

## **BUILDING AN INNOVATIVE STRUCTURE FOR A MANUFACTURING CORPORATION**

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### **ABSTRACT**

The importance of marketing and sales is undeniable. However, owning strategic technologies and new products obtained through innovation, reforming and R&D are crucial in accelerating the development of a manufacturing corporation. It requires powerful energy to realize the innovation potential of a corporation. It is not possible to innovate a corporation within the formal organization. It is also necessary to collaborate and work with people beyond the formal organization, especially those who have strong energy toward the innovation, beyond the formal organization.

The objective of this paper is to analyze and evaluate corporate innovations and reforming using an Analytic Hierarchy Process (AHP) and a Principal Component Analysis (PCA), and to clarify the effective structure of particularly innovative and reforming corporations. The importance and essence of corporate innovation are emphasized in this paper. The positive aspects of Japanese corporations are found in the continuous management of their mental innovation and reforming of their organization. This paper compares GE (General Electric Company) and Toyota (Toyota Motor Corporation), and explains their respective corporate innovation. It also clarifies the influential factors of GE and Toyota in corporate innovation. Seven other corporations are also analyzed using a 5-point scoring system to evaluate their various features. Analytical Hierarchy Process (AHP) and Principal Component Analysis (PCA) are used to analyze the obtained data.

**Keywords:** Innovative Structure, Management of Engineering, AHP

**JEL codes:** L60, G34

## **I. INTRODUCTION**

Toyota's turnover reached a trillion JPY in 2001, by its effective and efficient management, such as its KAIZEN attitude towards risk awareness in an organization. Toyota's method is well appraised.

On the other hand, Carlos Gohn, President and Chief Executive Officer of Nissan (Nissan Motor Co. Ltd.) succeeded in his shakeout and rationalization of Nissan by emphasizing the motivation of employees. He presented his vision to all employees through various means in order to share his vision with all employees. It was necessary to rebuild Nissan and tackle sensitive issues such as staff cuts, closing inefficient and ineffective factories and changing a relation with parts makers that Carlos Gohn made all employees understand the direction Nissan needed to take to be successful.

Backuner, CEO of Boston Consulting Ltd. in the USA, emphasizes that Japanese industry can remain competitive in important fields if high quality, good designs and superior levels of technology are maintained. Therefore, it is most important that Japanese companies continuously maintain Kaizen, which combines technological innovation and managerial innovation.

The objective of this paper is to explain the differences among Japanese companies from the perspective of two major companies GE and Toyota. Firstly, the paper compares these two companies. Secondly, an evaluation of 9 companies including GE and Toyota are conducted on the basis of published data. This data was collected from company information, journals, and other sources, Nikkei Sangyo, Nikkan Kogyo News, Mainichi News, Nikkei News, (many years).

The data is aggregated, analyzed and weighted. The appendix shows the results of pair-wise comparisons among attributes and object companies. The scaling technique, AHP, proposed by Saaty (1980) is employed to scale the companies.

Principal component analyses are employed to explain the structure of these companies and their features.

## **II. A COMPARISON OF TWO EXCELLENT COMPANIES**

This section explains the similarities and differences between Toyota and GE.

Corporate innovation is compared between GE and Toyota to pinpoint the most effective form of innovation. Jack Welch himself, the Chief Executive Officer of General Electric, played a central role in innovating and reforming GE in the 80s and 90s, as did Taiichi Ohno in the case of Toyota [Slater (1998); Welch et al. (2001); Tichy et al. (1994); Lowe (2007); Shibita et al. (2001)].

Both GE and Toyota are international companies. Both companies have had distinguished leaders, as well as effective personnel resources and learning cultures. They also successfully share information technology and maintain the continuity of their management systems. Both companies occupy a leading

position in the industry. Toyota’s policy makes all results organizational knowledge so that everyone in the organization can share such experiences as their own knowledge. This is called learning culture. Table 1 shows the history and features of innovations and reforming pursued in both companies.

The culture of Toyota is unique. It emphasizes that manufacturing success is achieved by the fostering of employees. Toyota held the top position in Corporate Brand, ranking number one among Japanese companies in 2006.

