. We define the marketable quality based on the quality aspects of products and services provided by corporations [3]. In order to increase profitability by enhancing marketable quality, the objective of this paper is to provide an evaluation method for both: marketable quality and profitability. In general, in some cases there is a trade off relation between marketable quality and profitability, but in other cases there is not. Therefore, it is an important problem to be considered how to increase the profitability by enhancing marketable quality.

The paper is organized as follows. In the next section, we present a the proposed model. In Section 3, we give the actual data of manufacturing corporations in Japan and derive an econometric methodology. In Section 4, we evaluate the proposed model. In Section 5, we discuss the relation between labor productivity and relative annual profit. In Section 6, we give some conclusions.

2. Proposed Model

2.1 Basic variables and indicators

2.1.1 Basic variables

We consider the following basic variables for our model. If a certain corporation consists of m kinds of processes or divisions for a certain period, we consider the capacity (total available operating time) of process i be T_i^c, and its costs (fixed costs) be F_i, $i = 1,\cdots,m$. The costs are divided into the capacity costs and activity costs by the source of their occurrence [4]. They are classified into fixed costs and variable costs based on the rate of operation or volume of operation. The capacity costs and fixed costs, and the activity costs and variable costs are almost the same, but the classification viewpoint is different. The necessary capacity (the total necessary time of operation) of process i is assumed to be T_i and the marginal profit which is calculated as the value of sales minus the variable costs (activity costs) is assumed to be M.

The potential variables for quality evaluation on the consumer side are as follows. There is a minimum required level to purchase a product considering a sacrifice (price or fee) from the customers' side related to the quality of products or services given by a corporation. Thus, any quality level can be quantified theoretically by comparing with the minimum passing level. Therefore, we consider the minimum passing point to be P_0 and other levels are considered as P.

2.1.2 Rate of operation indicator

The rate of operation of a corporation, β, is expressed in Eq. (1) as the average value of the rates β_i. The capacity cost F_i values are used as weights for each process [2].

$$\beta = \sum_i \beta_i F_i \Big/ \sum_i F_i = \sum_i T_i f_i \Big/ F \qquad (1)$$

Hence,

$$\beta_i = T_i / T_i^c,\ f_i = F_i / T_i^c,\ F = \sum_i F_i,\ i = 1,\ldots,m$$

Eq. (1) can be seen as a degree of used capacity costs. While, the rate of operation of the manufacturing industry in Japan is estimated by the Ministry of International Trade and Industry (MITI) and the Economic Planning Agency [5], and the Ministry of Economy, Trade and Industry [6]. The weighted average values are calculated by using added values of the rate of operation for each item which are considered as indicator of the rate of operation. Estimated values of the rate (β) of operation for each year are shown in Table 1.

Table 1. Annual relevant indicator values in the manufacturing industry.

Item	Year												
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
GVALP	9,774	10,257	11,540	12,378	12,979	12,550	11,887	11,430	11,685	12,558	13,534	13,660	12632
CER	10,603	11,139	11,657	12,455	13,506	14,474	15,411	15,925	15,982	16,441	17,027	17,658	18,311
GVAEP	92.18	92.08	98.99	99.38	96.10	86.70	77.13	71.78	73.11	76.38	79.48	77.36	68.99
ROI	3.87	4.80	6.17	6.13	5.55	4.28	2.98	2.35	2.82	3.57	4.16	3.84	2.68
RPS	3.74	4.70	5.95	6.13	5.63	4.36	3.19	2.62	3.12	3.93	4.44	4.15	3.11
r	1.128	1.159	1.207	1.214	1.198	1.154	1.109	1.087	1.100	1.127	1.146	1.135	1.098
Estimated β	77.09	76.59	81.77	83.82	85.55	83.62	76.49	72.92	72.06	73.77	74.20	77.34	71.34
AGAV	28,373	29,407	32,784	35,186	37,489	33,580	32,451	31,302	32,115	33,564	35,077	34,512	31,151
AFC	37,488	38,928	41,729	45,075	49,144	45,922	46,381	45,301	47,821	48,404	50,096	50,631	48,633
β_0	0.606	0.574	0.561	0.569	0.596	0.628	0.622	0.617	0.596	0.581	0.565	0.600	0.592
$E(\beta)$	79.48	77.72	77.00	77.44	78.93	80.68	80.36	80.08	78.93	78.11	77.22	79.15	78.71

1986-90: 912 corporations, 91-93: 1049 corporations, 94-98: 1064 corporations.

