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ENVIRONMENT and TECHNOLOGY STRATEGY of JAPANESE COMPANIES

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ABSTRACT

This paper reports the findings of a survey of technology strategy of the Japanese companies. Results show that different Key Success Factors (KSF) for competition within an industry can be explained by environmental uncertainty and new technology impacts and that some of the technology strategy differ among various KSF groups. Therefore the environmental factors more or less affect the content of technology stragegy. The other determinant of technology strategy is technological leadership within an industry, which is heavily influenced by a company's (internal) technological development capability.

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INTRODUCTION

Advancing technology has influenced many aspects of management decisions, including changes in product concepts, production processes, and marketing channels. Each firm has had to cope with rapid change caused by technological innovation, and must seek its own way of responding to this newly emerging complexity. Whether or not technology can be effectively incorporated into strategy has become a major concern for many companies.

Sharing this concern, the author carried out a survey of major Japanese companies (n=170, response rate=34%)1 which focused on the firm's perception of the significance of technology as a strategic variable. The purpose of this paper is twofold. First, it will present a conceptual model which seeks to explain various features of technology strategy of a firm, using the survey data from Japanese companies. Secondly, it will identify the sub-strategies which are affected by external factors and those affected by internal factors. Through this process, it is also expected that characteristics common to all Japanese firm will emerge.

ENVIRONMENTAL DETERMINANT OF TECHNOLOGY STRATEGY

Environmental factors influence the content of technology strategy. For our purposes, environmental factors are divided into environmental uncertainty and new technology influences.

Environmental Uncertainty

Environmental uncertainty has often been referred to as a key variable that influences strategic behavior. Abernathy and Utterback (1975) attempted to clarify the strong relationships between a firm's choice of a strategy and its environment. They regarded stages of development of a market as a firm's environment, and proposed the following three stages: uncoordinated, segmental, and systemic stage. They thought a firm's choice of a strategy should include process and product decisions, and they claimed that need oriented product innovation and manual processes are sought in the uncoordinated stage. Partially automated segmental processes and the application of advanced technology to well established product concepts are found in the segmental stage, and fully integrated processes and incremental product innovation are realized in the systemic stage. Freeman (1982) also pointed out that both technical and market uncertainty are involved with product innovation, whereas only technical uncertainty is concerned with process innovation.

New Technology Impacts

Another dimension which can be added as an important thrust to the environment is the influence of new technology. Microelectronics, computers, communication technology, and biotechnology have influenced not only product concepts but also production processes. New Technology Impacts can affect both products and processes. The extent to which new technologies influence the existing products and processes and can contribute to creating new products or processes may well be regarded as the

primary determinant of technology strategy. If the extent of new technology influences is broad and strong, fundamental technological change will be performed by the current technological leader or carried in by new entrants. If the degree of new technology influence is narrow and weak, incremental technological change will be performed mainly by the current technology leader. Abernathy, Clark, and Kantrow (1983) dealt with the various phases of technology evolution. They paid close attention to the two clearly different aspects of the influences of technical changes such as impact on market linkages and impact on productive systems. In opposition to the technological determinism which said that in the earlier stage of the industry development product innovation is prevalent, while later on process innovation becomes prevalent, Abernathy, et al. (1983) found that there have been two kinds of change in the automobile industries which they called maturity and de-maturity. Here, de-maturity means the reverse of the maturation process caused by an abrupt market and technology change. By emphasizing the two kinds of changes, they tried to shed light on the role of new technology in reversing the industry development stage, exemplified by quartz technology in the wristwatch industry and microelectonics in the automobile industry.

KSF(Key Success Factors) for comptetion

Possible determinants of strategy have been discussed in previous paragraphs, and included two environmental factors. Other than these two aspects, the nature of the competition facing a company also seems to play a major role in shaping a company´s strategic behavior. We seek here to characterize the nature of the

competititive environment, labelling the most strategic factor for getting competitive advantage within an industry as the Key Success Factor(KSF).

Lawrence & Lorsch (1967) considered competitive issues in their three sample industries. They discovered that a major competitive issue in the food industry was innovation, while the main competitive issue in the more certain container industry was the ability to provide customer service through rapid and timely deliveries and to maintain consistent product quality. Finally, they found that the dominant competitive issue confronting the most uncertain plastic industry was the development of new and revised products and processes. Lawrence and Lorsch (1967) suggested that the difference in the major competitive issues among these three industries directly affected the way those companies organized their business.