Table 1. Comparison of Corporate Innovation between GE and Toyota

Innovation ITEM	General Electric Company	Toyota Motor Corporation
(1) Person	Introduction of restructuring and “Concept of Stretch” Company to evaluate individuals	New Education Systems: Text “Management” Fostering managers Self-learning “Visualization of problems” Automatizing (Fostering managers) Manufacturing and Fostering
(2) Personnel System	Renewing Personnel Evaluation and Paying System	New Personnel System & Wage System Introduction of “Challenge Program” Revising “Pay per performance system” Placing stress on working process
(3) Organization	Organization with turning in a small radius, Inverted-Pyramid-Type Organization Structure Removing hierarchies (Innovation of organizations) Firing of employees more than 70 thousand employees Work-out (Visualization of problems at work places) Education of employees at work places	Developing an organization with Friendly Groups  Linkage among divisions by post-processing  Campaign of “Within 3 seals” and Flattering of Organizations
(4) Production System	Speed, simplifying, self-confidence Innovation Activities of GE way Introduction of Six Sigma Running a Six Sigma Program	Catching-up USA within 3 years, Knowledge and reforming, Respecting Humanity TPS (Toyota Production System) Innovation of companies, TQC (Total Quality Control) Friendly factories (Toyota Kyushu)
(5) Business	Market No 1 and 2 Strategy Services, Business directing Only services	

#### A. Success of GE in Innovation

The following are key factors of GE’s success in innovation.

- 1) The powerful initiative of the CEO,
- 2) An organization that could support it,
- 3) Linkage with an evaluation system,
- 4) An education and training system for promoting innovation and reform, and
- 5) Transparency of company objectives and responsibilities.

In particular, the concepts of their workouts, six sigma, etc. are admirable.

## B. Success of Toyota in Innovation

In a similar vein as GE, Toyota also has significant methods such as its “Kaizen” system and its “Kanban” system in its manufacturing system [Kazuaki (2002); Toyota (1978); Sanjushi (2002)].

These systems constitute a basic way to discover problems at an early stage and solve them quickly. They educate people in a way that also expands and accelerates reforming and innovation. Toyota’s way is to continuously reform and innovate its organization and manufacturing systems. This strategy is the most distinguishable feature of Toyota and many other companies are seriously deficient in this regard.

Reforming should reach to innovation. Reforming and innovation at GE and Toyota has become a model for other companies.

## III. ANALYSIS BY AHP

### A. Method

Analytic Hierarchy Process was proposed by Saaty (1980) in 1970s. The method is widely employed when building a decision structure. We explore the basis of the method below.

When a pair-wise comparison is defined by ratio  $w_{ij} = \frac{w_i}{w_j}$  of two values  $w_i$  and  $w_j$  of objects  $i$  and  $j$  ( $i, j = 1, 2, \dots, n$ ), respectively, the following relation holds:

$$Wa = na$$

where

$$a^t = [a_1, a_2, \dots, a_n],$$

$$W = \begin{bmatrix} w_{11} & w_{12} & \dots & w_{1n} \\ w_{21} & w_{22} & \dots & w_{2n} \\ \vdots & \vdots & & \vdots \\ w_{n1} & w_{n2} & \dots & w_{nn} \end{bmatrix},$$

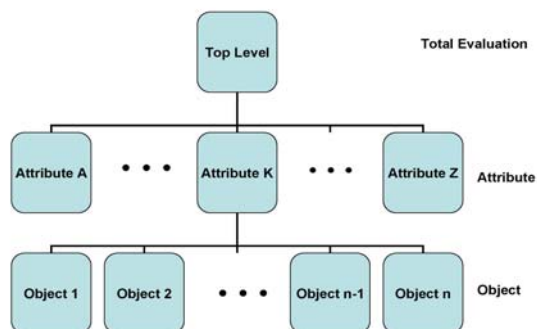
$n$  is the number of objects.

The proof is straight forward by substituting the ratio  $w_i / w_j$  of two weights to each element  $w_{ij}$  in matrix  $W$ . The weight of each object can be solved by an eigen value problem when we have the pair-wise comparison matrix  $W$ .

Saaty employed this relation to total evaluation under a hierarchical structure. When we have a hierarchical structure as illustrated in Figure 1, each weight of a linkage can be obtained by solving an eigen value problem and the accumulation of each evaluation through such a structure can enable us to obtain the total evaluation. When weights under attribute  $K$  ( $K = A, B, \dots, Z$ ) are denoted  $w_{iK}$  ( $i = 1, 2, \dots, n$ ) and all attributes  $K$  are evaluated with weight  $w_K$  ( $K = A, B, \dots, Z$ ), then the total evaluation,  $T_i$  of each object  $i$  is calculated as shown in Table 2 below:

$$t_i = \sum_{K=A}^Z w_{iK} \cdot w_K$$

**Figure 1. Hierarchical Structure**



**Table 2. Calculation of AHP**

	attribute A	...	attribute K	...	attribute Z	total assessment
Importance	$w_A$	...	$w_K$	...	$w_Z$	
Object 1	$w_{1A}$	...	$w_{1K}$	...	$w_{1Z}$	$t_1$
Object 2	$w_{2A}$	...	$w_{2K}$	...	$w_{2Z}$	$t_2$
⋮	⋮		⋮		⋮	⋮
Object n	$w_{nA}$	...	$w_{nK}$	...	$w_{nZ}$	$t_n$

where  $w_K$ ,  $K = A, B, \dots, Z$  is importance weight for attribute  $K$ .  $w_{iK}$ ,  $i = 1, 2, \dots, n$ ,  $K = A, B, \dots, Z$  is weight of object  $i$  from the viewpoints of attribute  $K$ .  $t_i$ ,  $i = 1, 2, \dots, n$ , is the total assessment of object  $i$  calculated in  $t_i = \sum_{K=A}^Z w_{iK} \times w_K$

**B. Corporate Analyses**

Table 3 shows the companies that are analyzed in this section.

**Table 3 Corporations analyzed in the paper**

1	GE	6	Nissan Motors
2	Hitachi	7	Honda Motors
3	Matsushita	8	Mazda Motors
4	Sharp Corp	9	Company A
5	Toyota Motor		

### C. Analytic Hierarchy Process

Corporate fundamentals are evaluated for four features: 1) capital, 2) the number of employees, 3) sales volume, and 4) fiscal profits as shown in Table 4.

Financial total evaluation consists of four features: 1) capital, 2) number of employees, 3) sales volume, and 4) current profits as shown in Table 5.

Corporate Kaizen activities are evaluated with reference to six features: 1) the degree of reforming and innovating of a company, 2) activities within a company, 3) leaders, 4) the culture of learning, 5) personnel resources, and 6) Information technologies as shown in Table 6.

In this paper we analyzed these 5-point pair-wise comparisons in the same scaling by means of the AHP and obtained the total evaluation of the companies as follows:

#### 1. AHP results for Fundamentals

As the total evaluation in Table 4 shows, GE and Toyota Motors are excellent in their capital, number of employees, sales amount and current profits. Hitachi Ltd. and Matsushita Electric Industrial Co. are outstanding in their number of employees and sales amount. Sharp Corporation has no significantly excellent points. Nissan Motor Co. is excellent in its capital, sales amount and current profits. Mazda Motor Co. Ltd. and Company A are inferior in all aspects compared to the other companies.

**Table 4 AHP results of fundamentals**

No	Name of Corporation	Fundamentals				Total Evaluation	Order
		Capital	Number of Employees	Sales Volume	Current Profits		
	<b>Importance</b>	0.109	0.189	0.351	0.351		
1	GE	0.265	0.195	0.175	0.217	0.207	1
2	Hitachi	0.073	0.195	0.175	0.041	0.070	7
3	Matsushita	0.073	0.195	0.103	0.041	0.101	5
4	Sharp	0.073	0.035	0.032	0.041	0.075	6
5	Toyota Motors	0.123	0.195	0.175	0.217	0.177	2
6	Nissan Motor	0.265	0.057	0.103	0.217	0.154	3
7	Honda Motor	0.042	0.057	0.175	0.143	0.116	4
8	Mazda Motor	0.042	0.035	0.032	0.041	0.056	8
9	Company A	0.042	0.035	0.032	0.041	0.043	9

#### 2. AHP results of financial total features

The analysis of financial total features shows the following results: General Electric Company is outstanding from the viewpoints of its scale, profit performance, safety and growth potential. Hitachi Ltd has a huge

scale. Matsushita Electric Industrial Co. Ltd. is excellent in its scale, safety

and strong potential for growth. Sharp Corporation has good profit performance and safety. Toyota Motors has huge scale size, profit performance and safety. Nissan Motor Co. Ltd. has good scale size, profit performance and potential for growth. Honda Motor Company is outstanding in its scale, profit performance, safety and potential for growth. Mazda Motor Corporation is outstanding in its profit performance. Company A is inferior in all aspects to the other companies.