We think that it is necessary to check the correlation between them considering the changes of added values and capacity costs for each year, when we apply these data to our approach from the industrial and corporate viewpoints. The corporation Average Gross Added Value (AGAV) and Average Fixed Costs (AFC) for each year [7] show that there is a high positive correlation (correlation coefficient = 0.721) between them. For this reason, we can apply the data of the rate of operation in Table 1 to the corporation rate of operation.

2.1.3 Profitability indicator

The indicator representing relative annual profit only in the time dimension can be obtained as follows [2]. The ratio of marginal profit to necessary capacity costs is defined as the following marginal profit rate.

$$\gamma = M \Big/ \sum_i T_i f_i \qquad (2)$$

The inverse number of γ, α, is the minimum utilization rate of the capacity costs (the minimum rate of operation) required to cover capacity costs F at the marginal profit rate γ. If the minimum capacity cost required to cover F is F_0, the α can be calculated as follows.

$$\alpha = \frac{F_0}{F} = \sum_i T_i f_i \Big/ M \qquad (3)$$

This equation can be obtained by using the following equation.

$$(M \Big/ \sum_i T_i f_i) F_0 = F$$

Therefore, the general relative profitability r can be measured by the ratio of β to α.

$$r = \frac{\beta}{\alpha} = \frac{M}{F} \qquad (4)$$

This parameter is considered as the relative annual profit.

2.2 Marketable quality indicator

The indicator P is impossible to be used as an evaluation indicator to compare the quality aspects of corporations. In order to build a quality indicator to compare product quality of corporations, we combine P with time and costs corresponding to it. By combining point P with time and costs, the minimum passage point P_0 is considered a point at which a full cost is just covered by sales. That is, at this point the fixed costs are just covered by marginal profit. This means the evaluation of the minimum passage point P_0 is based on the capacity costs as input and marginal profit as output for a certain rate of operation B ($0 < B \leq 1$) and capacity costs per rate of operation F / B [8]. The parameter B is the rate of operation at the break-even point, when the production is made at the minimum passage point $P = P_0$.

If marginal profit increases in proportion to the evaluated point P, the marginal profit V (P, β) at the evaluated point P and the rate β of operation is computed as follows.

$$V(P,\beta) = F\frac{P}{P_0}\frac{\beta}{\mathrm{B}} \qquad (5)$$

The marginal profit Eq. (5) on the corporations' side plus the variable costs is considered as the price (fee) which the consumers should pay (sacrifice). By considering the input (costs) indicator corresponding to output of the evaluated point P in Eq.(5), we obtain Eq.(6) as follows.

$$\text{Input (cost) indicator } = \frac{F}{B}\beta \qquad (6)$$

Therefore, the relative value of P can be obtained by the ratio of output indicator Eq. (5) to the conditional input indicator Eq. (6) under the rate B of operation.

$$\text{Conditional relative value} = P/P_0 \qquad (7)$$

However, the relative value of Eq. (7) is possible only between corporations having the same B.

It is very difficult to obtain a common qualitative indicator for all corporations, therefore it is necessary to carry out a more general comparable evaluation for the qualitative aspects of corporations. We deal with this problem as follows. For a certain corporation and for a certain period, a point (β, r) for each value of β and r is considered. There exists a function $r(\beta)$. The set of points (β, r) which can theoretically exist is considered to be R, and we consider also another set which is assumed to be Q (Q is a subset of R). If the price function (relative annual profit per unit at the rate β of operation is considered relative price) is expressed as $u(\beta)$, all points in the set Q are included in the following equation.

$$r(\beta) = u(\beta)\beta \quad (8)$$

The price function can be considered as a fair relationship when a rate of profit increases due to an increase in the rate β of operation ($\frac{dr(\beta)}{d\beta}$) (profit on the corporations' side) and the rate of reduction in the total price ($-\beta\frac{du(\beta)}{d\beta}$) (profit on the customers' side) are equal. This can be obtained by solving the following differential equation.