INTRA-FIRM FORCES IN TECHNOLOGY STRATEGY DETERMINATION

Two environmental variables that are possible determinants of strategy have been discussed above. Key Success Factors have also been considered. But another important factor which influences technology strategy cannot be overlooked. Intra-firm forces can affect the content of technology strategy. These forces include a particular type of goal, and some types of capability. As opposed to the environmental determinism which asserts that technology affects the content and process of strategy, an approach which emphasizes the role of intra-firm forces on strategy determination

suggests that the coalition members' evaluation of their organization's position and the choice of goals or objectives for the organizations could lead to a particular type of strategy. (Child, 1972) Based on diverse goals or orientations, several types of strategy could evolve.

Technological leadership

Related to the choice in technology strategy, Maidique (1982) has proposed a typology of technology strategy, including the First-to-market strategy, Second-to-market, Late-to-market, and Market-segmentations. On the other hand, Porter (1983) has proposed a typology of technology strategy based on the concept of technology leadership and followership. Freeman (1979) recognized the following types of technology strategy; Offensive, Defensive, Imitative, and Dependent. These approaches usually seek their source of explanation for strategic variation in goal formulation processes and capability condition. Out of the above classification, the division between technology leadership and technology followership might be regarded as basic. In other words, the other types could be reduced to either one of these. This technological leadership seems to be accompanied by high techcnological capability.

RESEARCH QUESTIONS

Based on the above brief literature review, the following research questions will be addressed:

(1) What is the determinant of KSF for competition? Is it environmental uncertainty and/or new technology influences?

(2) If companies are grouped by different Key Success Factors, do the different KSF groups have different technology strategies?

(3) Do the different technological leadership groups have different technology strategies?

(4) What part of strategy is determined by the KSF and technological leadership?

Method

Sample

A questionnaire on management strategies and advancing technology, which consisted of questions on management environment, technology, organization, and strategy, was sent out to 500 Japanese manufacturing companies in April 1983. Out of 500 companies, 170 companies responded(return rate=34%).

Out of 170, 144 companies which replied that their KSF was either New Product Development, Quality, or Price were employed for the sample of the analysis. The major portion of the sample firms were taken from large scale companies. Actually the largest 411 companies were selected to be asked to respond to this questionnaire. In addition, a certain number of companies from the fastest growing companies, those with the largest advertisement

expenditures, and those holding the largest number of patents were added to the sample firms. But most of the responses were from larger companies. Therefore they are regarded as representing large scale Japanese companies. 2

Measures

Environmental variables.

Two environmental variables were used in this analysis. They were the Perceived Environmental Uncertainty and the New Technology Impacts. Both environmental variables are related to changes in a broader sense. The former deals with much broader aspects of change in the business environment. The latter is concerned with the changes caused by new technologies.

Environmental Uncertainty

A variable named Uncertainty was created to express the level of perceived environmental uncertainty facing the company. In the questionnanaire, the following question was posed:

"How much uncertainty is there in the following aspects of the environment?" Several aspects were mentioned. Two of these were the speed of change in production technology and the frequency with which competitors change product concepts and introduce new products. Respondents rated the speed of change in production technology and frequency with which a competitor´s change in product concepts, and introduce new products. The summation of these score was used as a measure of perceived environmental uncertainty.

New Technology Impacts

With regard to the new technology impact, the following question was posed. "How much influence have the following advancements in technology had on the excution of your business strategy in the past five years?" The listed technologies included microelectronics, computer and peripheral technology, communication, robotics, resources and energy technology, new material technology, biotechnology, technological trends in foreign countries, technological trends in domestic areas, and so on. Respondents were asked to rate the influence of these technologies on their company's business using a five point scale (from 1=very strong influences to 5=almost no influence.)3 A variable named New Technology Impacts was also created to express new technology impacts as a summation of the evaluations of influences of new technologies.

Key Success Factors for competition (KSFs)

In this analysis, New Product Development, Quality of products, and Price were selected as the three major KSFs to be considered. These three groups seem to correspond to particular stages of industry competition. If an industry is at the embryonic stage, the most significant factor appears to be new product development. After the product concepts are established, achieving quality becomes the strategic factor. In the mature stage of an industry, Price is the key factor.