**Table 5 AHP results of financial total features**

No.	Name of Corporation	Financial Total Features				Total Evaluation	Order
		Scale	Profitability	Soundness & Safety	Growth Power		
	<b>Importance</b>	0.467	0.277	0.095	0.160		
1	GE	0.206	0.190	0.180	0.258	0.233	1
2	Hitachi	0.102	0.032	0.072	0.040	0.114	4
3	Matsushita	0.122	0.032	0.180	0.114	0.184	2
4	Sharp	0.034	0.111	0.180	0.068	0.062	6
5	Toyota Motors	0.206	0.190	0.180	0.068	0.175	3
6	Nissan Motor	0.122	0.190	0.032	0.258	0.049	7
7	Honda Motor	0.122	0.111	0.110	0.114	0.101	5
8	Mazda Motor	0.034	0.111	0.032	0.040	0.040	8
9	Company A	0.053	0.032	0.032	0.040	0.040	8

**Table 6 AHP results of corporate Kaizen activities.**

No.	Name of Corporation	Features of Kaizen						Total Evaluation	Order
		Innovation	Activities in a company	Leader	Culture of Learning	Personnel Resource	Computerization		
	<b>Importance</b>	0.288	0.170	0.288	0.098	0.098	0.059		
1	GE	0.224	0.227	0.242	0.267	0.217	0.227	0.234	1
2	Hitachi	0.077	0.081	0.081	0.095	0.217	0.227	0.103	5
3	Matsushita	0.077	0.081	0.145	0.095	0.131	0.142	0.108	4
4	Sharp	0.077	0.081	0.081	0.095	0.075	0.081	0.081	7
5	Toyota Motors	0.224	0.227	0.145	0.171	0.131	0.081	0.179	2
6	Nissan Motor	0.077	0.142	0.081	0.095	0.075	0.081	0.091	6
7	Honda Motor	0.138	0.081	0.145	0.095	0.075	0.081	0.117	3
8	Mazda Motor	0.077	0.048	0.048	0.053	0.046	0.048	0.057	8
9	Company A	0.031	0.032	0.032	0.035	0.031	0.032	0.032	9

3. AHP results for corporate Kaizen activities.

GE is excellent from the view of the following points: corporate reforming and innovation, activities, leaders, the culture of learning, and computerization and informatization. Hitachi Ltd. And Matsushita Electric

Industrial Co. Ltd. are excellent in personnel resource. Sharp Corporation is not particularly outstanding in these points but its excellent R&D brought the company to the today's state. Toyota Motors is excellent in all points. Toyota Motors is especially outstanding in reforming and innovation, and activities within a company. Honda Motor Company is outstanding from the point of view of innovation of a company and has had excellent CEOs in the past.

Mazda Motor Corporation and medium-sized company A are inferior in all aspects as compared to the other companies.

One objective of this research is to clarify what methods are the best when developing a middle-sized company such as company A. As the analysis of the features of corporate Kaizen activities is dependent on subjective evaluations, an analysis of more objective and numerical fundamentals and financial total features will be compared in the discussion.

**Table 7. Evaluation attributes employed**

2	Innovation	11	Current Profits
3	Corporate Activities	12	Scale
4	Leaders	13	Profitability
5	Learning Culture	14	Soundness and Safety
6	Personnel Resource	15	Growth Power
7	Computerization	16	Facility Investment
8	Capital	17	R&D Investment
9	Number of Employees	18	Number of Patents
10	Sales Volume	19	Competitiveness of patents

No is shown in Figure 2.

**Table 8 Eigen values and contribution ratios**

No	EV	CR	CCR
1	11.124	0.618	61.8%
2	3.151	0.175	79.3%
3	1.291	0.072	86.5%
4	1.037	0.058	92.2%
5	0.599	0.033	95.6%
6	0.513	0.029	98.4%
7	0.218	0.012	99.6%
8	0.067	0.004	100.0%