$$2\beta\frac{du(\beta)}{d\beta} + u(\beta) = 0$$

$$u(\beta) = c/\sqrt{\beta}, \quad C: \text{integration constant} \quad (9)$$

There exist price functions when the rate of profit increase and the rate of price reduction are equal within a region where the integration constant C is a positive number. An incremental profit and a reduction in the total price on a reasonable price function at the rate β of operation are both expressed by the following equation.

$$r(\beta) = \int_0^{\beta}\frac{dr(\beta)}{d\beta}d\beta = \int_0^{\beta} -\beta\frac{du(\beta)}{d\beta}d\beta = c\sqrt{\beta} \quad (10)$$

Eq. (10) shows a fair relationship between the relative annual profit and the rate of operation. If the rate of operation at the break-even point where fixed costs (capacity costs) can be just covered by an incremental profit is considered to be β_0, from Eq. (10) of relative annual profit, we obtain the following formulas.

$$r(\beta) = \sqrt{\beta/\beta_0} \quad (11)$$

$$0 < \beta_0 \le 1 \quad (12)$$

By Eq. (11) and Eq. (12), we classify the point $(\beta, r) \in R$ by considering β_0 as a relative profitability of the qualitative aspect from the viewpoint of fair relationship between β and r [9]. The value of β_0 is calculated by following equation by using Eq. (4) and Eq. (11).

$$\beta_0 = \alpha^2/\beta = \beta/r^2 \quad (13)$$

The β_0 is related to variables P, P_0 and B, and also β. From Eq. (5) and (13), we get the following equation.

$$\beta_0 = (P_0^2B^2)/(P^2\beta) \quad (13')$$

In fact, it is difficult to calculate Eq. (7) and the rate B of operation, but it is possible to calculate r by ratio M/F using Eq. (4). Also, it is possible to calculate β_0 using Eq. (4) and the rate β of operation.

Because point $(\beta, r) \in$ R corresponds to point (β_0, β), it is possible to measure the profitability function consisting of two variables: β_0 and β.

$$r(\beta_0, \beta) = \sqrt{\beta/\beta_0} \quad (11')$$

3. Data of Japanese Manufacturing Corporations and Econometric Methodology

3.1 Actual and theoretical standard values of marketable quality

Let us look at Table 1 to see how the proposed marketable quality indicator approaches the real values. For the period from 1986 to 1998, β_0 shows major fluctuations. This period includes the period of the bubble economy of leading Japanese manufacturing corporations. The average value of β_0 for thirteen years was 0.593.

Fukuda[10] presented the following approach to get the theoretical value. To find the marketable quality indicator β_0, it is important to consider the difficulty of production on the producers' side and the sacrifice on the consumers' side. The smaller is the β_0 value (from 1 to 0) in Eq. (12), the greater is the incremental profit in Eq. (11) (which is equal to a reduction in the total price for any rate β of operation). The increase of the marginal profit (incremental profit) by β_0 is desirable for both the producers' and the consumers' sides. If β_0 is small, the marginal profit is high. However, when β_0 is small, it is more difficult to realize the marketable quality on the producers' side. The sacrifice of the consumers' side is equal to the incremental profit on the producers' side. When the degree of difficulty on the producers' side at which β_0 is realized is in proportional relation with the incremental profit, then both are in a fair relationship. This means that, the difficulty on the producers' side is related with the sacrifice on the consumers' side and vice-versa. It should be noted that the degree of realizing β_0 is in the inverse proportional relation with the size of the incremental profit in Eq. (11). As easy as is the degree of realizing β_0, the greater becomes the possibility to realize marketable quality. Therefore, in the case when β_0 is a value within the range of Eq. (12), its probability distribution is set independently from β in the following way. If the probability density function of β_0 is assumed to be $f(\beta_0)$, its value is obtained as equation (14) by using Eq. (11).

$$f(\beta_0) = \sqrt{\frac{\beta_0}{\beta}} \Big/ \int_0^1\sqrt{\frac{\beta_0}{\beta}}\,d\beta_0 = 1.5\sqrt{\beta_0} \quad (14)$$

Therefore, the expectation of the marketable quality indicator β_0 is obtained by Eq. (15).

$$E(\beta_0) = \int_0^1\beta_0 f(\beta_0)d\beta_0 = \int_0^1\beta_0(1.5\sqrt{\beta_0})d\beta_0 = 0.6 \quad (15)$$

By this expectation, the standard value of β_0 can be set equal to 0.6. The theoretical standard value of β_0 nearly agrees with the average 0.593 of β_0 in Table 1.

