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GLOBAL CORPORATE COMPETITION: WHO'S WINNING, WHO'S LOSING, AND THE R&D FACTOR AS ONE REASON WHY

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This study summarizes the major changes over the period 1960–86 in the shares of world markets of the world's leading American, European and Asian corporations based in 15 major industries. It relates the differential sales growth rates of the gaining and losing firms to national trends in industrial competitiveness, to employment change and to long-term returns to shareholders. One principal determinant of firms' global growth rates, and thence gains and losses in 'world market share', corporate research and development (R&D) intensity, is examined and tested on an 83-firm, six-industry subset of the overall data base. The proportion of corporate sales revenues allocated to commercially oriented R&D emerges as a, perhaps the, principal indicator of subsequent sales growth performance relative to competition over 5–10-year periods. Insofar as many U.S. and U.K. firms have lost global market share relative to Asian and European competitors over the past two decades, a significant contributory factor would appear to have been negligence on the part of many U.S. and U.K. firms of investment in technology as a factor determining strategic, competitive advantage.

Discussions of international competition tend to be dominated by generalizations about the performance of nation-states or regional blocs. The most current of these generalizations asserts that 'America' and 'Europe' are losing the industrial race to 'Japan'.

Comparisons of macroeconomic performance—especially statistics on productivity change, rather than the often-misused trade balance data—may have validity as summations of changes in national well-being or of national production capabilities. They nonetheless obscure the sometimes vast differences among those who in fact compete on the global business playing field: the individual corporations themselves.

Some qualifications to the more gross generalizations about national industrial performance are occasionally made. Even those most convinced of secular U.S. industrial decline note that, in sectors such as computers and aerospace, U.S. firms appear well able to hold their own. And the fact that Japan has virtually no truly world-class competitors in the chemicals or pharmaceuticals industries cannot long escape the attention of even the most fervent believers in Japanese industrial invincibility.

How, though, is one to arrive at some valid scorecard of how well firms in different industries are really doing against their foreign competitors? Moreover, what measures can illuminate a phenomenon evident to those acquainted with the business scene, but quite hidden from view in the aggregate or even sectoral data on price-competitiveness, productivity and foreign trade disgorged by public authorities—to wit, the wide variations in performance among firms based in the same sector in the same country?

Data available on and from the world's leading firms provide a striking, and curiously underutilized, source of insight into the dynamics

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of world-wide business competition over the past two decades. Table 1, entitled 'Changes in "world market share" in major industries', provides a picture of global competitive change in 14 manufacturing industries plus banking from 1960 to 1986.

The data underlying Table 1's estimates of world market shares for 1960, 1970, 1980 and 1986, industry by industry, consist of world-wide consolidated sales figures (expressed in dollars) for the largest 12 firms in each sector. These data were obtained from the *Fortune* lists of largest and U.S. and non-U.S. industrial and banking enterprises for each of these years, supplemented by company annual reports and sources such as *Capital International Perspective* (see Appendix 1 for a discussion of methodology and assumptions). The total of these firms' sales is taken as a proxy for 100 percent of the 'world market' in broad industry categories.[1] The industry classifications of firms are those used by *Fortune* with minor exceptions, the principal one being that only automobile and truck assemblers, not parts producers, are included in 'the auto and truck industry' in Table 1. U.S., European and Japanese companies are thus treated as *de facto* global competitors, with decisions to serve markets by local production or exports being of evident tactical convenience or necessity, but with global position being the ultimate test of firms' strategic performance.

Table 1 also shows the number of firms on each year's 'top 12' list headquartered in each country. Including firms which exited the 'top 12' over this quarter-century period, the histories of over 230 companies are summarized in Table 1.

Although many of the companies whose long-term performance is summarized in Table 1 have diversified product lines, the vast bulk of this diversification was of a 'related' nature and thus does not obscure major trends. Unrelated acquisitions could, and in one or two cases did, materially distort trends. For example, in the case of DuPont's acquisition in 1981 of Conoco, an oil company, an adjustment was made to exclude this 'unrelated' oil-producing and refining business from DuPont's total in the chemicals industry from subsequent 'market share' calculations. Further adjustments would not have significantly altered the major trends for two reasons. First, 'conglomerate' or 'unrelated' diversification and acquisition was far more common to U.S. firms than to those based in other countries and thus, if anything, distorted U.S. 'market shares' *upwards*. Moreover, the firms 'growing' by external acquisitions of unrelated business tended, provocatively enough, to be low-growth firms over 5–10-year time horizons even *including* the effect of acquisitions. Indeed, in five industries undergoing a decline in U.S. corporate dominance during the 1970s, i.e., chemicals, computers and office equipment, electrical equipment and electronics, pharmaceuticals, and tires, U.S. unrelated diversifiers were clearly among the low-growth losers of world market share in their industry groups (Franko, 1989).

CORPORATE DATA AND NATIONAL PERFORMANCE

The trends that emerge from Table 1 are striking, and, for U.S. firms taken as a group, predominantly negative.

