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GLOBAL BENCHMARKING of the STRATEGIC MANAGEMENT OF TECHNOLOGY

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Global Benchmarking of the Strategic Management of Technology[1]: A Preliminary Report

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1. A New Global Benchmark on Strategic Management of Technology

In 1992 I led a major study aimed at establishing measures of practice in global strategic management of technology, as well as measures of R&D and overall company performance. That survey was sent to all companies in Japan, western Europe and North America whose 1991 R&D expenditures topped $100 million in then current dollars, totaling 244 firms. The present research[2], undertaken in 1999, aims to update the prior study, assessing what changes have occurred in the intervening seven years on a global basis.[3] This paper presents just a first cut at findings arising from the data collected globally. The topics discussed are my own biases of emphasis, to be elaborated with more comprehensive coverage and deeper data analyses later.

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[1] This study was sponsored by a grant by the German-American Academic Council to the MIT Industrial Performance Center, funds from the global industrial sponsors of the MIT International Center for Research on the Management of Technology, and a grant from the National Science Foundation to the MIT Center for Innovation in Product Development.

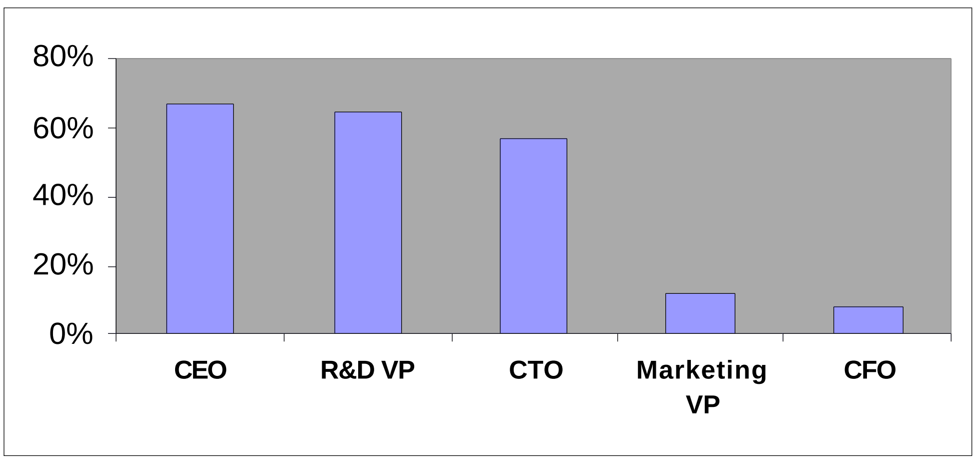
[2] My deep thanks to my MIT faculty colleagues Richard Lester and Richard Locke who participated in all aspects of this research. I appreciate the vital contributions by our German collaborators, Frieder Meyer-Krahmer and Guido Reger from the Fraunhofer-Institute ISI in Karlsruhe and Alexander Gerybadze of the University of Hohenheim, who helped in the design of the study and who collected all the data from European firms, and Ryo Hirasawa from the National Institute for Science and Technology Policy in Tokyo, who translated the questionnaire into Japanese and collected all the data from the Japanese companies. I am especially indebted to three MIT doctoral students: Eugene Bae, who identified all the eligible North American companies and collected the data from them; Jason Wittenberg, who developed the data coding forms and carried out the overall global data analyses; and in particular Kathy Liu, who did all of the statistical analyses and created all of the figures and charts used in this presentation. I also thank my assistant Lisa Breede who prepared the various versions of the extensive questionnaire and Anita Kafka who coordinated many different aspects of the project.

[3] The current study applied the same criteria for inclusion in the sample, i.e. last year expenditures of U.S.$100 million or more in current dollars, thereby due to growth and inflation making far more firms eligible. The analyses reported in this preliminary presentation are based upon data provided by 209 companies. An extensive English-language questionnaire was mailed to the senior technical officer of firms believed to be eligible in North America and in western Europe (the latter handled by the Fraunhofer-Institute ISI in Karlsruhe), and an exact Japanese translation was mailed to eligible Japanese firms (by the Japan NISTEP). In the coding of the questionnaires by the receiving institution all company identifiers were omitted, leaving the resulting data base as an anonymous collection of information.

2. **Strategic Leadership of Technology**

a. **Roles in linking technology to business strategy.** A few key people in the firm are critical to providing the form of leadership that I deem vital to a company's strategic-level management of technology efforts, i.e. the linking of corporate technology strategy to overall corporate business strategy. The results found now are comparable to those of 1992, namely that the Chief Executive Officer (CEO) and the senior corporate technology executive (the Vice President of R&D and/or the Chief Technology Officer (CTO)) are the principal integrators. The Vice President of Marketing, who ought to be far more engaged in this effort, is considerably less visible, and the Chief Financial Officer (CFO) still less important. We did not find any important differences among the three regions in regard to this rank-ordering of importance.

Figure 1. % of Companies Indicating Each Role as Important in Linking Technology to Overall Corporate Strategy



We sought to understand better the nature and consequences of technology-business ties. Figure 2 indicates the percentage of companies in each region that self-assess themselves as highly linked in this regard. Both Japan and North America companies show significant improvement over their 1992 positions with European firms remaining about the same as earlier.

Figure 2. % of Companies Indicating High Linkage between Technology and Business Strategy

Globally the strength of these linkages between technology and corporate strategy significantly relates to several major performance measures as listed in the Figure 3 chart. These overall findings are especially strong for North American firms.

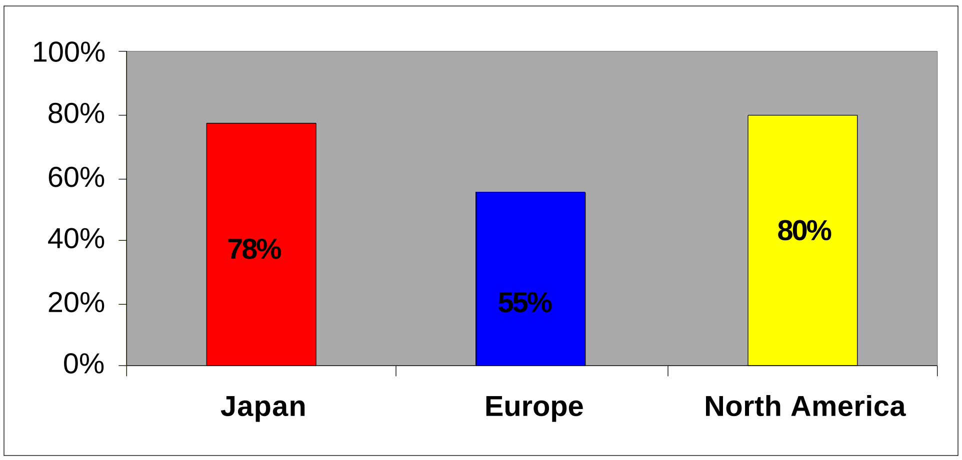


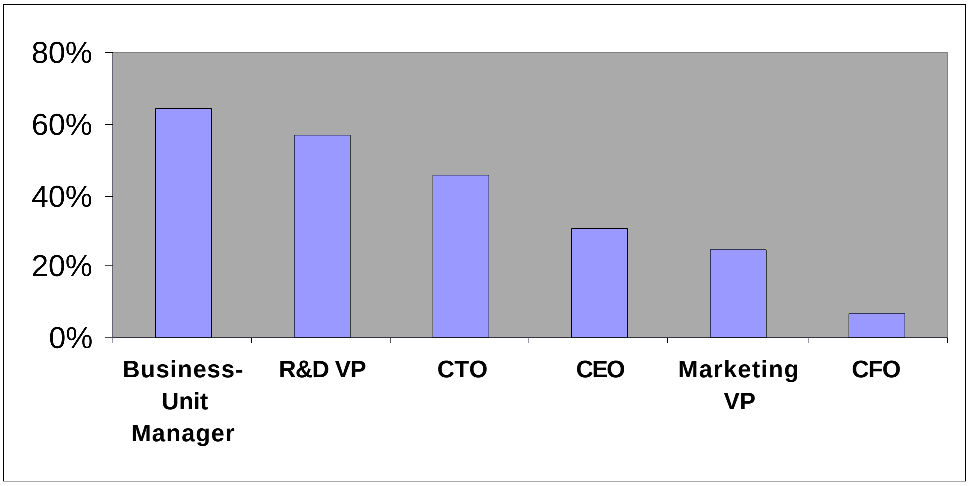
Figure 3. Technology-Business Strategic Linkage is Critical