3.2. Relationship of marketable quality and relative annual profit

We obtain the relation between β_0 and relative annual profit r considering the theoretical standard value of the rate of operation for any β_0 as a parameter [9].

The difficulty degree to realize the rate β of operation for each β_0 in Eq. (11) exceeding the break-even point (within the range of $\beta_0 \le \beta \le 1$) is in proportional relation to the size of the incremental profit in Eq. (11). The probability density function of β is obtained by Eq. (16).

$$f(\beta)=\sqrt{\beta_0/\beta}\Big/\int_{\beta_0}^{1}\sqrt{\beta_0/\beta}\,d\beta=\{2(1-\sqrt{\beta_0})\sqrt{\beta}\}^{-1} \quad (16)$$

Therefore, the expectation of β is obtained by Eq. (17).

$$E(\beta)=\int_{\beta_0}^{1}\beta f(\beta)d\beta=\frac{1}{3}(\beta_0+\sqrt{\beta_0}+1) \quad (17)$$

The $E(\beta)$ can be established as the theoretical standard value of β at β_0. Therefore, the standard relationship between the marketable quality indicator β_0 and relative annual profit r is derived by Eq. (18), where $E(\beta)$ is considered as a parameter. The r value can be obtained by putting Eq. (17) into Eq. (11).

$$r=\left\{\frac{1-\beta_0\sqrt{\beta_0}}{3(1-\sqrt{\beta_0})\beta_0}\right\}^{0.5} \quad (18)$$

The r value and its incremental rate increase with the decrease of β_0. This represents a gradual increase in profitability (returns) by improvement of marketable quality.

In order to measure the effect of profitability of marketable quality, it should be considered that what level of profitability can be achieved by the standard marketable quality. This value is obtained as shown in Eq. (19) by using Eq. (18) and considering the standard marketable quality $\beta_0=0.6$

$$r=1.1486 \quad (19)$$

In following, we obtain the value of marketable quality. The distribution of r can be obtained as shown in Fig.1, by transforming Eq. (18) to Eq. (20) and applying this value to the distribution of β_0 in Eq. (14).

$$\beta_0=\left\{\frac{1+\sqrt{12r^2-3}}{2(3r^2-1)}\right\}^2 \quad (20)$$

Then, the expectation of r is theoretically calculated as follows.

$$E(r)=\int_0^1 r(\beta_0)f(\beta_0)d\beta_0=\frac{1.5}{\sqrt{3}}\int_0^1(1+\sqrt{\beta_0}+\beta_0)^{0.5}d\beta_0=1.2649 \quad (21)$$

Therefore, the effect in the standard value of the gradual increase of profitability due to improvement of marketable quality can be measured by the profitability Eq. (21) minus profitability Eq. (19), i.e. 0.116. The target value of marketable quality for this effect is $\beta_0=0.437$.

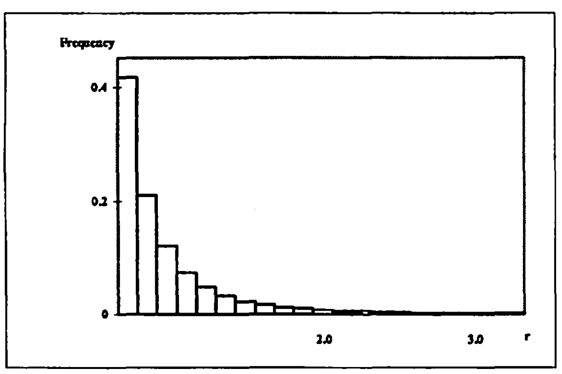

Fig.1. Theoretical distribution of profitability r.