In the questionnaire, the question about the KSF was posed in the following manner:

"In your estimation, what is the most important factor involved in holding a competitive advantage in your industry?" The respondents were asked to choose one of six options: Quality, Price, Advertisement, New Products Development, Distribution channel, and Information Processing System. By asking the question in this way, it was hoped to generate replies that related to the respondent's perception of the industry as a whole and not merely the goals and objectives of his own firm.4 The extent to which the KSF reflects the nature of environment is a question that should also be addressed. The perception of a particular KSF, whatever the reason it may have, is assumed to lead to a particular type of technology strategy.

Technological leadership variables

Each company was asked about its technological capability, using questions such as "How do you evaluate the following aspects of your company's technological capability?" The various aspects included companies' technological excellence compared to that of competitors, technological development capability, and so on. A question concerning management resources was also asked. Aspects that were evaluated included product quality, levels of technological excellence, technology development capability, etc.

The above aspects are divided into two groups; one is related to technological development capability, and the other is concerned with technology excellence. The former group consists of two types of evaluations of technological development capability, and the summation of these variables was calculated and called Technological Development. The latter group concerned the evaluation of product

quality and technology excellence, and the summation of the evaluation scores of these variables was calculated and called Technology Excellence. Through these two calculations both variables were adjusted so that their mean score was zero. If the value of these variables is positive, a company is regarded as having a low level of those aspects. It was decided that companies which have high technological development capability would be categorized as technological leaders. Similarly, companies with low technological development capability are considered here to be technological followers.

Technology Strategy Variables

The dependent variables in this study were technology strategy variables. These variables were divided into three groups. The first one was called the technology enhancement pattern. The conceivable method included the creation of technology, the introduction of patents, imitation, the combination of several technologies, the development of components technology, and making parts in-house, etc.

The second variable dealt with the focus of the R & D; that is, the variable related to the emphasis which the companies place on different R & D efforts. This area includes basic research, model change, process change, and improvement of existing products.

The third group is concerned with manufacturing policy. This group was regarded as an indispensable consideration for examining Japanese companies' technology strategy. It includes cost reduction, comfortable workplace, efficient processes, labor saving manufacturing, automation, innovation of processes, product quality.

The relationships among these three groups are depicted in Figure-1. R & D focus variables clarify the direction of R & D, or emphasis of R & D expenditures. The technology enhancement pattern is concerned with the method used in creating technological capability. The manufacturing policy enables a firm to produce products which reflect a company's technological capability.

