A COMPARATIVE STUDY OF JAPANESE, AMERICAN, AND EUROPEAN HIGH TECHNOLOGY CORPORATIONS IN JAPAN

– Based on Multidimensional Scaling Method –

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I. Introduction

Conventional wisdom states that "Big business doesn't innovate". However, in contrast to this, there are plenty of exceptions . . . large companies that have done well as entrepreneurs and innovators. This paper aims to research the interrelationships among the major components of the organizational milieu as well as between the organization and its environment.

The American and European companies which have penetrated into the Japanese high technology market and the Japanese companies which have operated in the same competitive market will be examined. The companies to be studied here were of different sizes, and their technologies were all at different stages of maturity. Despite these differences, they must have been adopting some similar managerial approaches. Because they must be all confronted with the important subjects: how to unleash the creativity that promotes growth and change; and how to control innovation without stifling it.

This research takes the integrative contingency theory as the theoretical background [1] and couples it with the application of real data by adopting the multidimensional scaling method.

Thus, the underlying objective of the present research is to determine the relationship between variables which are based on the integrative contingency theory. The specific phenomenon to be investigated is

the innovation-adoption structure in the organizations centered on the Japanese, American and European high technology corporations in Japan. The task in specifying the objectives of this research is to: (1) identify the dimensions (elements) of the phenomenon to be investigated, (2) specify the variables associated with each of these dimensions, and investigate those variables found, and (3) map the relationships that exist between variables. Findings are presented for accomplishing the final task . . . the mapping of significant relationships between variables.

II. Multidimensional Scaling Method (MDS)

(1) *The Purpose of Multidimensional Scaling*

Multidimensional Scaling (or MDS) is a set of mathematical techniques that enable a researcher to uncover the "hidden structure" of data bases. The purpose of this technique is the double one; (a) of somehow getting hold of whatever pattern or structure may otherwise lie hidden in a matrix of empirical data, and (b) of representing that structure in a form that is much more accessible to the human eye . . . namely, as a geometrical model or picture. The objects under study are represented by points in the spatial model.

Multidimensional scaling, then, refers to a class of techniques. These techniques use *proximities* among any kind of objects as input. A proximity is a number which indicates how similar or how different two objects are, or are perceived to be, or any measure of this kind. The chief output is a spatial representation, consisting of a geometric configuration corresponding to one of the objects. This configuration reflects the "hidden structure" in the data, and often makes the data much easier to comprehend.[2]

(2) *Conceptual Basis*

The basic premise underlying these methods is that similarity judgements are useful indices of perceptual structure, and from perceptual strucure one can understand relevant dimensionality of choice criteria. MDS provides spatial representations in minimum dimensional space so that interstimulus distances in the space are monotonically related to the similarity judgements. Unlike metric methods, in which the linearity

assumption is made between similarities and distances in an underlying multidimensional space, nonmetric methods allow one to make the much less restricted assumption that similarities or proximities in general, measure only the ordinal relations in the data. The objective of nonmetric MDS is to metricize nonmetric data, transforming the data into a metric space, thereby reducing dimensionality.

The conceptual basis of nonmetric MDS that was originally formulated by Shepard and Kruskal in the elementary form is very simple. For illustrative purposes, the Kruskal and Carmone's M-D-SCAL (SM) program is described here by virtue of its clear conceptual foundation.[3]

For expository purposes assume that we have a set of ranked pairs of δ_{ij} $(i = 1, 2, \ldots n-1; j = 2, 3, \ldots n)$. Our objective is to find a configuration $x = \{x_1, x_2, \ldots x_n\}$ consisting of n vectors in a space of r dimensions. The coordinates of a given vector x_i can be specified as: $x_i = (x_{i1}, x_{i2}, \ldots x_{ir})$ where r = number of dimensions. For each x_i, x_j in x we can compute a distance d_{ij}. For Minkowski p-metric distance, use the formula

$$d_{ij} = \left[\sum_{t=1}^{r} \mid x_{it} - x_{jt} \mid^{p} \right]^{1/p} \qquad (p = 1)$$

where t = number of dimensions $(t = 1, 2, \ldots r)$.
In the case of ordinary Euclidean distances, $p = 2$ and

$$d_{ij} = \sqrt{\sum_{t=1}^{r} (x_{it} - x_{jt})^2}$$

If x is a good configuration in that the ranks of its distances d_{ij} approximately reproduce the input ranks δ_{ij}, then the configuration should be final or close thereto for representing the δ_{ij} in a specified dimensionality. The appropriate numbers which are perfectly monotone with the δ_{ij} can be denoted as $\hat{d}_{ij}$. The M-D-SCAL algorithm considers relationships among the three sets:

1. The δ_{ij} the input data ranks
2. The d_{ij} computed distances between all pairs of points in the configuration x

3. The $\hat{d}_{ij}$ a set of ratio-scaled numbers, chosen to be as close to their respective d_{ij} as possible, subject to being monotone with the δ_{ij}.

The resulting interpoint distances d_{ij} are monotonically related to the given input data ranks δ_{ij} in the sense that

$$d_{ij} \leq d_{kl} \text{ whenever } \delta_{ij} \leq \delta_{kl} \text{ (dissimilarities) or}$$
$$\delta_{ij} \geq \delta_{kl} \text{ (similarities)}$$
$$\hat{d}_{ij} \leq \hat{d}_{kl} \text{ whenever } \delta_{ij} \leq \delta_{kl} \text{ (dissimilarities) or}$$
$$\delta_{ij} \geq \delta_{kl} \text{ (similarities)}$$

For nonmetric scaling, monotone ascending regressing should be used for dissimilarities, and monotone descending regression for similarities. Based on these relationships, Kruskal (1964) gave an index of goodness of fit as follows; [4]

$$\text{Stress formula 1} = \sqrt{\frac{(d_{ij} - \hat{d}_{ij})^2}{d_{ij}^2}}$$

The measure of stress serves two functions. First, it is a measure of how well the derived configuration matches the input data. Second, it is used in deciding how points should be moved on the next iteration. In more recent versions, the stress formula has been modified and uses a variance-like expression involving d in the denominator as follows: [5]

$$\text{Stress formula 2} = \sqrt{\frac{(d_{ij} - \hat{d}_{ij})^2}{(d_{ij} - \bar{d}_{ij})^2}}$$

where d = the mean of all the d_{ij} s

The choice of the one used is under the control of the researcher. Occasionally iterations may increase stress rather than decrease it. Interpretations of the stress for the final configuration depends on whether the research chooses to use stress formula 1 or 2. Formula 2 yields substantially large values of stress for the same degree of goodness of fit, simply because of the denominator is smaller. Kruskal and Carmone (1969) compared stress formula 1 and 2. They emphasized that the

interpretation of stress values could be affected by parameters such as the number of stimuli (N) and the number of dimensions, and gave the following table of verbal evaluation for the usual range of values of N (from 10 to 30) and the usual range of dimensionality (from 2 to 5):

Table 1 Vertical Evaluations of the Goodness-of-fit[6] in Stress Formula 1 and 2

Goodness-of-fit	Formula 1	Formula 2
Poor	20%	40%
Fair	10%	20%
Good	5%	10%
Excellent	2.5%	5%
Perfect	0%	0%

ALSCAL, developed by Young, Lewyckyj of University of North Carolina and Yoshio Takane from McGill University, is one of the most comprehensive packaged programs of MDS. ALSCAL is employed as the present analysis.

ALSCAL is able to do not only multidimensional scaling based on proximity data, but also multidimensional unfolding based on preference data.[7] The latter feature of ALSCAL was adopted in the present study to characterize organizational structures in the Japanese high technology industry.

III. Major Findings

This section is to discuss the findings of this research based on the interviews in the eighteen respondent companies operating in Japan.[8] The Japanese, American and European firms are compared in terms of (1) environment, (2) interorganizational relationships, (3) business strategy, (4) business goal, (5) organizational structure, (6) characteristics

of senior executives, (7) business results (the extent of goals achieved), and (8) research and development. These eight dimensions stemming from the hypotheses are examined one by one based on the results of data gathered from the interviews. As was explained in section II, a multidimensional scaling method of measurement was used to determine the general tendency. It seems appropriate to state a few limitations of subsequent data analysis at this point before preceeding to interpretation of the results of this study.

First, we have named dimensions subjectively due to the failure of the factor analysis for the dimension interpretations. Green and Carmore (1970) pointed out, the typical approach should be more or less ad hoc judgements of the researcher, as formed by examining the configuration itself.[9] This extra-statistical approach was taken in the present study.