3.3. Analysis of profitability distribution

We analyze the real situation in Japanese corporations and show the accuracy of the proposed model with real data of manufacturing corporations [7].

Let us consider the marketable quality indicator β_0 of the manufacturing industry in Table 1 and show how the theoretical standard value 0.6 reflects the reality. After 1991 during the bubble economy, the profitability r had been at low level, but the marketable quality was improved. The reason is that the rate of operation was higher than its standard value before 1991. But, the rate of operation is lower than the standard value after 1991. This problem happens because considering the demand and supply situation for a year, when the capacity of demands and supplies is balanced at a value of β_0 (which represents a certain marketable quality level), the producers' side and the consumers' side are conceptually equal in the market. The relationship between demand and supply capacity can be taken as the rate of operation. The standard rate of operation is computed based on the fair relationship. Therefore, when the actual rate of operation is equal to the standard rate of operation, the consumer demands and the corporation capacity of supply is considered to be in balance. As a result, when the actual rate of operation is equal to the standard rate of operation for the actual marketable quality indicator value β_0, the producers' and the consumers' sides are in an equal relationship. When the actual rate of operation is greater than the standard rate of operation, the producers' side is in advantageous position and when the standard rate of operation is greater than the actual rate of operation, the consumers' side is in advantageous position.

Let us now see the actual rate (β) of operation and the standard rate (E(β)) of operation in Table 1. The producers' side and the consumers' side were nearly in equal position in the period from 1986 to 1987 (before the bubble economy). The producers' side was in advantageous position during the bubble economy (from 1988 to 1991), while the consumers' side was in advantageous position from 1992 to 1998 (after the bubble period). Therefore, in such a situation, it is important that the corporations need to increase the rate of operation by reducing capacity while maintaining or improving marketable quality.

We evaluate the effect of profitability gradual increase due to the improvement of marketable quality of Japanese manufacturing corporations considering Figure 1. In Table 2, the average value of r with condition $r\geq 1$ becomes the average value of r in the range of "any $\beta_0 \leq \beta$". Thus, the effect of average gradual increase of r due to the reduction of β_0 can be calculated as "the average value of r with condition of $r\geq 1$" minus "r in Eq. (19)". In Table 2, the range where the distribution of r satisfies the condition of $r\geq 1$ is $1\leq r<2$. While, the theoretical average value of r in the range of $1\leq r<2$ is calculated to be 1.200. The theoretical standard value of the gradual increase of profitability in this case is calculated as: $1.200-1.149=0.051$.

If we see the actual values in Table 2 considering this theoretical value, we find that the average value r of corporations where $r\geq 1$ shows a sharp increase which exceeds the standard level of the gradual increase of profitability at the start of the bubble economy in 1988. Then, it fell to a level below the standard in 1991 at the end of the bubble economy and remained at a level corresponding to the standard marketable quality (which shows a gradual effect from 1992 to 1995). It has a level of little gradual effect in 1996 and 1997, but shows a small decrease effect in 1998. The average of the gradual increase of profitability for thirteen years was computed to be 0.0268. This corresponds to 53% of the standard value.

4. Validity of proposed evaluation method

4.1 Calculation for *w* variables

We extend our study considering the unfair relationship and compare the results with the fair relationship. If the ratio of the increase rate in profit and the reduction in price is $w:1-w$, $0<w<1$, the function of profitability can be obtained by Eq. (22) [10].

$$r(\beta)=\left(\frac{\beta}{\beta_0}\right)^w \qquad (22)$$

When $w=0.5$, we have a fair relationship. In this case, the β_0 can be considered a candidate of the marketable quality indicator if we assume that the profit ratio of the producers' side and the consumers' side is $w:1-w$. The density function of β_0 can be calculated by Eq. (23), and the standard value (expectation) of β_0 by Eq. (24) [10].

$$f(\beta_0)=(w+1)\beta_0^w \qquad (23)$$

$$E(\beta_0)=\int_0^1 \beta_0 f(\beta_0)d\beta_0=\frac{w+1}{w+2} \qquad (24)$$

The density function and the standard value of β where $\beta \geq \beta_0$ are obtained by Eq. (25) and Eq. (26). Profitability function where $\beta=E(\beta)$ is calculated by Eq. (27).