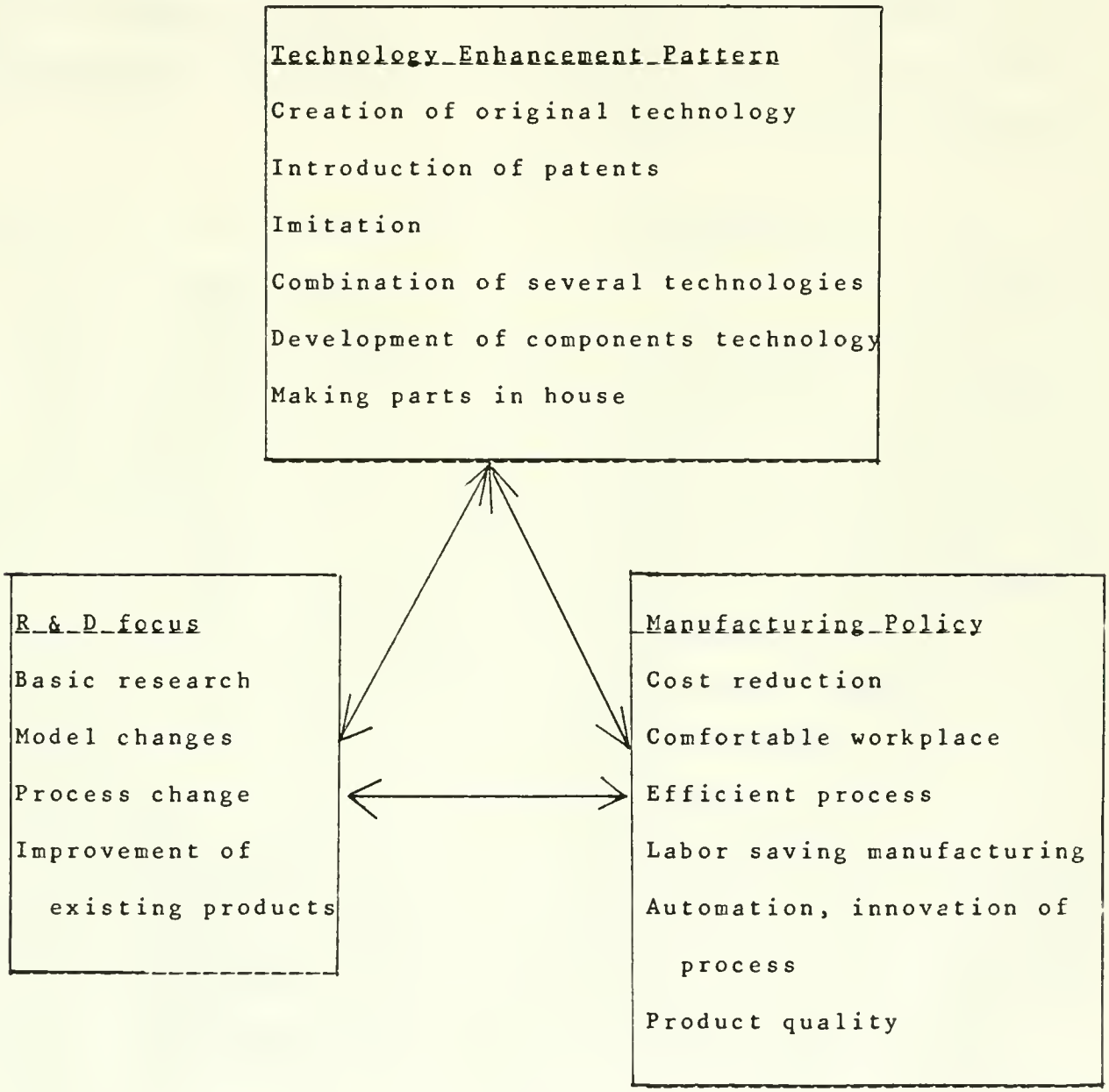

Figure 1 System of Technology Strategy

Framework

As stated above, the variables used in the analysis in this paper include environmental variables, KSF for competition, technological leadership variables, and technology strategy variables.

First, it is assumed that the KSF for competition is determined by environmental uncertainty and new technology influences. On the other hand technological leadership is assumed to be influenced by the technological capability.