Second, the selection of control parameters, for example, number of iterations, goodness-of-fit cutoff values, has been somewhat arbitrary for each analysis of the eight topics examined. However, parameter values were set at the maximum for some control parameters and at the minimum for others in order to get better results.

Third, most of the discussions have been limited to only two dimensional solutions. The data in this study was presented in three and two dimensional solutions successively and showed minor differences in goodness-of-fit measures between them. Since one of the advantages of MDS is the potential to reduce data to a visual configuration, the smallest dimension that can be represented easily — two — to maximize the information that could be obtained through visual inspection.

As shown in the following eight figures[10], each of them is the stimulus-company space and also the stimulus-items space plotted together in the same space by the ALSCAL program. The stimulus coordinates and interpoint distances were defined as preferred each factor for the respective companies. It was possible to plot selected cluster contours in order to visually represent the groupings when making decisions that may determine the overall performance of the companies. So, some of the clusters in the following figures could be named. Moreover, the contour plots quite regularly in two space, suggesting that the two dimensions

summarize much of the information in the input data. It should be understood that the name attached to the dimensions are only descriptive. The primary intention in naming them is to display differences in their tentative perceptions.

As was indicated in this research, the most noticeable point is that the characteristics of firms in each country were not generated by a common latent adaptation mode consistent with and largely derived from the country's culture. It should rather be asserted that the different characteristics of organizations are generated by the predispositon of the members of the company or the different goals and different policies of the companies themselves. In the course of this research, some of the companies create various small groups to make the organization more innovative in a holistic way. It is stressed that the role of several informal groups or small teams as well as the "market gatekeepers" [00] are the critical elements for the innovative organizations which seem to be the most adaptable to the drastically changing envrionment. Without them, many research and development projects and laboratories become misdirected with respect to market trends and needs.

Notes

(1) This paper takes the position that a business organization is considered as a unified whole. Its objectives, strategy, technology, organizational predispositions of its members are interrelated and interdependent. If the organization is to cope effectively with its environment, it must develop an integral configuration among its components. The theoretical perspective is an extension of the theory of organizations developed by contingency theorists. This holistic view of the organization and its validity is based on the joint research of Kagono, Nonaka, Sakakibara and Okumura (1976) and they say that it may be termed "integrative contingency theory" (1983).

(2) Joseph B. Kruskal et al., *Multidimensional Scaling*, (Sage publications, 1978), p. 7.

(3) Clyde H. Coombs, *A theory of Psychological Scaling,* (Engineering Research Institute, University of Michigan, 1951).
(4) Clyde H. Coombs, *Theory of Data,* (John Wiley and Sons, Inc., 1964).
(5) Marshall E. Dimock, *Administrative Vitality,* (Harper and Brothers, 1959).
(6) Robert B. Duncan, "Characteristics of Organizational Environments and Perceived Environmental Uncertainty", *Administrative Science Quarterly,* Sept., 1972, 17., pp. 313-327.
(7) Forrest W. Young et al., *The ALSCAL Procedure,* (SAS Institute Inc., 1983), p. 2.
(8) All eighteen companies are currently operating in Japan. These are listed in Fortune's top 1000 industrial firms in the United States and included in 1031 stock listed companies on the Tokyo Stock Exchange. The firms to be examined are as follows: ANALOG DEVICES (U.S.), BURROUGHS (U.S.), DATA GENERAL (U.S.), DIGITAL EQUIPMENT CO. (U.S.), IBM (U.S.), INTEL (U.S.), TEXAS INSTRUMENTS (U.S.), YAMATAKE-HONEYWELL (U.S.), NIXDORF (W. GERMANY), SIEMENS (W. GERMANY), THOMSON (FRANCE), PHILIPS (HOLLAND), FUJITSU (JAPAN), MITSUBISHI (JAPAN), NEC (JAPAN), OKI (JAPAN), SHARP (JAPAN).
(9) Renato Tagiuri, "Social preference and its perceptions", in Tagiuri, Rand Petrullo (eds.), *Person Perception and Interpersonal Behavior,* Stanford, Calif., Stanford University Press, 1958.
(10) Each interpretation and analysis is shown and indicated in the following eight figures.
(11) Edward B. Rogerts and Alan R. Fusfeld, "Staffing the Innovative Technology-Based Organization", *Sloan Management Review,* Spring 1981. * "Market Gatekeepers", who are engineers, scientists, or possibly marketing people who focus on market-related information sources and communicate effectively to their technical colleagues and are sensitive to competitive information.