Significantly relates to:

- Overall corporate sales growth rate
- % 1998 sales from new products/services
- % sales from new and improved products
- Technology leadership

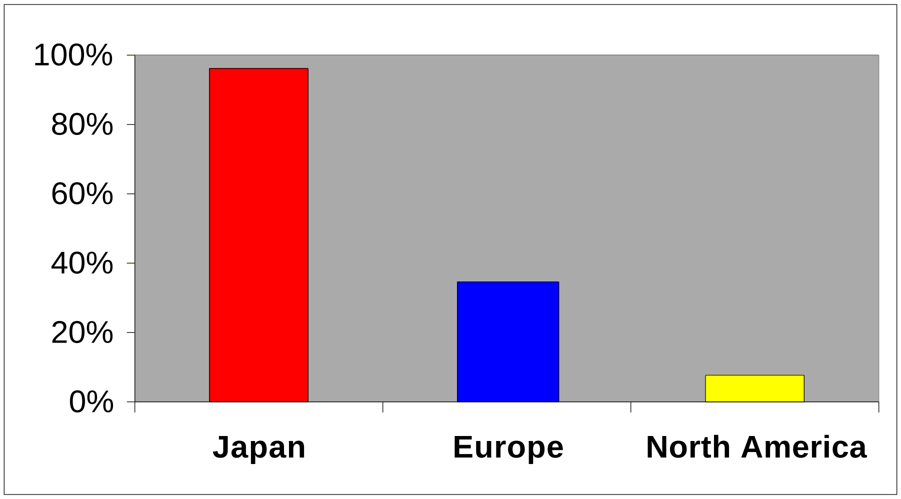
We also inquired about the key contributors to technology-business linkage at the Business-Unit or Division level of the firm. Our findings, shown in Figure 4, reflect the increasingly strengthened role of the Business-Unit General Manager that is consistent with the overall decentralization that has occurred over the past 7 years. The 2-to-1 ratio of perceived General Manager role in relation to the CEO is the same as was seen in 1992. Note, relative to the corporate level, the increased importance of the Marketing VP as a business-unit level integrator of technology and overall business strategy, again at the same magnitude as seen in the earlier survey.

Figure 4. % of Companies Indicating Each Role as Important in Linking Technology to Business-Unit Strategy



b. The Chief Technology Officer (CTO). Our probes relating to key leaders next focused on the Chief Technology Officer or equivalent in the firm. The regional differences in CTO membership on the Board of Directors/Main Board of the company? The results shown in Figure 5 are comparable to 1992, with over 90% of Japanese major R&D spenders having their CTO on the Main Board, about 35% of European companies with this practice and about 8% of North American firms. Both Europe and North America have actually declined in the number of CTOs in board-level positions.

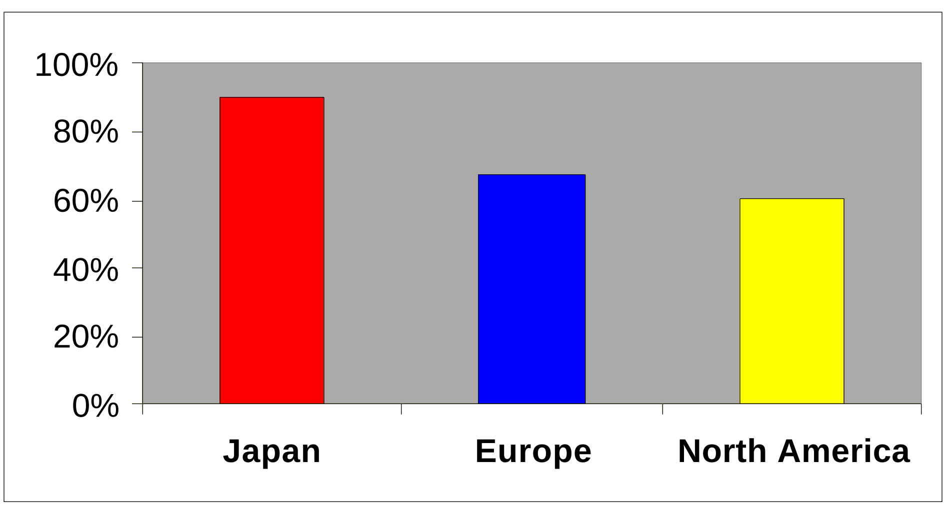
Figure 5. % of Companies with CTO on Board of Directors or Main Board



Unfortunately, the global data on CTO Board membership tend to correlate negatively, but seldom statistically significantly, with a variety of corporate-level performance measures. We do not have a reasonable explanation for these results. Incidentally, among these very large firms CTO Board (and also executive committee) memberships do not relate to size differences.

We also checked one step down in organizational importance, i.e. having the CTO serving as a member of the company's senior management committee, e.g., the executive committee?

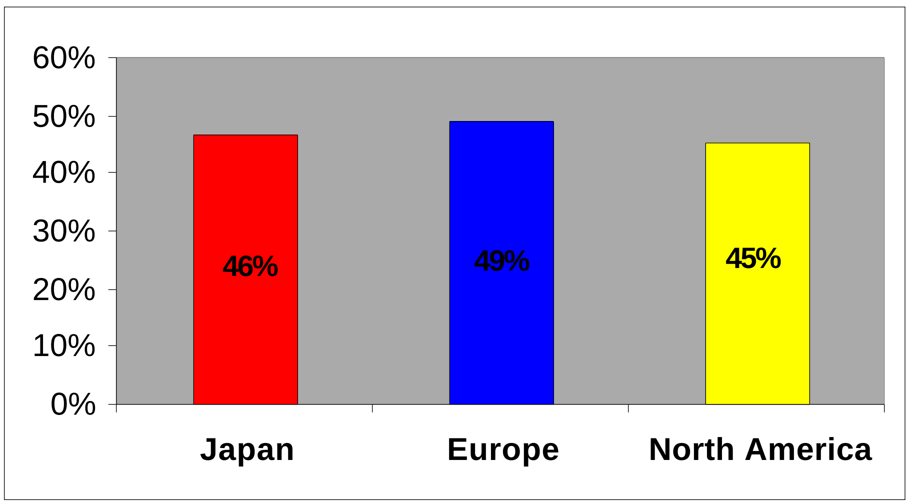
Figure 6. % of Companies with CTO on Executive Committee



Here the results show European and North American equivalence at a fairly high percentage of firms, but Japan is still dramatically different in regard to this practice, presumably because the Japanese Main Board is usually seen as the senior management committee of the firm. But no important correlates distinguish senior committee membership from corporate Board membership in their consequences.

c. The Chief Executive Officer (CEO). We then took a closer look at the CEO. First we examined data on whether or not the CEO had a strong technical background, a characteristic we did not check in the 1992 study.