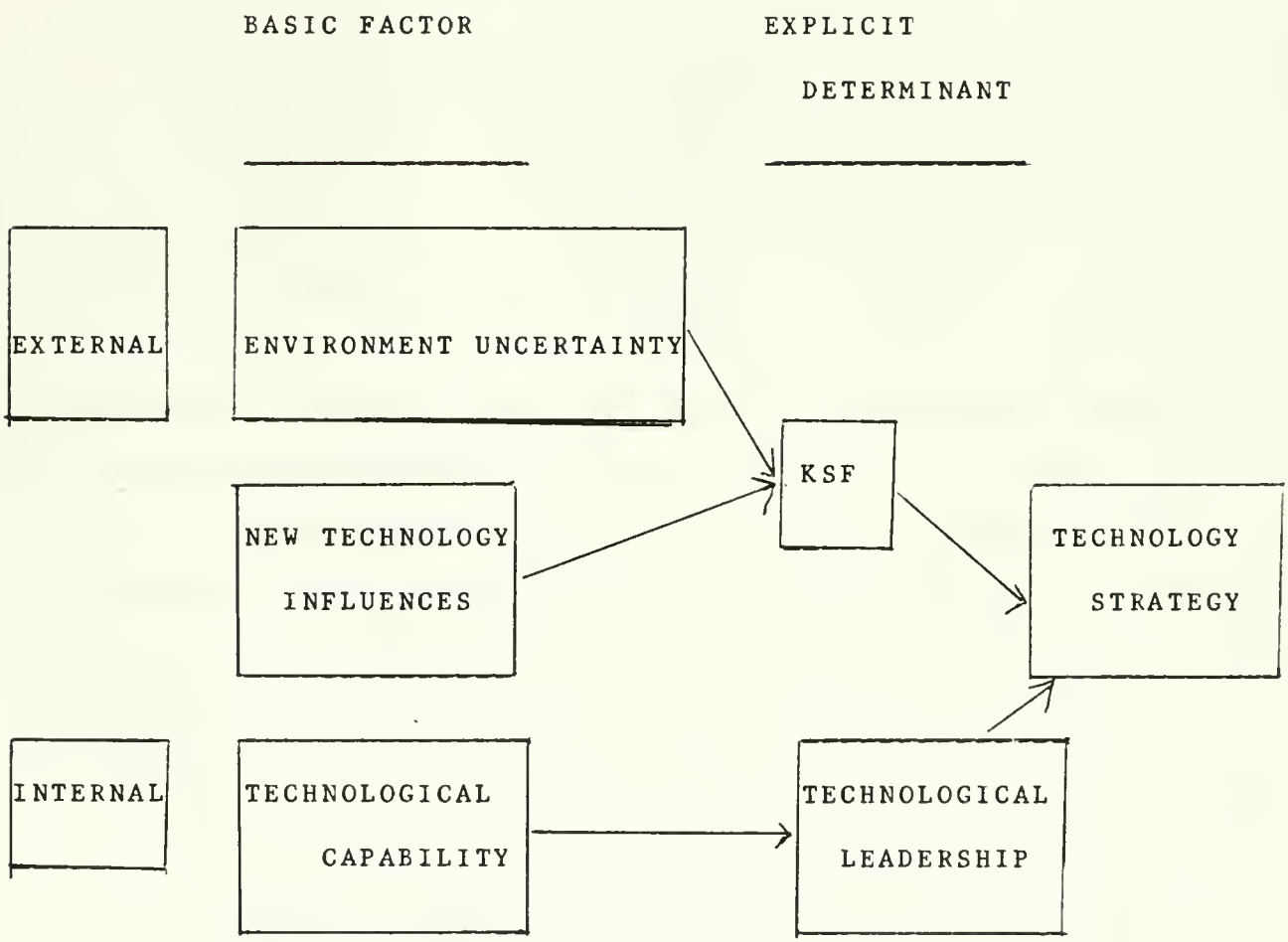

Figure 2 Framework of this study

It is assumed that technology strategy variables are explicitly formulated based on the KSFs and technological leadership. Various kinds of technology differences will be found among the KSF groups, the technological leadership groups, and interaction of these groups. Some aspects of technology strategy may be mainly determined by the KSF differences, while others might by influenced by the fact that the companies are technology leaders or technology followers. What part of technology strategy falls into these classes will be addressed later.

RESULTS

Determinant of Key Success Factors for competition

A discriminant analysis was performed to find a way to divide the three KSF groups. Table 1 contains the results of the discriminant function analysis, in which two functions were found. The first one is statistically significant and can be viewed as representing the level of uncertainty. The second one is not statistically significant, but can be seen as the level of influence of new technology. A territorial map (Figure 3) shows that a group whose KSF is new product development is likely to face not only new technology but also severe uncertainty. Under those circumstances the speed of technological changes is quite high, and production technology and competitor's behavior also vary often. Therefore the present product and processes can easily become obsolete, or at least less competitive. Accordingly, this type of environment makes the KSF for this type of competition New Product Development. A territorial map also shows that the group whose KSF is Quality faces strong new technology influences, but that the influence of new

technology does not necessarily lead to environmental uncertainty. For these companies, new technology is not a threat to their business, but a promising opportunity to maintain competitiveness. Therefore, it appears that in this kind of environment, the KSF is Quality, instead of New Product Development.

Table 1 The results of Discriminant analysis

	Function 1	Function 2
Uncertainty	.912	-.597
New Technology Impacts	.185	1.074
signi-ficance	.0005	.2848
KSF	Group means (centroids)	
new product	-.492	-.062
quality	.079	-.095
price	.530	-.110