$$f(\beta)=\left(\frac{\beta_0}{\beta}\right)^w \Big/ \int_{\beta_0}^1\left(\frac{\beta_0}{\beta}\right)^w d\beta=\frac{1-w}{\left(1-\beta_0^{1-w}\right)\beta^w} \qquad (25)$$

$$E(\beta)=\int_{\beta_0}^1 \beta f(\beta)d\beta=\frac{1-w}{2-w}\frac{1-\beta_0^{2-w}}{1-\beta_0^{1-w}} \qquad (26)$$

$$r=\left\{\frac{1-w}{2-w}\frac{1-\beta_0^{2-w}}{1-\beta_0^{1-w}}\frac{1}{\beta_0}\right\}^w \qquad (27)$$

The value of β_0 is obtained by Eq. (28).

$$\beta_0=\beta r^{-\frac{1}{w}} \qquad (28)$$

We consider $w=0.75$ as the representative case when the profit on producers' side is greater than the profit on the consumers' side and $w=0.25$ as the representative case when the profit on consumers' side is greater than the profit on producers' side. We investigate which is the best parameter among $w=0.75$, $w=0.25$ and $w=0.5$ that reflect better the real economical situation of corporations using the actual data of Table 1 and Table 2. The candidate, β_0, of the annual marketable quality indicator with two unfair relations *w*'s is calculated using Eq. (28) (based on the data of Table 1). From the results, it is easy to see that among three parameters of marketable quality indicators, the value of $w=0.5$ is very close with the theoretical standard value calculated from Eq. (24) (the average value for the period of 13 years). Therefore, the theoretical standard value of the marketable quality indicator in the case of $w=0.5$ reflects better the real economical situation of corporations.

The theoretical average *r* value for the range of $1\leq r\leq 2$ is calculated to be 1.230 if $w=0.75$, and 1.143 if $w=0.25$. The standard *r* value for the standard β_0 value is calculated using Eq. (27) as follows.

$r=1.196$ when $w=0.75$, $r=1.086$ when $w=0.25$

The results for three parameters and the actual values are summarized in Table 3. It can be seen that gradual increase of profitability *r* where $1\leq r<2$ is the closest to the actual value when $w=0.5$. We conclude that the fair relationship which indicates that the incremental profit on the producers' side is equal to that on the consumers' side is the most suitable relation.

4.2. Proposed Algorithm

1. In Eq. (18) is shown standard relationship between β_0 and relative annual profit *r* when the *w* is considered to be 0.5. We also calculated values of β_0 for $w=0.25$ and $w=0.75$. We can calculate the values of β_0 for different *w* by using the following algorithm. Based on Eq. (27), a *w* value between $0<w<1$ is given.
2. The value of β_0 between $0<\beta_0\leq 1$ is considered as a variable and the function $r(\beta_0)$ is calculated for each β_0 as: $r(0.05)$, $r(0.10)$, $r(0.15)$, …, $r(0.95)$ and $r(1.00)$. This is considered as a set A.
3. Then, in the set A, the algorithm finds the maximum value of *r* which is less than 1.1 or equal with 1.1 (that is $r_{1-}=\max(1.1\geq r\in A)$) and the minimum value of *r* which is bigger than 1.1 or equal with 1.1 (that is $r_{1+}=\min(1.1\leq r\in A)$). In this way is decided the region for β_0 calculation.
4. For $r=1.1$, if we put β_{01} instead β_0, the calculation is carried out as follows. If we write as β_{01-} the value of β_0 within this region (0.05, 0.10, 0.15, … , 0.95, 1.00) which is related to r_{1-} and write as β_{01+} the value of β_0 related to r_{1+}, respectively from
   $\frac{\beta_{01-}-\beta_{01}}{\beta_{01-}-\beta_{01+}}=\frac{1.1-r_{1-}}{r_{1+}-r_{1-}}$, we have
   $$\beta_{01}=\beta_{01-}-(\beta_{01-}-\beta_{01+})\frac{1.1-r_{1-}}{r_{1+}-r_{1-}}$$
5. The values of the probability density for the range of $1\leq r<1.1$ can be calculated by using Eq. (23) as follows.
   $$1-F(\beta_{01})=1-\int_0^{\beta_{01}}(w+1)\beta_0{}^w d\beta_0 = 1-\beta_{01}^{w+1}$$
6. By repeating the steps from (3) to (5) and putting instead $r=1.1$: $r=$ 1.2,1.3, … 2.0, and so on, the values of probability density are calculated to be in the following regions: $1.1\leq r<1.2$, $1.2\leq r<1.3$, …, $1.9\leq r<2.0$, …, respectively.