Figure 7. % of CEOs with Strong Technical Background



The similarity shown in Figure 7 of the three regions each having just under 50% of their CEOs with a strong technical background destroys one old myth, i.e. that American firms have suffered in their long-term view due to their lack of technically-trained CEOs!! Furthermore, to more strongly kill the myth, there is no significant correlation between the CEO having a technical background and any overall corporate performance measures.

However, let's look at the CEO's involvement with key technology-related activities (Figure 8). Around the globe CEOs have become consistently and highly involved in the more strategic issues of technology strategy development and overall R&D budgeting. But generally Japanese CEOs, 50% more frequently than Europeans, and nearly twice as often as North American chief executives, get highly involved with the somewhat more detailed aspects of technology management.

Figure 8. % CEOs Highly Involved in Technology Strategy

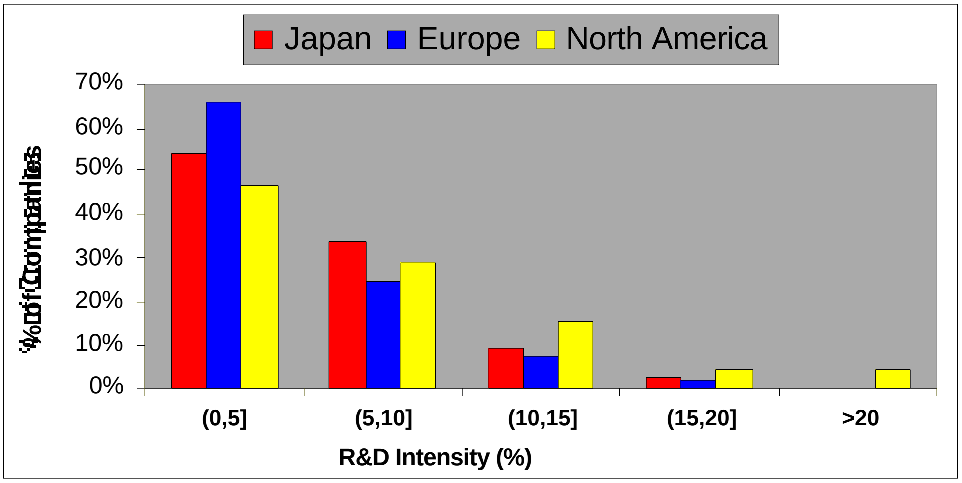
	Japan	Europe	North America
Technology Strategy Development	52	45	47
Overall R&D Budget	67	67	66
Project Selection/Prioritization	49	33	26
Internal Technology Resource Allocation	37	24	17
Selection of Outside Technology Investments	60	44	34

The further statistical analyses demonstrate that around the globe those CEOs with strong technical background consistently and significantly involve themselves in the development of technology strategy, as well as with some other activities. And these high CEO involvements correlate strongly and significantly at the global level, and most true in North America, with key competitive measures such as technology leadership and decreased breakeven time. As a relevant aside, technically trained CEOs have no special bias in regard to appointing their CTOs either to the company Board of Directors or even to the senior management committee of the firm, and this is true for both the global sample as well as for each region separately.

3. R&D Budgets and Control

a. R&D spending overall, and its allocation. One of the first questions posed by R&D "benchmarkers", whether general or technical executives, is how does a company's R&D spending stack up against its competitors. Figure 9 shows the distribution of R&D expenditures as a percentage of annual sales volume, or "R&D Intensity" as it is usually called, for the three regions studied, with the mean percentages for each region shown under the graph. These spending percentages for the reporting firms are significantly different across the three regions as a whole, although the distinction between the Japanese and European subsamples is not significant.

Figure 9. R&D Intensity (R&D $/Annual Sales)

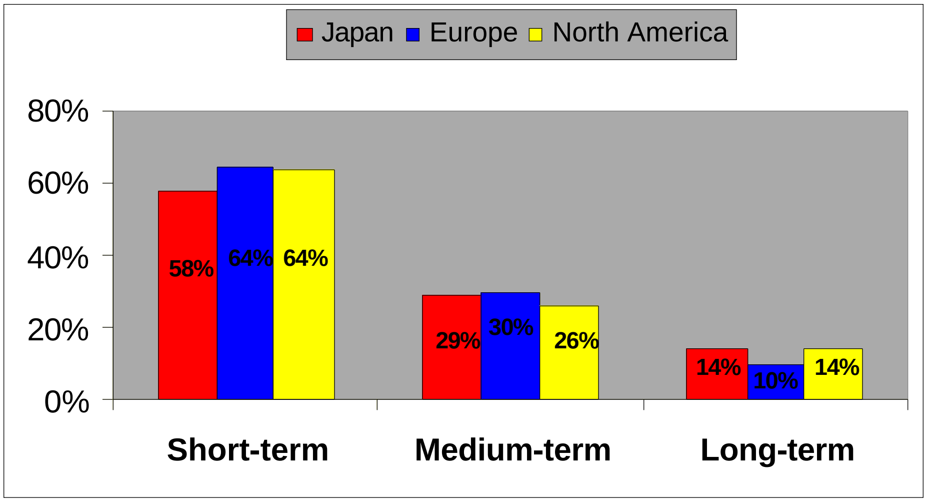


Mean: Japan - 5.3%   Europe - 4.7%   North America - 7.4%

The correlation results for R&D Intensity are a both a top and bottom-line dream for R&D executives who are seeking budget increases (i.e., all R&D executives!!). R&D as a percentage of annual revenues correlates strongly with annual sales growth rate, % sales from new products and profitability. Strategically it also correlates strongly with overall newness of the firm's technology, but it relates negatively to improving breakeven time and to perceived competitive performance in satisfying manufacturing.

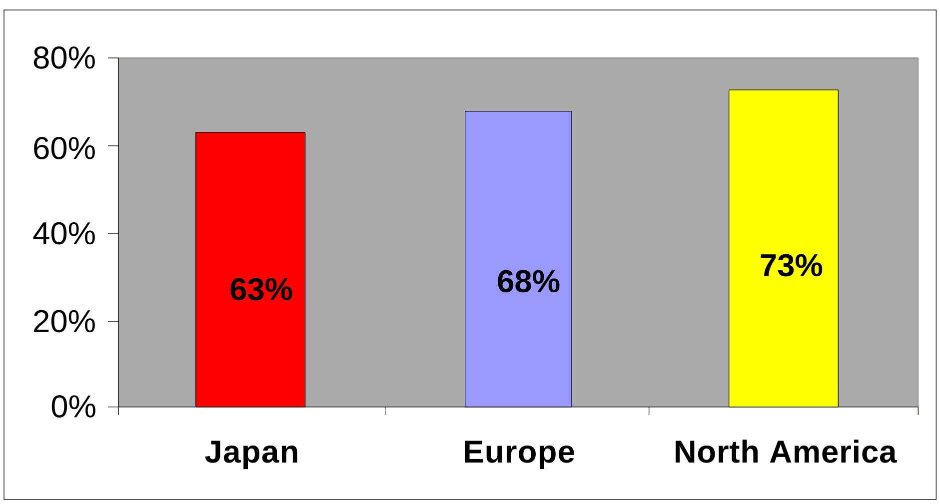
Next we look at the allocation of those funds. Figure 10 shows that the three regions are basically uniform in their relative emphases upon short, medium and long-term R&D spending (unnormalized means in each category for each region are displayed), with short-term spending consuming nearly two-thirds of each region's R&D and long-term percentile spending being in the low-teens.