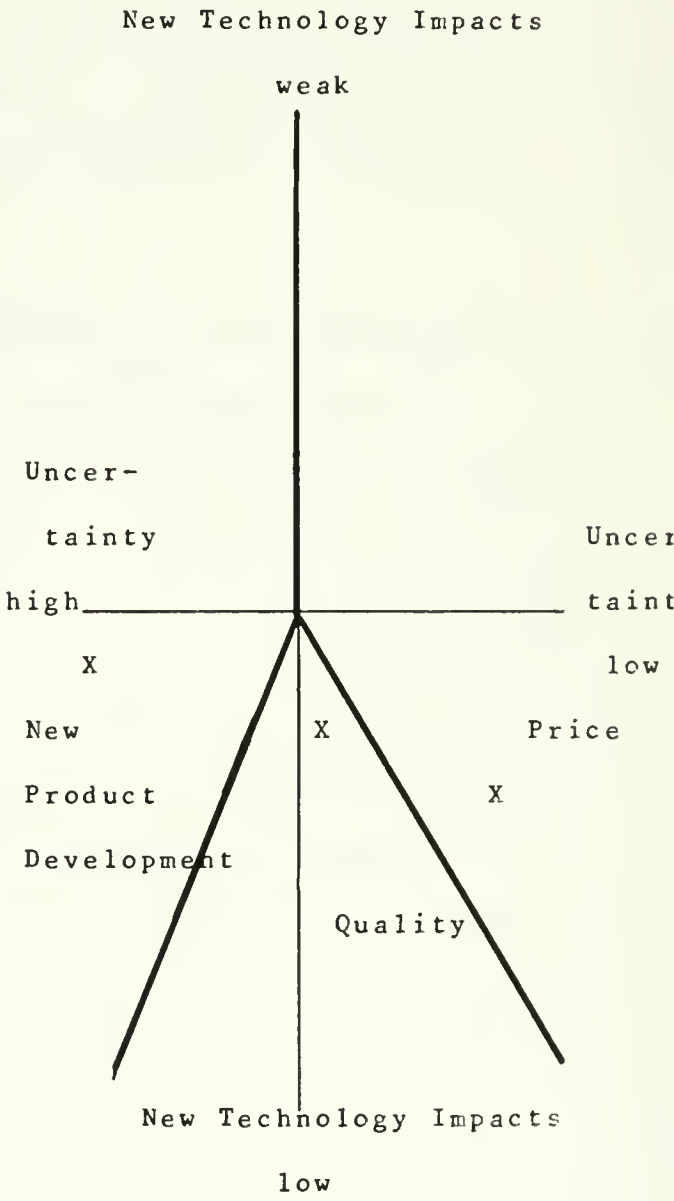

Figure 3 Territorial map

On the other hand, a group whose KSF is Price faces a more certain environment and is less influenced by new technology. These industries tend to be mature, and their environment from the perspective of market and technology is stable. This kind of environment appears to make the KSF for this type Price.

This set of criteria correctly predicts the KSF for approaximately 42.7% of the class. Table 2 shows the results of classification analysis. The row degignates the actual groups, and the column represents the predicted groups.

Table 2 The results of classification analysis

Predicted group / Actual group	N	1	2	3
1 New product	45	30	5	10
		(66.7%)	(11.1%)	(22.2%)
2 Quality	66	30	13	23
		(45.5%)	(17.7%)	(34.8%)
3 Price	32	10	4	18
		(31.3%)	(12.5%)	(56.2%)

Code for the groups : 1=New product development,
2=Quality, 3=Price

Differences in Technology Strategy among KSF groups and Technological Leadership Groups

An effort was made to clarify the effects on technology strategy for three KSF groups; New Product Development, Quality, and Price, and for the technological leadership groups. In order to do this, a series of two-way analyses of variance were conducted with the existing data. Table 3 reports the means, the standard deviation, and F statistics for these variables, and the two-way interaction effect. The analysis indicates that three types of technology sub-strategies exist.

First, several technology strategy variables appear to differ depending on the KSF. Those variables include the creation of original technology, the introduction of patents, R & D efforts toward model changes, and low cost manufacturing. If the KSF is New Product Development, the company generally seriously evaluates original technology and/or model changes. If the KSF is price the company generally evaluates introduction of patents and low cost manufacturing seriously. Those variables' importance might be different among various industries.

Secondly, several technology strategy variables seemed to reflect technological leadership. Those variables include the creation of original technology, the combination of technology, the development of components, R & D effort in basic research, the improvement of processes, the quality of products, the comfortable work environment, and automation of processes, etc. All of these variables are evaluated highly by technological leaders. Conversely, the following aspects are not paid particular attention by the technological leaders: introduction of patents, imitation,

etc. Since the different emphasis in these aspects have been found among technological leadership variables, these sub-strategies may well be regarded as related to competitiveness within an industry.