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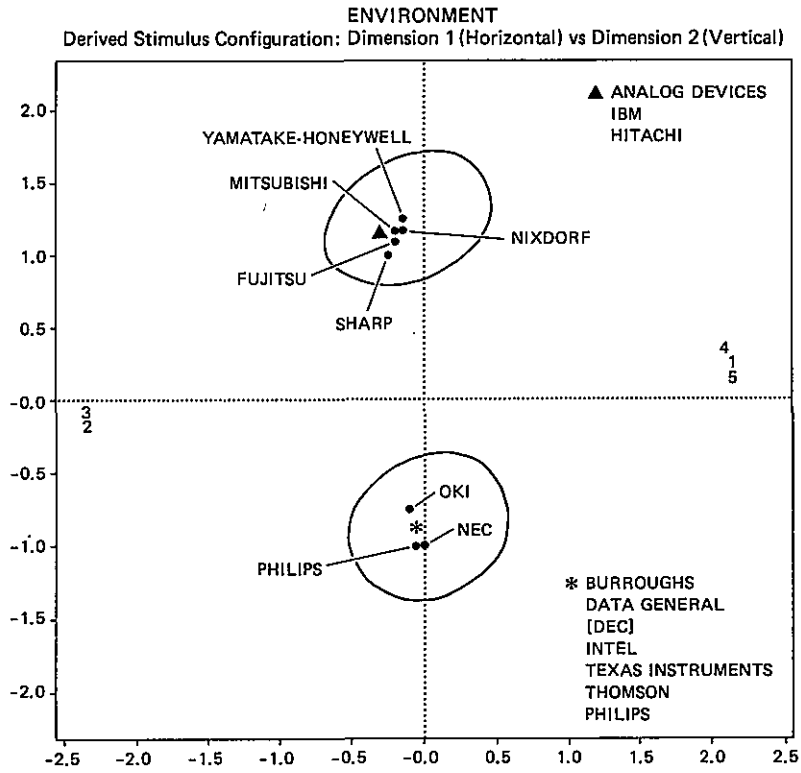
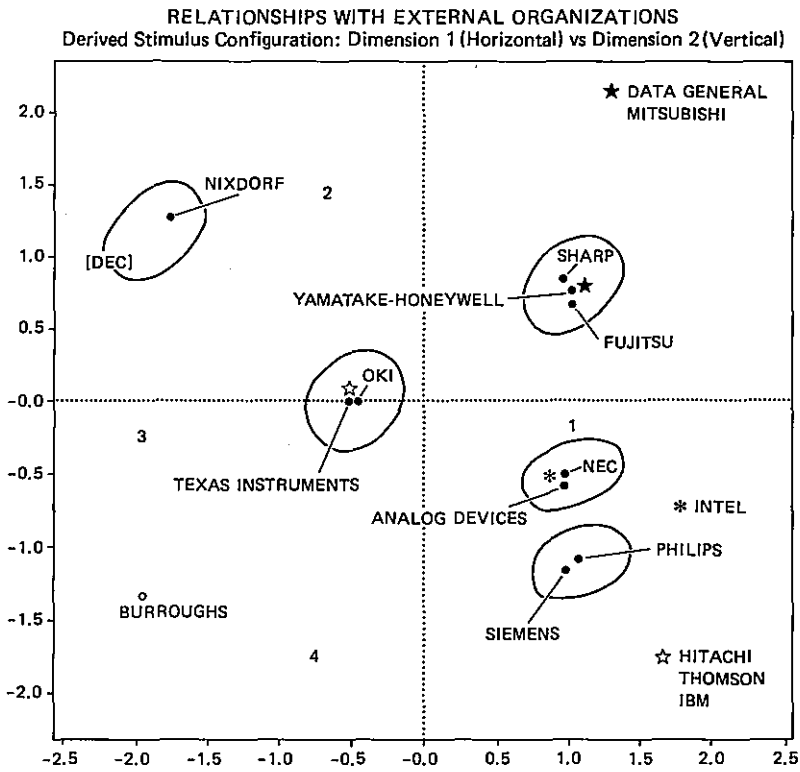


* Five items are ranked in order of importance.