Figure 10. Total R&D Budget Allocations



Similarly we show in Figure 11 the mean percentages by region of the allocations that we labeled "Short-term R&D orientation", the sum of spending on "Product/process maintenance (impact within one year)" and "Short-term development projects (<3 years)", with North American companies being slightly more short-term oriented than Europe and Japan.

Figure 11. Short-Term R&D Orientation



R&D executives will probably not be pleased to know that the higher the % spent on long-term R&D, the poorer the perceptions of several indicators of corporate and long-term R&D performance. This negative finding is true for many measures and statistically significant for most of them.

In contrast, some executives will be delighted that the higher the % spent on short-term R&D, the better the company performance on a series of shorter term but important measures, such as perceived efficiency, timeliness, improved time to market, meeting target dates for commercialization and process implementation. Strong and consistent results also are reflected in our assessment of what we have called "short-term R&D orientation", the sum of budget percents spent on "Product/process maintenance (impact within one year)" and "Short-term development projects (<3 years)". Short-term R&D orientation correlates positively with essentially all short-term outcome measures and negatively with nearly all long-term results. Those interested in the methodological issues of the survey will be pleased to know that the % of budget spent on short-term R&D correlates extremely strongly (both globally and in each region independently) with what we have separately measured and called short-term R&D orientation.

A next perspective on the budgeting data is the comparison shown in Figure 12 between the prior survey's indications of 1991 global spending patterns and the present survey's reporting of 1998 expenditures.

Figure 12. Overall Global R&D Spending Patterns (normalized)

	Corporate(%)		***BusinessUnit(%)***	
	1991	1998	1991	1998
Research	42	32	13	10
Development	37	42	47	45
Product Technical Support	11	15	24	28
Process Technical Support	10	11	15	17
Total	100	100	100	100

The significant shift over this seven year period is apparent in the movement away from Research work at both the Corporate and the Business Unit levels, moving funds emphases in part toward Development but also with further movements at both levels toward even more near-term product and process support.

But in order for a firm to benchmark its own spending patterns, it at least needs comparisons with data from its own industry. Consequently, we show in Figures 13 and 14 the data for R&D allocations for the five industries for which we have the largest groupings in our global sample: automotive, chemicals/materials, electrical equipment, industrial/agricultural machinery, and pharmaceuticals (including biotechnology).

Figure 13. RD&E Budget Allocations Across Industries (chart)

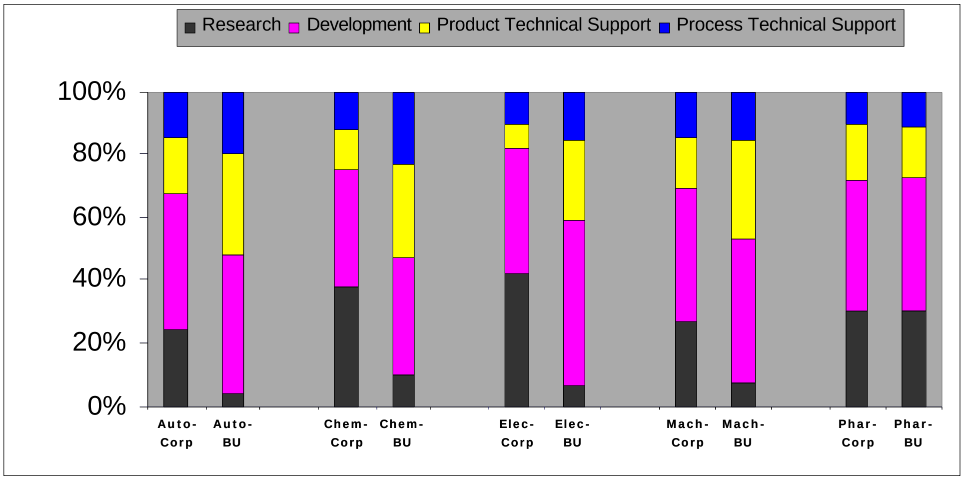


Figure 14. RD&E Budget Allocations Across Industries (table)

	Research	Development	Product Technical Support	Process Technical Support
Auto-Corp	22	40	16	13
Auto-BU	4	40	29	18
Chem-Corp	38	37	13	11.5
Chem-BU	9.8	37	30	23
Elec-Corp	39	38	7	10
Elec-BU	7	51	25	15
Mach-Corp	25	39	15	13.5
Mach-BU	7	43	29	14.5
Phar-Corp	28	38	16	10
Phar-BU	29	41	16	11

The side-by-side comparisons of corporate-level versus business-unit-level R&D percentile allocations show for all industries except pharmaceuticals the dramatically smaller divisional emphases upon research, the comparable or greater divisional allocation to development, and the considerably greater divisional budgeting of both product and process research, matching in overall patterns the total global sample for all industries shown above in Figure 12. For the chemicals/materials industry, where our previous sample was reasonably large, the data reaffirm primarily a decline from 1991 in the research portion of the corporate R&D activity, with far more corporate-level efforts being devoted today to product and process technical support. Divisional R&D

spending patterns in pharmaceuticals/biotechnology are nearly precisely the same as corporate allocations in that industry, with both levels necessarily sustaining a high percentage of long-term efforts.

b. Control of R&D activities. While R&D budgets have been shifting, what has been happening to overall control of these activities?

Figure 15. Changes in the Control of Technology Resources for Research

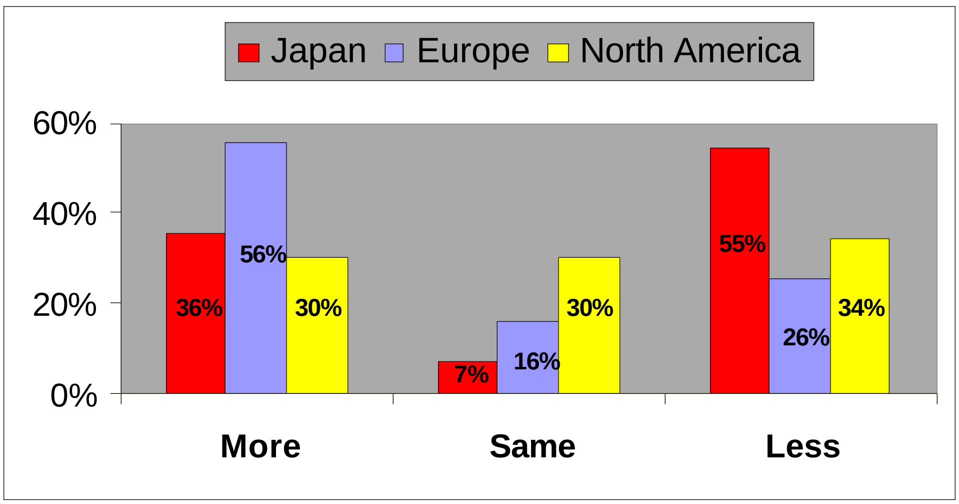
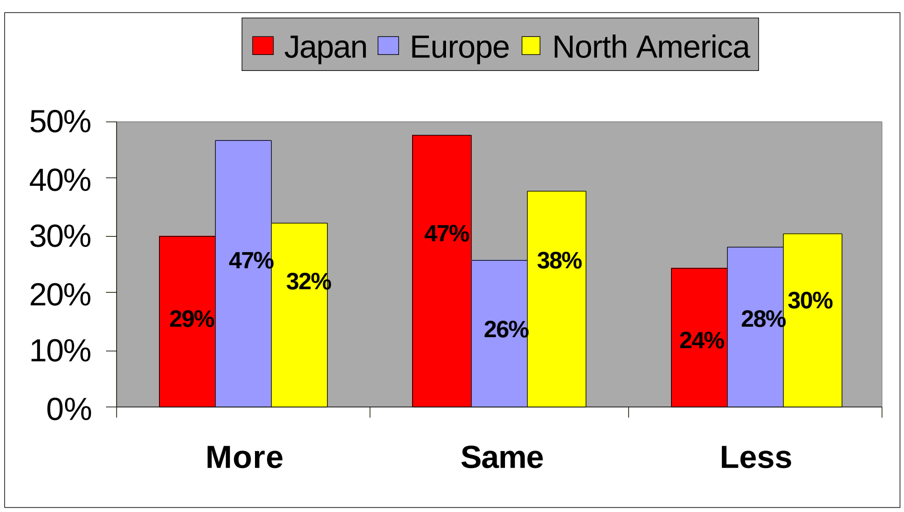