Third, several variables do not differ among KSF groups or technological leadership variables. Those variables included making parts in-house, the improvement of existing products, and labor saving manufacturing. One can conjecture that these characteristics are common to all Japanese companies.

DISCUSSION AND CONCLUSIONS

From these results, it appears clear that environmental uncertainty is the main factor in dividing Key Success Factor for competition. It is also obvious that the influence of new technology plays some role in differentiating the KSF for competition. That is, if market uncertainty and new technology influences are both intense, the KSF is likely to be New Product Development. If new technology influences are strong, but market uncertainly is not so high, the KSF is likely to be Quality. uncertainty and new technology influences are both fairly low, the KSF is likely to be Price. On the other hand, the KSF will clearly affect the content of technology strategy. These findings support the notion that the environmental factors more or less affect the content of technology strategy by specifying the focus of the competition.

Table 3 Differences in Technology Strategy among KSF groups and Technological Leadership group

	New Product	Quality	Price	F	Techno-logical leader	Techno-logical follower	F	Two-way interac-tion F
Original Technology	-.32	-.01	.36	4.34	-.44	.37	28.12	0.40
Introduction of Patents	.36	-.19	-.02	4.56	-.01	.04	0.20	2.97
Imitations	.13	-.13	.09	1.06	.04	-.03	0.19	0.08
Combination of Technology	-.09	.01	.07	0.04	-.42	.37	27.11	0.24
Development of Components	.01	-.03	.01	0.15	-.40	.35	24.23	0.29
Make Parts in House	-.16	-.10	.23	1.64	-.16	.07	1.68	0.76
Basic Research	-.05	-.07	.11	0.23	-.42	.34	26.00	0.58
Improve Existing Products	.15	-.11	.04	0.90	.06	-.04	0.34	0.14
Model Change	-.27	.04	.24	5.98	.00	-.01	0.13	0.43
Improvement of Process	.11	-.06	-.09	0.91	-.26	.20	9.35	2.12
Quality of Products	.00	-.15	.19	1.33	-.19	.13	3.95	1.33
Low Costs	-.01	.26	-.50	7.88	-.07	.05	1.24	1.72
Compfortable Workshop	-.02	-.05	.13	0.26	-.30	.29	13.66	0.08
Efficient Production	.00	.01	-.13	0.31	-.07	.01	0.39	4.19
Labor Savings	-.01	.12	-.28	2.12	-.07	.04	0.71	1.44
Automation of Process	-.19	.03	.07	0.81	-.18	.11	2.99	1.79

* $p<0.1$ ** $p<0.05$ ***$p<0.01$

** The smaller the number in the table, the more emphasis is put on each aspect.

But the KSF, or the environment as a background factor, is not the only determinant of technology strategy. One must also look at the attitude toward and/or momentum of technology strategy. In other words, one must consider whether or not the company seeks technological leadership.

While the sub-strategy is different according to the KSF, this suggests that those strategies are associated with environmental characteristics. Considering the clarified relationship between the KSF and environmental variables, one can say that these strategies, such as the creation of original technology, R & D efforts toward model changes, the introduction of patents, and low cost manufacturing, etc, strongly reflect the nature of the environment. The order in which they have been listed reflects the level of environmental uncertainty facing the company. A company must formulate its strategy based on both market uncertainty and new technology influence, in other words, on both a relatively short term and a considerably longer term basis. After identifying the KSF for competition, a relevant level of strategy orientation might be worked out in this manner.

But a different side of sub-strategies exist. In considering these strategies, one should take into account management resources such as technology development capability, etc. This aspects causes the variations in the creation of original technology, the combination of several technologies, the development of components, R & D effort in basic research, the improvement of process, the

quality of product, the comfortable work environment, and the automation of processes. All of these strategies are expected to be developed by the technology leader more aggressively than by any other company.

In addition, some strategies should take into account not only environmental factors but also the management resources factor. This consists of the introduction of patents and an efficient production system. Finally, a great many companies made similar comments about certain aspects of technology strategy. These similar response areas included making parts in-house, improvement of existing products, labor saving manufacturing methods, etc. These aspects appear to relate to the characteristics to all Japanese companies.