EV: Eigen value

CR: Contribution ratio

CCR: Cumulative contribution ratio

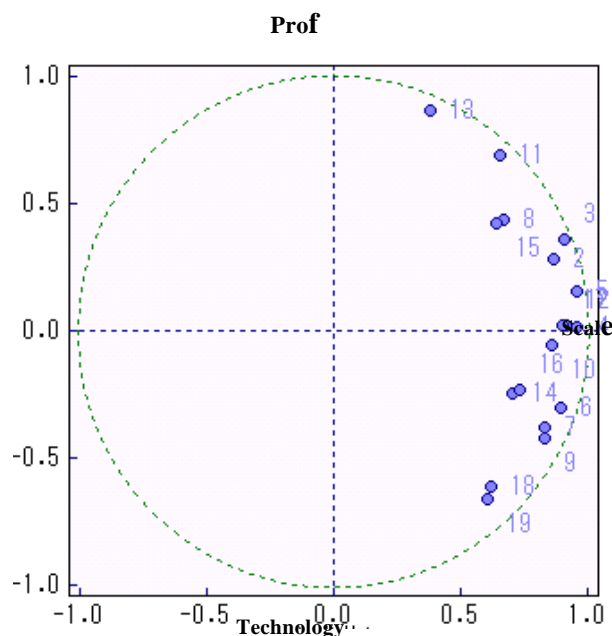


#### IV. PRINCIPAL COMPONENT ANALYSIS

The principal component analysis is applied to all the corporate features discussed above including additional features, to obtain the following results as illustrated in Figures 2 and 3. Table 7 shows all features employed in this PCA.

Nissan is superior in profitability and current profits, while Hitachi and Matsushita are superior in the number of patents, the competitive power of patents and the number of employees. GE and Toyota are superior in leadership, the culture of learning, scale and R&D investment.

Figure 2. Results of principal component analysis



#### V. DISCUSSION

It is not easy to explain the influence of the various attributes of a company and its management using dimensions of innovation, reforming, activities within a company, leadership, the culture of learning, personnel resource and computerization effect on a company.

##### A. Comparison and discussion

##### 1. Comparison between GE and Toyota

##### i. Personnel resources

GE strengthened the education and training of personnel resources by

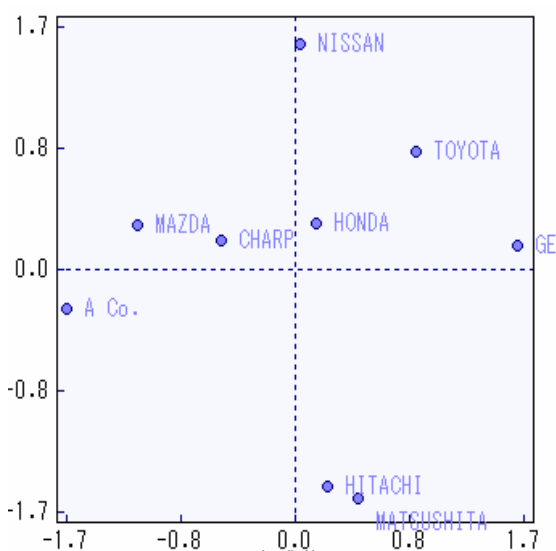
clarifying the personnel features of the leader in the company, expanding stock

options, and employing the concept "Stretch." On the other hand, Toyota placed emphasis on fostering employees by means of educating managers, training supervisors, and employing the motto: "manufacturing is to foster employees." Both companies have reaped their results from this and many distinguished people have been developed in both companies.

**Table 9. Factor loading for each principal component**

No	Attributes	PC1	PC2	PC3	PC4	PC5
2	Innovation	0.861	0.284	0.309	0.144	-0.123
3	Corporate activities	0.909	0.356	0.090	-0.054	0.140
4	Leaders	0.953	0.012	0.126	-0.026	-0.240
5	Learning culture	0.957	0.153	0.138	-0.129	-0.060
6	Personnel resource	0.895	-0.299	-0.021	-0.012	0.031
7	Computerization	0.826	-0.381	-0.160	-0.111	-0.121
8	Capital	0.664	0.438	-0.370	-0.395	0.241
9	Number of employees	0.829	-0.418	-0.013	0.114	0.345
10	Sales volume	0.859	-0.059	-0.246	0.430	0.016
11	Current profits	0.657	0.686	-0.157	0.191	0.043
12	Scale	0.912	0.021	-0.216	0.289	0.132
13	Profitability	0.377	0.864	0.192	-0.083	-0.170
14	Soundness and safety	0.701	-0.243	0.573	-0.111	-0.167
15	Growth power	0.637	0.418	-0.429	-0.346	-0.201
16	Facility investment	0.727	-0.233	0.436	-0.313	0.291
17	R&D investment	0.897	0.019	0.094	0.357	0.036
18	Number of patents	0.618	-0.608	-0.198	-0.372	-0.013
19	Competitiveness of patents	0.602	-0.663	-0.266	0.083	-0.328

**Figure 3. Results of principal component analysis**



ii. Personnel system

GE changed its personnel evaluation and reward systems, and linked the personnel evaluation system with six sigma. Toyota employed a new personnel system for managing and controlling employees and the wage system "Challenge Program," revised its pay-per-performance system and emphasized the evaluation of processes.

iii. Organization

GE built an organization which can adjust itself by reducing the number of hierarchies, power-shifting to line managers, and workout. Toyota realized an organization which consisted of friendly groups, and flexibly combined divisions after the process. It also reduced the number of approval processes (Ringi) to within three persons, and flattened the organization. Both the companies made their operations more efficient.