Figure 16. Changes in the Control of Technology Resources for Development



As always company organization change behavior is mixed, some firms moving toward stronger corporate control, some further decentralizing, some unchanged. These charts as well as the data in Figure 17 indicate that Japanese firms have reversed their earlier trend and are now moving toward more decentralization especially for Research and somewhat for Development. That should augur well for enhancing short-term Japanese competitive performance in new and improved product outputs. European companies in contrast are at a different place in their cycle of change, moving generally toward increased corporate level controls. North American firms are more-or-less stabilized as a group, no longer rushing toward further decentralization as had been the situation six years ago.

Figure 17. % Companies Increasing Corporate Control of R&D

	Research (%)		Development (%)	
	1992	1998	1992	1998
Japan	72	36	50	29
Europe	38	56	49	47
North America	36	30	15	32

Upward shifts toward the corporate-level in the locus of Research control now show up as statistically significant correlates of diminished satisfaction of end-customers as well as manufacturing, and also relate to the perceived worsening of breakeven time for new products/services. Companies must somehow find a requisite balance between decentralized business-unit but shorter-term control and corporate-level but longer-term focus, or they will continue to engage in these swings of emphasis and governance every seven to ten years, depending upon their industry and overall economic conditions.

4. Globalization of Technology Activities

a. Trends in R&D spending outside of home region. In trying to track the globalization of R&D activities we wanted to find how much of the R&D budget was being spent in countries outside of the home region of the firm. For Japanese companies this includes all work outside of Japan. For Europe, however, this is more complicated and involves not all non-domestic spending but rather only that spent outside of western Europe. Similarly, any monies spent in either the United States or Canada are regarded as "home-based spending" for the North American firms.

Figure 18. % of Total R&D Activity Outside of Home Region (graph)

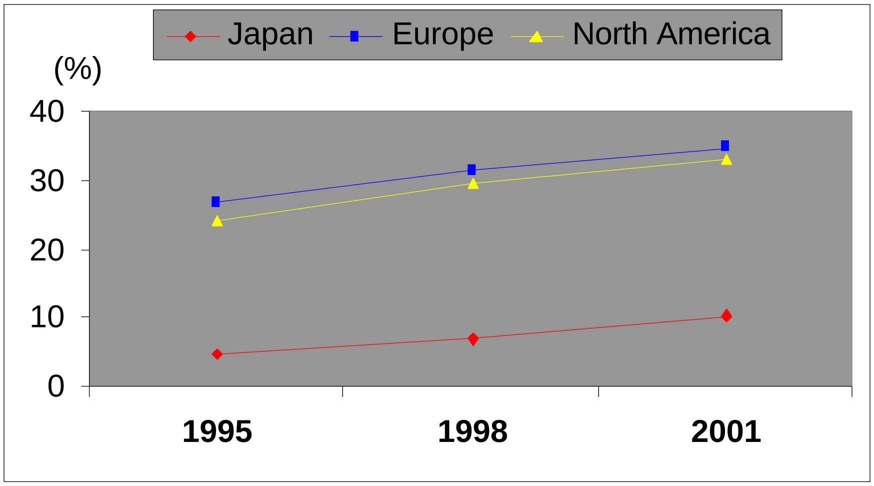


Figure 19. % of Total R&D Activity Outside of Home Region (table)

	1995	1998	2001
Japan	4.6	6.9	10.4
Europe	26.8	31.4	34.9
North America	24.3	29.6	33.0

The overall trend in moving R&D to a global basis (defined in the manner described) continues to rise, from 15% of our sample's R&D spending in 1995 to 18.7% in 1998 to an estimated 22% in 2001. Two aspects seem worthy of note. First, European and North American firms are converging in their degree of R&D globalization. Second, while Japanese firms are indeed increasing their non-Japan-based technology activities, these are still minimal at 6.86% in 1998 for the sampled Japanese firms. Overall, high correlation exists, especially among European firms, between their percentage of sales revenues from non-domestic operations and their current non-domestic R&D spending percentage. This argues that international R&D has become an integral part of the firm's efforts to support and extend sales beachheads already established abroad.

b. Functions of non-domestic R&D. When we sought explanation of the function of these non-domestic facilities, we found the same rank ordering for each home region: the primary reason for foreign R&D centers has become the establishment of worldwide "centers of excellence" for a particular technology or discipline. Second in frequency is to carry out more of the same type of activities as is done domestically, but adapted to the local market. Third are facilities that focus primarily on regional technical support activities. Regional technical support would inevitably be more highly emphasized by smaller companies than the very large firms that are in our sample. Finally, a small percentage of the sampled companies seek to carry out basic and/or applied research in other countries.

Figure 20. Functions of R&D Facilities Outside of Home Region (chart)

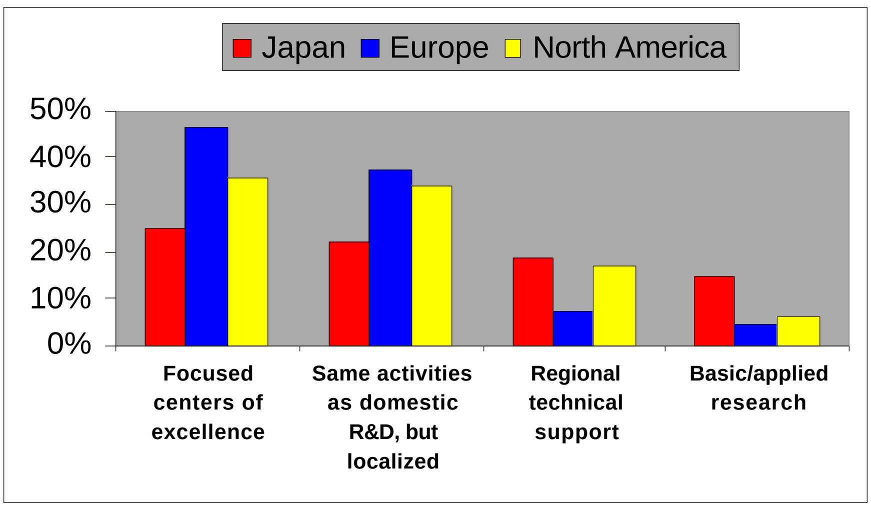


Figure 21. Functions of R&D Facilities Outside of Home Region (table)

	Japan	Europe	North America
Focused centers of excellence	25%	47%	36%
Same activities as domestic R&D, but localized	22%	37%	34%
Regional technical support	19%	7%	17%
Basic/applied research	15%	5%	6%

While rank ordering is the same for all regions, Japanese companies differentiate to a much lesser extent among these several target objectives for their foreign R&D operations, and they are more than double every one else in trying to capture benefits from foreign basic and applied researchers. We had noted this unique Japanese posture in our 1992 study and point out that the new data reemphasize this strategic difference.

c. Foci of foreign technology efforts. We highlighted four alternatives for further assessment of their importance in regard to non-domestic technology activities. While there are not big differences in their use among the overall sample, we did rank order them in terms of their overall significance to the firms.