Notes

1. This questionnaire was sent to the highest ranking people in charge of corporate planning and policy, directors who were in charge of corporate planning and policy. The actual respondents were classified according to the following job titles: Executive director 22, General manager 26, Deputy director 8, Section chief 24, others 33, and rank and file 41, The first group can be regarded as members of top management, about 13 % of this sample were filled out by this group. The next four levels are regarded as middle managers. About 53 % of the responses were from this group.

2. In the selection of the companies to which I sent my questionnaire, I used both the Diamond Corporate Ranking and the Nikkei NEEDS financial data. The sample firms basically consisted of larger firms. Besides the above, the 170 companies which had the fastest growth rate, firms with the largest advertisement expenditure, top 200, firms holding the largest number of patent rights, top 100, were also used as a part of the sample.

Many of the companies belong to more than one group. The composition of the sending list and respondents is given in Table 4. A comparison between the sample and respondents are made in relation to several aspects. The results are shown in Table 5.

Table 4 The Composition of Sample and Respondents

	The largest sales volume	The fastest growing companies	Companies holding the largest number of patents	Companies with the largest advertising expenditures	total number of companies
Sample	411	118	85	132	500
	(82.2%)	(23.6%)	(17.1%)	(26.4%)	(100.0%)
Res-	156	28	36	50	170
pondents	(91.8%)	(16.5%)	(21.2%)	(29.4%)	(100.0%)

Table 5 Comparison between the sample and respondents

	Sample Mean (S. D.)	Respondents Mean (S. D.)
Assets	1836.8 (163.1)	2161.1 (257.4)
Capital	111.2 (10.6)	128.0 (15.9)
Sales	2123.7 (183.3)	2371.1 (263.7)
Employees*	4710 (379)	5795 (672)
	n=500	n=170

lunit=100 million yen(4/10, million dollar)

* In this case, the number designates number of people.

3. In the question about the impacts of new technology, respondents were asked to rate the impacts of new technologies. The score goes from 1=very strong to 5=very weak. The mean for the rating about each technology is shown in table 6.

Table 6 New Technology Impacts on Business Strategy

New Technology Impacts	Mean	S.D.	N
Microelectronics	2.60	1.29	162
Computer and peripheral technology	2.40	1.05	167
Communications	3.29	1.26	160
Robotics	2.47	1.14	164
Resources and energy technology	2.86	1.20	165
New material	2.95	1.15	160
Biotechnology	4.19	1.13	160
Technological trend in foreign countries	3.50	1.15	159
Technological trend in domestic area	2.89	1.01	158

* The number in the column of Mean signified the strength of new Technology Impacts. The score goes from 1=very strong to 5=very weak.

From the above results, three tendencies are found. First, on the average, companies are aware of a condiderably stronger influence of microelectronics, computer and peripheral, robotics on their implementation of business strategy.

Second, companies do not think that the influence of biotechnology is as strong.

Third, technological trend in domestic areas are perceived to be stronger than technological trends in foreign countries. This does not necessarily negate the importance of the latter. Even if the influences of technological trends in foreign countries are fundamentally strong, they could influence the technological trends domestically first, and those technology trends in the domestic area might be perceived stronger by the companies.

4. A check to see how these three KSF groups are distributed among several industries was done. The results are shown in Table 7.

According to the results, one can say that the Pharmaceutical, Electric machinery, and Precision machinery industries are characterized by new product development. The Food, Paper & Pulp, Rubber, Steel industries belong to the Quality group.
The Peteroleum , Automobile, and so on belong to Price group.

Table 7 Key Success Factors by Industry

KSF / INDUSTRY	NEW PRODUCT DEVELOP-MENT	QUALITY	PRICE
FOOD	5	8	3
TEXTILE	4	1	0
PAPER,PULP	0	3	2
CHEMICALS	3	9	8
PHARMACEUTICAL	4	0	0
PETROLEUM	0	0	2
RUBBER	0	5	1
GLASS,CEMENT	2	5	0
STEEL	0	10	3
NONFERROUS METAL	3	4	2
MACHINERY	4	8	6
ELECTRIC MACHINERY	14	9	2
SHIP BUILDING	0	2	3
AUTOMOBILES	2	4	4
OTHER TRANSPORTATION	3	0	1
PRECISION MACHINERY	3	2	2
OTHER MANUFACTURING	0	3	0

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