5. Discussion

We discuss the relation between the Gross Value Added Labor Productivity (GVAEP) and relative annual profit. Considering the results of Table 1, Capital Equipment Ratio (CER) continues to increase, but Gross Value Added Equipment Productivity (GVAEP) shows decreasing tendency.

Let us consider the following relation between CER and GVAEP: (CER, GVAEP) = (*x*, *y*). The graph shown in Fig.2 is based on the 13 years actual values.

$y=-0.00365x+137.383$

The maximum labor productivity is 12,927 when $x=18{,}820$ and $y=68.69$. Here, the Correlation Coefficient (CC) between *x* and *y* is - 0.865. These values are almost the same with the last year values. In this pattern, it is impossible to increase more the labor productivity.

The relative annual profit has the same trend as the GVAEP as shown in Fig.3 ($y=234.11r-183.82$). They have a CC of 0.909. In order to increase the relative annual profit, the marketable quality should be increased. The increase of marketable quality can be achieved by enhancement of human resources quality and CER quality.

Table 2. Annual distribution profitability *r* for each corporation in the manufacturing industry.

Grouping r \ Year	1986	87	88	89	90	91	92	93	94	95	96	97	98
$r \le 1.0$	12.50	7.70	3.00	2.50	3.70	6.30	15.10	21.70	15.60	11.70	9.20	11.70	24.00
$1.0 \le r \le 1.1$	32.16	28.27	21.42	20.30	24.27	33.38	39.60	39.96	41.91	41.20	37.75	39.78	38.39
$1.1' \le r \le 1.2$	28.75	31.28	31.97	33.07	32.23	29.83	23.71	20.01	23.57	25.97	28.31	25.02	19.31
$1.2' \le r \le 1.3$	12.28	15.13	18.69	17.95	17.07	13.72	10.06	8.77	8.74	9.60	11.11	10.14	7.46
$1.3' \le r \le 1.4$	6.60	8.78	11.57	11.85	9.95	7.43	5.93	4.70	4.64	4.75	6.54	6.09	4.92
$1.4' \le r \le 1.5$	2.95	3.65	5.32	5.61	4.67	3.44	2.52	2.02	2.27	2.51	3.00	2.81	2.17
$1.5' \le r \le 1.6$	1.47	1.55	2.77	3.07	2.52	1.81	1.13	0.92	1.30	1.60	1.55	1.47	1.05
$1.6' \le r \le 1.7$	1.12	1.19	2.09	2.27	1.93	1.38	0.83	0.68	0.92	1.15	1.12	1.09	0.79
$1.7' \le r \le 1.8$	0.39	0.45	0.69	0.63	0.72	0.51	0.21	0.18	0.15	0.24	0.24	0.30	0.27
$1.8' \le r \le 1.9$	0.39	0.45	0.69	0.63	0.72	0.51	0.21	0.18	0.15	0.24	0.24	0.30	0.27
$1.9' \le r \le 2.0$	0.39	0.45	0.69	0.63	0.72	0.51	0.21	0.18	0.15	0.24	0.24	0.30	0.27
$2.0 \le r$	1.00	1.10	1.20	1.50	1.50	1.10	0.60	0.70	0.70	0.80	0.70	0.90	0.90
Conditional average for $1.2' \le r \le 1.3$	1.175	1.191	1.227	1.228	1.215	1.182	1.155	1.144	1.146	1.153	1.164	1.159	1.146
Conditional average r minus 1.149	0.027	0.042	0.078	0.079	0.066	0.033	0.006	-0.005	-0.003	-0.004	0.015	0.010	-0.003

1986-90: 912 corporations, 91-93: 1,049 corporations, 94-98: 1,064 corporations.

Table 3. *w* and relevant values.