Figure 22. Significance of Non-Domestic Technology Activities

1. Joint technology development with other companies
2. Our own labs
3. Licensing of technology
4. Acquisition of companies or products

These are slightly differentiated by regions, with both the Japanese and European companies placing stronger emphasis on joint technology development and North American firms more focused upon their own labs in other countries. We'll return to this issue of foreign sources for joint technology development when we discuss External Acquisition of Technology.

Further, we asked respondents for the criteria used in their company decisions to employ non-domestic R&D. The top four reasons are closely clustered for the entire sample, the first two being market-oriented and the second two reasons being more related to foreign technology acquisition.

Figure 23. Criteria for Doing Non-Domestic R&D

1. Adapt products to local requirements
2. Learn from foreign lead markets or customers
3. Keep abreast of foreign technologies
4. Access skilled researchers and new talent

Both the Japanese and the Europeans emphasize as most important the opportunities to learn from foreign lead markets and lead customers. North American companies place greater stress upon the need to adapt products to local requirements, regulations and ingredients.

5. External Acquisition of Technology

My judgment is that the most important change in technology management over the past decade is the relentless intensification of all companies' dependence upon external sources of technology. This was a major aspect of the current and prior global benchmarking survey.

a. Trends in external dependency or leverage. Major corporations worldwide continue to move to relying upon others for substantial aspects of both research and development objectives. Whether this is good or bad varies from firm to firm, but clearly every company has become more exposed as these dependencies have grown over the years.

Figure 24. % of Companies with High Reliance on External Sources for Technology (graph)

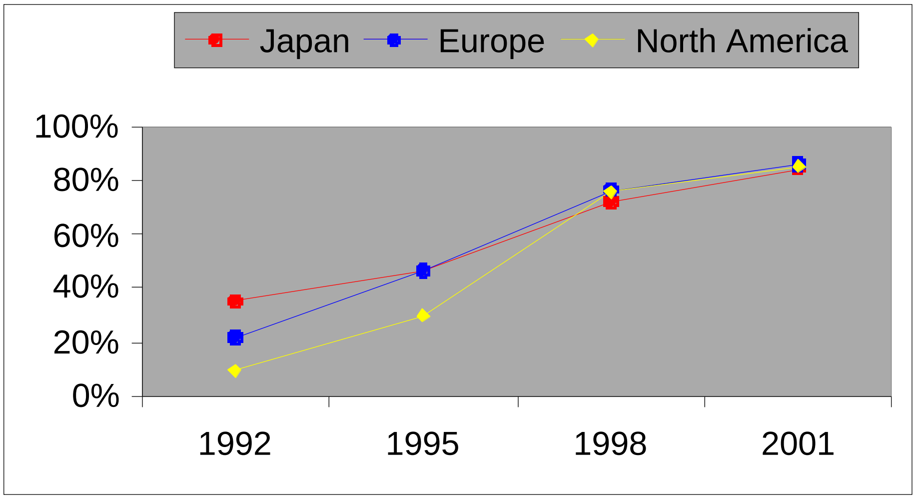


Figure 25. % of Companies with High Reliance on External Sources for Technology (table)

	1992	*1995*	*1998*	*2001*
Japan	35	47	72	84
Europe	22	47	77	86
North America	10	30	75	85

The numbers indicate an expected overall doubling from 1995 to 2001 of the firms that sense a high dependency upon some forms of external technology acquisition, the most dramatic trend in the survey data, and an even higher rate of increase for North American companies. Interestingly, the global sample shows strong positive correlates of the current degree of external reliance with both the actual percent as well as the perceived competitive performance in generating revenue from new products. External sourcing also correlates strongly with newness of technology and sensed ability to adjust to changes, suggesting the external sources are perceived for the most part as adding flexibility not constraints. And the external reliance measure also ties statistically to actual overall company profitability as well as perceived R&D efficiency, indicating that outside sourcing adds "bangs for the buck"!

b. Rank ordering the sources of technological know-how. As we did in 1992, we sought to understand the specific contributions both to Research Work and Development Work of a comprehensive listing of 16 different potential mechanisms for obtaining technology. We developed a weighted rank ordering of the importance of each of those mechanisms for the global sample.

Figure 26. Overall Rank-Ordered Importance of Sources for Research Work

	1992	1998
1.	Central corporate research	Central corporate research
	-------------------------------	==================
2.	Internal R&D within divisions	Internal R&D within divisions
	-------------------------------	
3.	Sponsored university research	Sponsored university research
4.	Recruiting students	Recruiting students
5.	University liaison programs	Continuing education
6.	Consultants/contract R&D	University liaison programs
7.	Continuing education	Consultants/contract R&D
8.	Joint ventures/alliances	Joint ventures/alliances

The similarity of the top eight sources for Research Work in the 1992 and 1999 surveys is remarkable, even to the fact of the statistically significant differences in the degree of impact of Central Corporate Research over all other contributors, despite the continuing decline that has occurred in that sector. (The separation lines between listed items indicate strong statistical differences in the relative contributions of those items.) Internal R&D Within Divisions continues to rank second in importance for Research, again despite budgetary declines there too. In the world outside of the firm the broad role of universities as multi-faceted contributors to the research strengths of major industrial firms around the globe remains very strong.

Let's now examine the findings for Development Work.

Figure 27. Overall Rank-Ordered Importance of Sources for Development Work

	1992	1998
1.	**Internal R&D within divisions**	**Internal R&D within divisions**
	====================	====================
2.	**Joint ventures/alliances**	**Central corporate research**
3.	**Central corporate research**	**Incorporating suppliers' technology**
4.	**Incorporating suppliers' technology**	**Joint ventures/alliances**

5.	**Licensing**	**Licensing**
6.	**Acquisition of external technologies**	**Incorporating customers' technology**
7.	**Acquisition of products**	**Continuing education**
8.	**Consultants/contract R&D**	**Acquisition of products**

Again, the most significant observation is the similarity between 1992 and 1999 of the key sources for obtaining technology for Development Work. The slight movement upward in the importance of the Central Corporate Research organization no doubt reflects the significant increase from 1992, shown earlier in the budget breakouts, in the amount of Development now being carried out by corporate-level R&D organizations. Note that the contributions of Customer Technology, indicated now as #6 in importance to Development, cannot be compared with 1992 because we had not included it among the earlier survey's alternatives.

c. More details on outside collaboration and communications. Going more deeply into the issues of external technical involvements we sought to understand how frequently firms collaborated with various types of outside organizations. Most important among these collaborators are customers, suppliers and universities.

Figure 28. % of Companies with High Frequency of Outside Collaboration

Collaborates with:	Japan	Europe	North America
Customers	52	38	44
Suppliers	41	45	45
Universities	34	32	34

The only regional differences indicated above are in the far greater claimed Japanese collaborative activities with customers, and the far fewer similar European endeavors. Globally the only significant correlations of collaborative activities are the strong connection between the frequency of both customer and supplier collaborations and the % of 1998 sales coming from new and improved products introduced during the past three years. Strong customer linkages and customer inputs do seem to facilitate new product development.