1. Geographical diversity
2. Product diversity
3. Strategic diversity
4. Rate of environmental change in technology
5. Diversity of promotional media

Stress and squared correlation (RSQ) in distances
By the Kruskal's stress formula 2; stress = 0.029 RSQ = 0.999

Figure 1. Environment

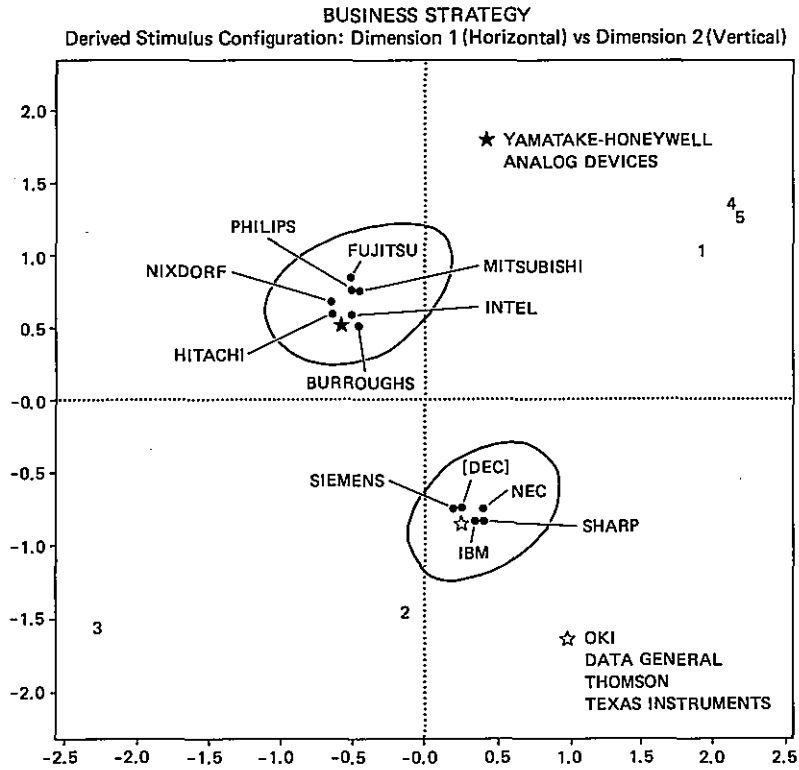


* Four items are ranked in order of importance.

1. Existing relationships with major distributors & customers
2. Existing relationships with major suppliers & subcontractors
3. Existing relationships with banks and major stockholders
4. Existing relationships with government

Stress and squared correlation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.055 RSQ = 0.997

Figure 2. Relationships with the External Organizations

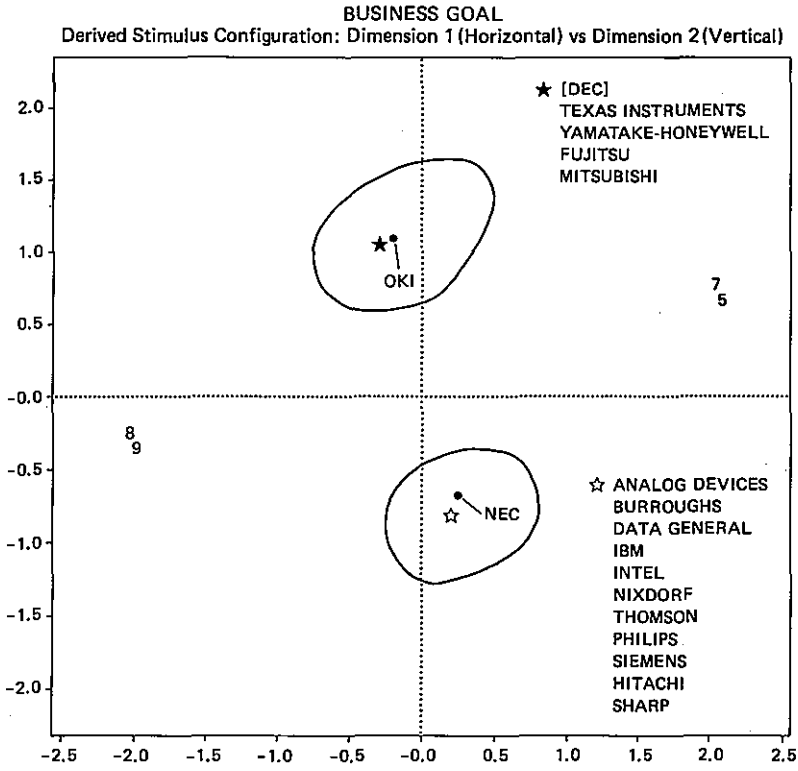


* Five items are ranked in order of importance.