	Conditional average r when $1.0 \le r \le 2.0$	Standard r based on Standard β_0	Effect of gradual increase of profitability		
$w = 0.75$	1.23	1.196	0.034		
$w = 0.50$	1.2	1.149		0.051	
$w = 0.25$	1.143	1.086			0.057
Actual values	1.176		-0.02	0.027	0.09

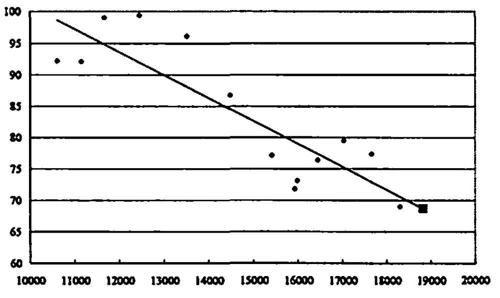

Fig.2. Relationship between y and x.

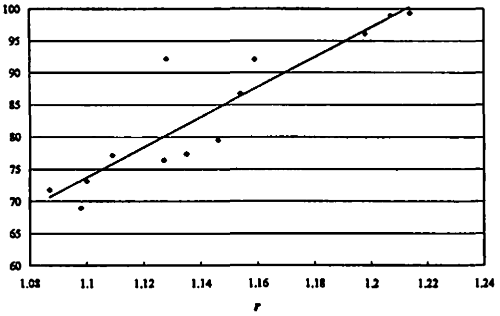

Fig.3. Relationship between y and r.

By increasing the CER, the GVAEP can be increased. It is important in the future to increase the GVAEP while keeping constant a positive CC of r and y by marketable quality.

6. Conclusions

We proposed an evaluation method in order to increase profitability by enhancing marketable quality. We defined the marketable quality as a qualitative aspect of profitability that is "measurable as a relative value". We presented a model to identify a profitability function by the marketable quality indicator, which is the rate of operation at the break-even point from the viewpoint of the fair relationship. We applied this model to actual values of leading Japanese manufacturing corporations and carried out analysis of the marketable quality indicator and the profitability. Based on our study we got the following results. The general average value of the marketable quality indicator is very close to the theoretical standard value 0.6 (60%). We considered the theoretical standard value of the rate of operation as a function of marketable quality indicator in the range more than the marketable quality indicator and obtained a profitability function where the profitability gradually increases due to the increase in marketable quality. We obtained a theoretical distribution of profitability by the profitability function and "the theoretical distribution of marketable quality indicator". We verified that the fair relationship better reflects the real economical situation of corporations than the unfair relationship.

The proposed model can be applied in the network field. We would like to use our model for Quality of Service (QoS) by considering network providers and users relationship.

References

[1] C.E. Knoeppel, "Profit Engineering, applied economics in making business profitable", New York: McGrow-Hill, 1933.

[2] H. Fukuda, "An economy indicator for process capability and capacity planning", Journal of Japan Industrial Management Association, Vol. 39, pp.139-145, 1988.

[3] D.A. Garvin, "Managing Quality", New York: The Free Press.

[4] National Accounting Association (NAA), Research Report No.39: Accounting for costs of capacity, 1963.

[5] MITI and the Economic Planning Agency in Japan. URL at http://wp.cao.go.jp/zenbun/keizai/wp-je91/wp-je91bun-3-1-3z.html.

[6] Ministry of Economy, Trade and Industry, "Explanation of Index of Industrial Production", 2003.

[7] MITI, "Business Analysis of Japanese Corporation-Industrial Classification Statistics Compilation", The Printing Bureau of Japanese Ministry of Finance (1988-1993-2000).

[8] T. Nakata, H. Fukuda, and Q. Yang, "Construction of an indicator for measuring white-collar productivity", Journal of Japan Industrial Management Association, Vol.50, pp.20-26, 1999.

[9] F. Koga, H. Fukuda, and T. Matsuo, "Development of quality evaluation technique for service enterprises", Journal of Japan Industrial Management Association, Vol.53, pp.282-291, 2002.

[10] H. Fukuda, "A standard relationship between relative annual profit and production ratio", Journal of Japan Industrial Management Association, Vol.40, pp.171-176, 1989.