The weakness of European firms in terms of outside collaborations was also observed somewhat in our 1992 survey, where although not examining explicit forms of collaboration we did seek data on the degree of direct customer inputs used by each company. In 1992 European companies were dramatically lower than their global counterparts on all five measures of customer inputs to early-stage technology activities. We show below the updated numbers from the current study.

Figure 29. % of Companies Claiming Extensive Direct Customer Inputs

Technology Activity	*Japan*	*Europe*	*North America*
Technology strategy development	55	44	55
Setting program objectives	68	49	43
Concept development	54	42	40
Prototype development	55	47	97
Average	58	45	59

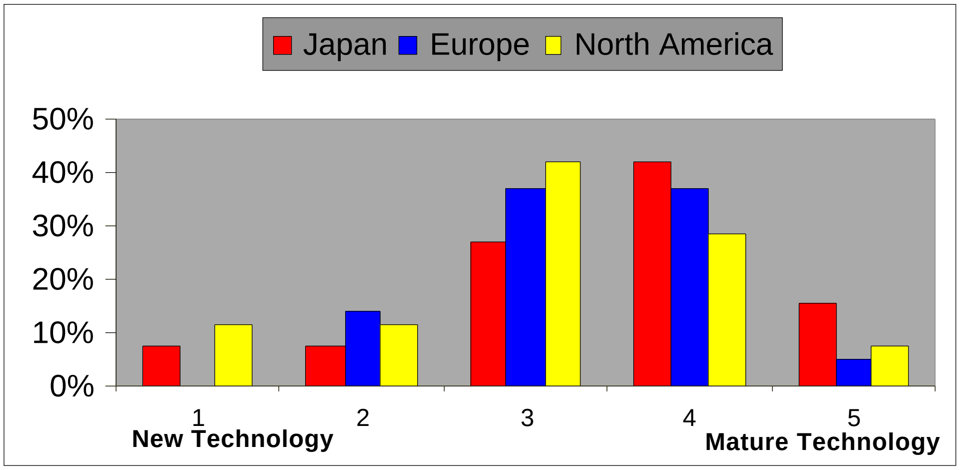
While the European numbers are up from the prior survey, and in some cases even slightly ahead of their North American counterparts, European companies in general still seem in need of stronger customer involvement in technology development.

6. Overall Technological Effectiveness

We made a number of attempts to assess the overall technological effectiveness of each respondent. This section covers those measures, and their apparent causes and consequences.

a. Technological maturity. The first metric we used in our multi-variate approach to evaluating technological effectiveness is the average maturity of key technologies in the most typical business unit of the company, indicated in Figure 30 as estimated by the senior technical officer of the company from 1=Extremely New Technology to 5=Extremely Mature Technology. The statistically significant differences among these regions present the North American firms as possessing on average considerably newer technology than their European and even moreso than their Japanese counterparts, at least for the companies included in this sample.

Figure 30. Average Maturity of Key Technologies



Weighted Technology Maturity Measure

Japan	Europe	North America
3.52	3.35	3.09

We lack a clear explanation for the influences upon technological maturity in the firm. At the global level lower R&D Intensity and less reliance upon external technology sources do relate in a statistically significantly manner to more mature average technology, and these connections seem reasonable in a causal manner. But other variables that show statistical significance are far less easy to explain. However, looking in the other direction, technological maturity appears to influence the other key company performance measures in astonishingly strong statistically and consistent ways across the entire global sample, worsening time to market, new product sales and sales growth, profitability and overall perceptions of R&D effectiveness, as indicated in Figure 31.

Figure 31. Consequences of Technological Maturity

Worsened change in "time to market" for new products/services

Lower % sales from new, and from new and improved, products/ services

Lower sales growth rate

Lower overall company profitability

Lower perceived R&D effectiveness

b. Technology leadership. We next examined perceived technology leadership relative to key competitors, shown in the next table, Figure 32.

Figure 32. Perceived Technology Leadership (% of companies, normalized)

	Japan	Europe	North America
Technology leadership	20	35	45
On par with competitors	54	47	34
Fast follower	21	16	17
Later technology follower	5	0	4

These perceptions may reflect differences in national cultures to some extent, but they are statistically tied to important variables that might well help determine a leadership strategy. For example, having a CEO with a strong technical background and having strong linkage between technology and business strategies both relate well to the degree of technology leadership of the firm. In turn technology leadership shows amazingly strong statistical ties to many outcome measures in the overall global sample, as indicated below in Figure 33. Technology Leadership relates strongly to enhanced time to market, increased sales from recent new products and services, improved satisfaction of all internal and external "stakeholders" of the R&D organization, and broadly perceived increased R&D performance in every measure.

Figure 33. Benefits of Technology Leadership

Improved "time to market"

Higher % sales from new products/services

Increased satisfaction for all "stakeholders": end customers, internal strategic customers, internal manufacturing/operations customers

Higher perceived R&D efficiency, effectiveness, timeliness, % revenues from new products, cost reduction success, and ability to adjust to change

Incidentally, the relationship between Technology Leadership (a measure of positioning and behavior) and Technological Maturity (a measure of product age) is indeed negative as expected, but only small and not statistically significant.

c. "Time to Market". Time to Market can well be labeled as the management consultant's key to assuring his/her own full-time employment for the past few years, and for several more to come. It has generated infinite seminars, myriad articles and even several books, and has already been mentioned above as worsened by Technological Maturity and enhanced by Technology Leadership. In our benchmarking survey we defined "Time to Market" as "the time from generation of the idea for a new product/service until it reaches the market". The relative changes over the past five years are shown in Figures 34 and 35 for the three regions in the study.

Figure 34. Changes in Time to Market (% of companies, normalized) (chart)

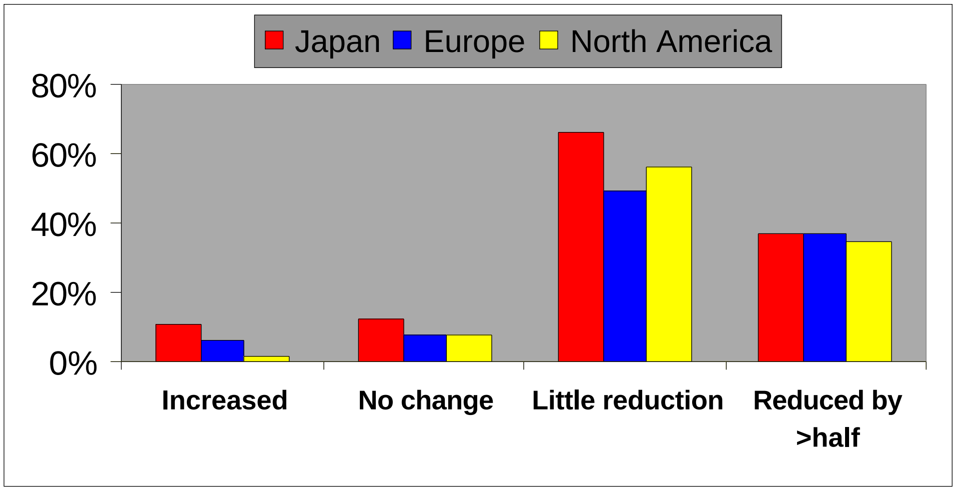


Figure 35. Changes in Time to Market (% of companies, normalized) (table)

	Japan	*Europe*	*North America*
Increased	11	6	2
No change	12	8	8
Little reduction	66	49	56
Reduced by >half	11	37	34

Most of these giant firms in our global sample show some improvement in time to market, not surprising given the enormous emphasis upon this metric. Europe and North America are quite comparable in this regard, but Japanese firms do seem to be lagging in accomplishing significant changes here, perhaps attributable to the recent overall problems in the Japanese economy.