1. Product strategy (product planning, market research for new product, R & D)
2. Promotional strategy (sales management and personal selling, advertising and other marketing communication strategies)
3. Distribution strategy (choice of distribution channel, distribution and inventory program, etc.)
4. Pricing strategy (price policy, pricing decision, etc.)
5. Production strategy (economy of scale, cost reduction, flexibility of production system, etc.)

Stress and squared correlation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.044 RSQ = 0.998

Figure 3. Business Strategy

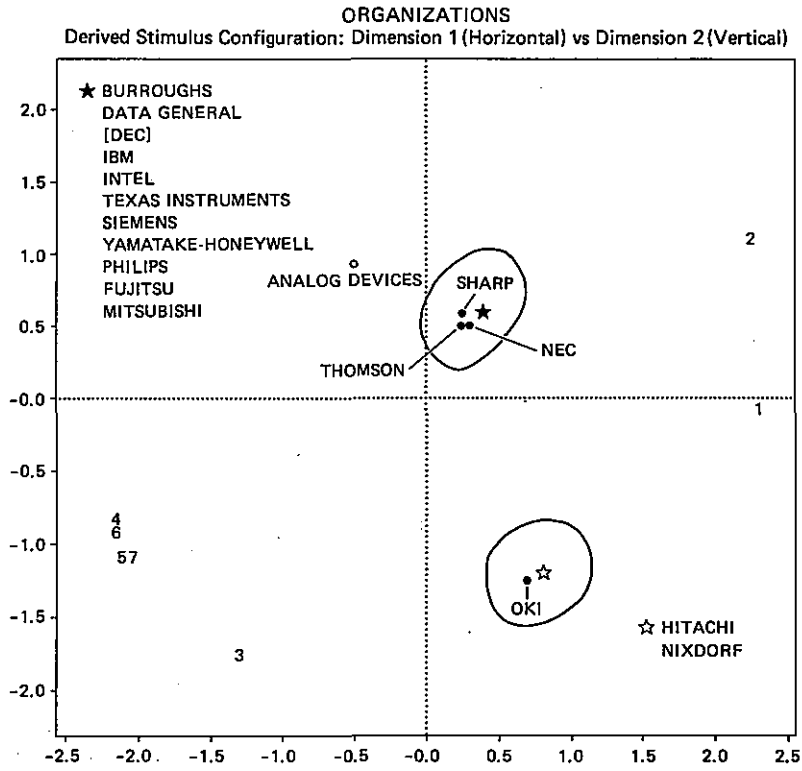


* Nine items are ranked in order of importance.

1. Return on investment
2. Increase in market share
3. New product ratio
4. Capital gain for stockholders
5. Efficiency of production and physical distribution
6. Equity / debt ratio
7. Improvement of product portfolio
8. Improvement in quality of working conditions
9. Improvement in public image of the company

Stress and squared correlation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.012 RSQ = 1.000