Iv. Manufacturing System

GE realized a speedy, simplified and steady manufacturing system, through the GE way of innovation, six sigma. Toyota employed its Toyota activities of corporate innovation (TPS), All Toyota Quality Control Activity (TQC), wisdom and Kaizen, respect for people friendly factories.

v. Sales and Marketing

GE employed the strategy of being No 1 or 2 in the market, business portfolio, and the development of strategies, and services. It also built business directing services, and started its whole company activities for realizing value-adding services.

**B. Factors that make corporate innovation succeed.**

1. CEO

Jack Welch (GE) is a strong leader. He created various ideas to lead world-wide companies and had the ability to realize them. He has unbelievably persuasive powers and the ability to draw enthusiasm from its employees.

2. The Company

GE employed real ability-ism. The conditions of an ideal model company is 1) a changeable system, 2) a CEO who exercises strong leadership over the company, 3) people who support the leader in innovating the company such as Taiichi Ohno at Toyota., 4) ambitious employees who are eager to promote such innovation.

### **C. Discussion about AHP**

From the analysis of Corporate Kaizen Activities, it is clear that GE, Toyota and Honda are successful in corporate innovation and restructuring. Hitachi and Matsushita follows these Kaizen activities. Let us discuss the comparison with an analysis of the features of fundamentals and, the features of Financial Total Assessment. The result is obvious. The innovation and reforming of a company should be locomotive power to develop a company.

Let us explain this in greater detail. GE is excellent in all features. Hitachi is excellent in personnel, computerizing, the number of employees, sales amount, and the competitive power of patents, but inferior in current profits, profitability, and growth. Matsushita is excellent in the number of employees, soundness and safety, facility investment, the number of patents, competitiveness of patents, however it is inferior in current profits and profitability. Sharp is excellent in soundness and safety, but inferior in the number of employees, sales volume, current profits, scale, R&D investment, the number of patents, and the competitiveness of patents. Toyota is excellent in corporate innovation, activities within a company, number of employees, sales volume, current profit, scale, profitability and soundness and safety, but inferior in its number of corporate features and the competitiveness of its patents.

Nissan is excellent in capital, current profits, profitability, growth power, but inferior in soundness and safety, facility investment, number of patents and the competitiveness of patents. Honda has a good sales volume but its capital, facility investment and number of patents are poor.

Mazda has no excellent features and its capital, number of employees, sales volume, current profits, scale and soundness and safety are all poor. Company A is inferior in all features.

The typical features of the automobile industry are that the number of patents and the competitiveness of patents are poor. But Honda has comparatively good competitive power of patents.

### **D. Discussion about the results by PCA**

From the results by PCA we can not conclude that the number of patents and the competitive power of patents result in profitability and current profits. Compared with electronic makers, automobile companies are inferior in these features. However profitability and current profits are better in the automobile industry than in the electronic industry. This is an important point.

## VI. CONCLUSION

According to the analysis of R&D projects, we understood R&D played an important role in developing a company as written in Imoto, Yabuuchi, Watada (2007). It is not possible to continuously develop a company without corporate innovation and reforming of the company. Therefore, it is important and essential to have continuous and sustainable innovation and reforming of a company. Whether innovation will succeed or not depends on the corporate culture of the company. Therefore, we can also say the development of a company depends on its corporate culture.

The total Research and Development (R&D) investment of companies like Hitachi, Toshiba, Mitsubishi Electric, Matsushita, Sony, NEC and Fujitsu and precise machinery manufacturing companies such as Cannon, Fuji Film and Ricoh in the consolidated basis was 33.5 trillion JPY with a 1.7% increase in 2005. It is predicted to reach 35.3 trillion with a 5.4% increase in the near future.

The development of a company depends on corporate innovation, reforming and other activities within the company (Kaizen in the company) and the development of new products by R&D. These sustainable activities are a locomotive of developing a company. The results of the analyses of features of fundamentals and the features of financial total assessment shown in this paper, explain that the corporate innovation and reforming and analysis of features about corporate Kaizen activities results in the development of a company.

The corporate innovation and reforming activities, leaders, learning culture, personnel resource and computerization of GE and Toyota can be a model of corporate success, even for a middle sized company such as Company A.

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