We examined the correlates of decreases in time to market and found many with statistically significant indicators, as indicated in Figure 36. Of course, in some cases time to market might be the influence upon and not the result of these factors, such as technological leadership, and inevitably strong feedback loops are present.

Figure 36. Some Possible Influences Upon Improving Time to Market

- Technology leadership
- Technological newness
- More short-term R&D spending and orientation
- Increased use of outside vendors
- Frequent collaboration with suppliers
- Senior management sponsors to help move products forward
- Early formation of multi-functional teams
- Simultaneous engineering and product development process
- Extensive direct customer inputs to technology strategy development

A measure that is related to but different from the decrease in time to market is the perceived timeliness of R&D. The strongest correlates of that high priority performance objective are: the degree of linkage between technical and business strategy, CEO involvement in R&D budgeting, the % of budget devoted to short-term R&D and the overall short-term orientation of the R&D program, and the amount of development, in contrast with research, carried out by the corporate R&D organization.

We also examined a series of eleven different approaches adopted recently by companies to try to improve their technology management. Three of these correlate strongly with the several different measures of enhanced R&D timeliness (Figure 37).

Figure 37. Further Influences Upon R&D Timeliness

- Use of automation and other non-human resources in R&D
- Use of information and communications technology
- Streamlined R&D organization

Also related to these parameters, but of course quite different, are the "Changes in Breakeven Time" that have occurred over the past five years.

Figure 38. Changes in Breakeven Time (% of companies, normalized)

	Japan	*Europe*	*North America*
Increased	19	9	7
No change	51	30	28
Decreased	30	61	65

Again European and North American companies are quite comparable in their corporate performance on new product breakeven times, and Japanese firms lag in this dimension too.

We examined the correlates of decreases in breakeven time and found several with statistically significant indicators. A few of these relationships are interesting and suggestive, and are listed in Figure 39.

Figure 39. Some Possible Influences Upon Decreasing Breakeven Time

- CEO involvement with technology strategy development
- Senior management sponsors to help move products forward
- Stronger identification of R&D's contribution to profits
- Co-development with lead customers
- Simultaneous engineering and product development process

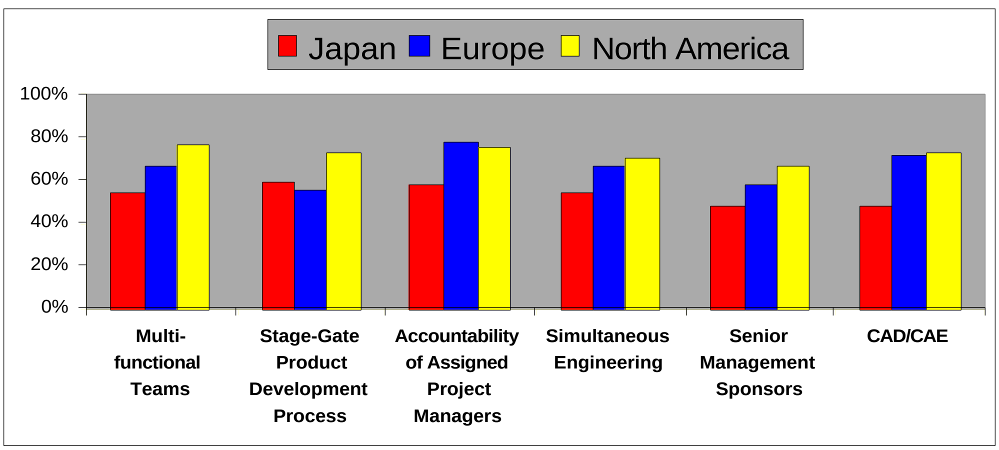
Again, those concerned with data consistency in the study will be pleased to know that for the entire sample there are strong correlations among the responses in regard to decreased breakeven time, improved time to market, perceived R&D timeliness, meeting target dates for product/service commercialization, and meeting target dates for process implementation.

d. **Influence of managerial practices.** Recognition of these several influences suggested that we should check the overall adoption of various managerial practices upon other aspects of technical and overall corporate performance (Figures 40 and 41).

Figure 40. Potentially Important Managerial Practices (table)

	Japan	*Europe*	*North America*
Multi-functional Teams	54%	67%	77%
Stage-Gate Product Development Process	59%	56%	74%
Accountability of Assigned Project Managers	58%	79%	75%
Simultaneous Engineering	54%	67%	72%
Senior Management Sponsors	48%	58%	68%
CAD/CAE	48%	72%	74%

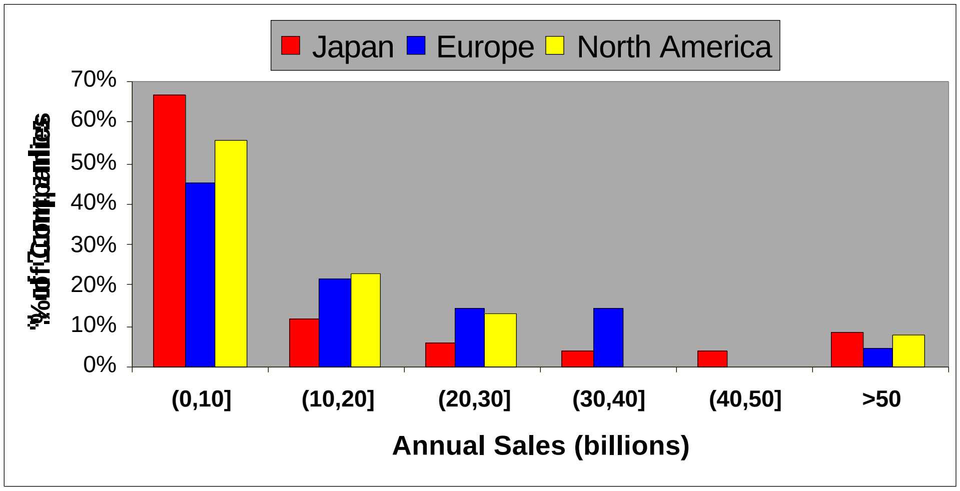
Figure 41. Potentially Important Managerial Practices (chart)=



The charts and table show that in almost every case North American firms are more likely to have adopted these various methods, and almost always Japanese firms are least likely. But except for the previously identified possible influences on time to market and breakeven time, which do indeed seem quite important, no other important consequences are apparent in the statistical analyses from the adoption of these managerial techniques.

e. Possible impact of company size? Explorations of these measures led to a speculation that some of the technology effectiveness outcomes may reflect influences of non-technical factors. One such possibility is the size of the company itself as indicated by its annual sales, the regional distribution of these numbers shown in Figure 42.

Figure 42. Annual Sales Regional Frequency Distribution



Mean: Japan - 25 bil Europe - 18 bil North America - 15 bil

Statistically the three regions are not different in terms of company sizes. But does size really matter anyway? Among these very large global companies, the relationships between size and outcomes is mixed. The larger firms in the global sample do have higher technological leadership and more improved time to market for delivering new products and services. But the larger firms suffer lower profitability, the only indicator that is even weakly consistent within each of the three regions. So size differences do not explain much of what is going on in overall technological performance.