Figure 4. Business Goal

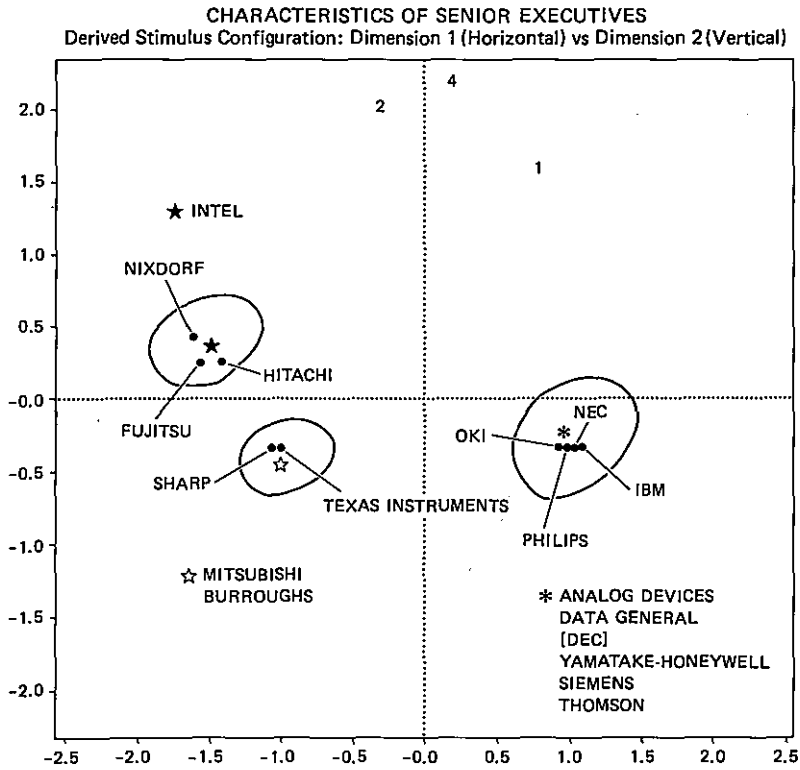


* Seven items are ranked in order of importance.

1. Sales and marketing
2. R & D
3. Production
4. Control and finance
5. Personnel, labor relations
6. Corporate planning staff
7. Purchasing, procurement

Stress and squared correlation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.065 RSQ = 0.996

Figure 5. Organization

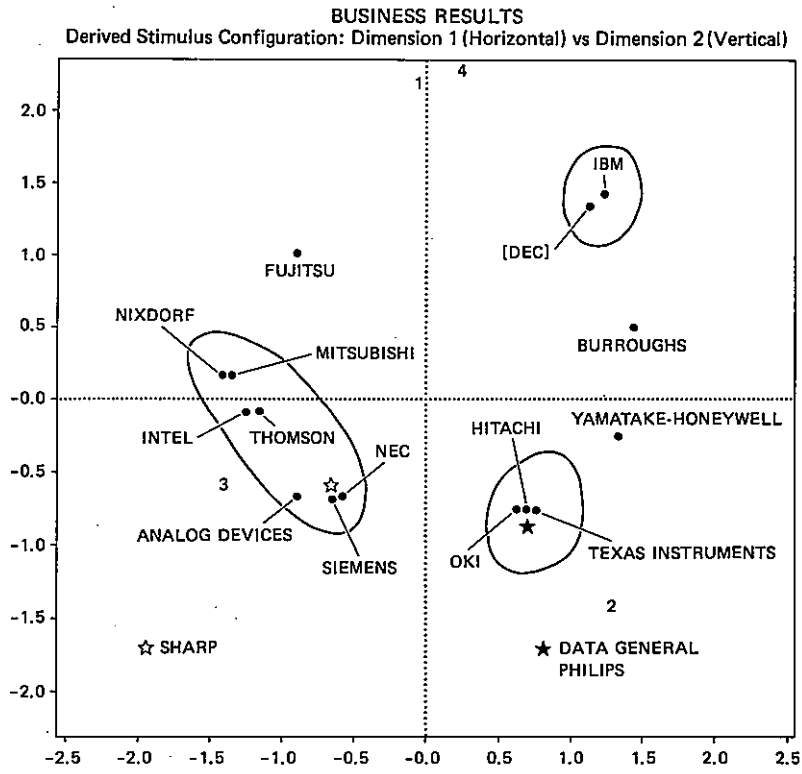


* Four items are ranked in order of importance.

1. General management ability (general knowledge of the company and its business, ability to formulate detailed plans, ability to organize and lead, ability to integrate diverse information, etc.)
2. Interpersonal skills (commitment to and identification with the company, ability to promote harmony and collaboration among executives, sense of equity and fairness)
3. Entrepreneurship (ability to produce and accept new and creative ideas, sound and consistent value and belief, willingness to take risk)
4. Past records (past records of high performance, experience in other companies, credibility each stockholders and banks)

Stress and squared correlation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.054 RSQ = 0.997

Figure 6. Characteristics of Senior Executives

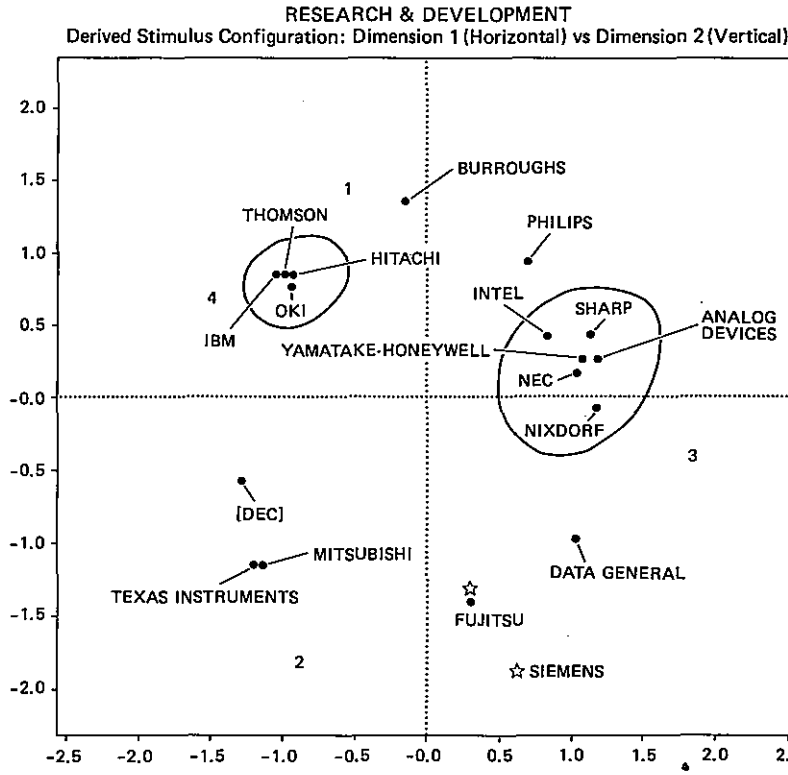


* Four items are ranked in order of importance.

1. Managerial resources (new product ratio, capital gain for stockholders, improvement of product quality, improvement of efficiency of production and physical distribution, strengthening of product ratio)
2. Earning rate (growth of earnings, return on investment, liquidity of assets)
3. Growth rate (sales growth, increase in market share)
4. Human resources (increase in pay, job security, and opportunity for promotion from within, improvement of work environment), reduction of labor turnover, development of human resources.

Stress and squared correlation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.197 RSQ = 0.964

Figure 7. Business Results



* Four items are ranked in order of importance.
1. Basic research on new technologies
2. Research on improving and undating existing products
3. Development of new products
4. Development of new production methods and processes

Stress and squared coreelation (RSQ) in distances
by the Kruskal's stress formula 2; stress = 0.234 RSQ = 0.948

Figure 8. Research and Development

日本のハイテクノロジー産業における日米欧企業比較

——多次元測定法をもとにして——

〈要　約〉

各務洋子

世界経済に対し最も強い影響力を持つもののひとつに，技術の変化がある。産業は，それが古い分野のものにせよ，新しいものにせよ，技術の変化に応じて，その置かれている業界内部での位置を絶えず移動させ，その特徴的な性格と働く人たちの質を変えて行く。新しい技術が組織に浸透するにつれて経営のメカニズムと形態もまた変わる。

本稿は，技術の変化に影響される組織構造の特徴をさぐるために，日本のハイテクノロジー産業において現在操業中の，日米欧の合計18の企業を取り上げ，実証研究を行った。これらの企業での調査と個人面接によって集められたデータは，多次元測定法を通して分析された。環境とそれに適応する組織構造との関係を指摘するために，このテーマを導き，方向づけした概念構成は，組織の環境適応理論である。

18社各社の意志決定時における重要度の順に回答されたアンケート結果をもとに，8項目に関しての多次元測定法によるマッピングを見ると，いくつかのグループに分けられる。その結果，国別(文化的相違)による組織の特徴は，予想以上に見られないことがわかる。むしろ，各企業のもつ目標設定，戦略，政策における類似が，国を越えて，組織構造，組織行動を特色づけている。例えば，技術志向か，市場志向かによって分類されたグループは，8項目をほぼ一貫して同グループに分けられてい

る。ハイテクノロジー産業は，イノベーションを生み出す組織調査というテーマの中でのひとつの焦点であった。しかし，技術革新は，すべての産業で積極的に進められなければならない。他の産業における調査は，今後の課題のひとつである。