U.S. firms accounted over two-thirds of 'the world's business' in 10 of 15 industries in 1960, in nine in 1970, and only three by 1980. American firms continued in 1986 to maintain global dominance in the aerospace, paper, and computer and office equipment industries, albeit with some erosion in favor of Japan in the last of these. There was a marked erosion during the 1960s and 1970s of the once-commanding positions of U.S. firms in electrical equipment and electronics, pharmaceuticals, chemicals, autos and trucks, steel, non-ferrous metals, textiles, tires and rubber, non-electrical machinery and petroleum products. There was also a precipitous decline in the global position of U.S. banks. Not only was there a major decline in the proportion of the total assets of the world's largest banks accounted

[1] The use of a larger data set, e.g. up to the top 25 firms per industry, is not possible prior to 1975 given the limits of *Fortune* coverage up to that time. An expanded data set for the years 1975 through 1986 has been assembled by the author and, in all manufacturing industries surveyed, the sales of the 'top 12' firms account for two-thirds or more of the 'top 25'. Moreover, in no case are major trends altered or reversed. In particular, there is no evidence that smaller US firms are 'picking up the slack'. In electrical equipment and electronics, a sector of supposed US 'smaller-firm' dynamism, the 'world market share' of U.S. firms in the 'top 25' goes from 38 percent in 1980 to 26 percent in 1986.

Table 1. Changes in 'world market share' in major industries.
Numbers of firms, and percentages of consolidated world-wide sales accounted for by the 12 largest companies world-wide in each industry, by country of corporate headquarters (totals may not equal exactly 100 percent due to rounding)

Industry and headquarters country of firms	Number of firms in 'top 12'					Percentage of sales of 'top 12'				
	1960	1970	1975	1980	1986	1960	1970	1975	1980	1986
Aerospace										
U.S.	9	9	10	9	10	85%	88%	88%	81%	91%
France	0	1	1	2	1	0	3	6	10	5
U.K.	3	2	1	1	1	15	9	6	9	4
Total	12	12	12	12	12	100%	100%	100%	100%	100%
Autos and trucks										
U.S.	*6*	*4*	*4*	*3*	*3*	*83*	*66*	*62*	*42*	*50*
Japan	0	3	3	3	4	0	12	14	17	20
Germany	2	2	2	2	2	7	11	12	14	15
France	2	1	1	2	2	4	4	6	15	9
Italy	1	1	1	1	1	3	4	4	10	5
U.K.	1	1	1	1	0	3	4	3	3	0
Banking						*(Percentage of total assets)*				
Japan	0	0	4	2	9	0	0	29	15	77
France	0	2	3	4	2	0	12	23	37	14
U.S.	*6*	*6*	*3*	*3*	*1*	*61*	*67*	*35*	*26*	*9*
U.K.	3	2	1	2	0	22	15	7	15	0
Germany	0	0	1	1	0	0	0	7	8	0
Italy	0	1	0	0	0	0	6	0	0	0
Canada	3	0	0	0	0	17	0	0	0	0
Chemicals										
Germany	3	3	3	3	3	18	27	34	36	38
U.S.	*8*	*5*	*4*	*4*	*4*	*68*	*40*	*30*	*31*	*30**
U.K.	1	1	1	1	1	14	11	10	10	10
Italy	0	1	1	1	1	0	9	8	7	6
France	0	1	1	1	1	0	6	6	5	5
Norway	0	0	0	0	1	0	0	0	0	5
Japan	0	0	1	0	0	0	0	5	0	0
Computers and office equipment (*n*=9)										
U.S.	*7*	*9*	*8*	*8*	*8*	*95%*	*90%*	*90%*	*86%*	*84%*
Japan	0	1	1	2	2	0	3	3	7	10
Italy	1	1	1	1	1	3	5	4	4	4
U.K.	1	1	1	1	1	2	2	2	3	2
France	0	0	1	0	0	0	0	2	0	0
Total	9	12	12	12	12	100%	100%	100%	100%	100%
Electrical equipment and electronics										
Japan	2	3	3	3	4	8	17	18	21	35
U.S.	*6*	*5*	*5*	*5*	*3*	*71*	*59*	*49*	*44*	*27*
S. Korea	0	0	0	0	2	0	0	0	0	13
Netherlands	1	1	1	1	1	8	9	13	11	11
Germany	2	2	2	1	1	10	12	15	11	10
France	0	0	1	2	1	0	0	5	12	6
U.K.	1	1	0	0	0	4	5	0	0	0

(Continued overleaf)

Table 1. (Continued).

Industry and headquarters country of firms	Number of firms in 'top 12'					Percentage of sales of 'top 12'				
	1960	1970	1975	1980	1986	1960	1970	1975	1980	1986
Food and beverage products										
U.S.	*9*	*10*	*8*	*8*	*8*	*62*	*67*	*50*	*50*	*54*
U.K	1	1	2	3	3	24	25	32	36	29
Switzerland	1	1	1	1	1	10	8	13	14	17
Canada	1	0	0	0	0	4	0	0	0	0
Japan	0	0	1	0	0	0	0	5	0	0
Iron and steel										
Japan	1	4	5	4	5	5	30	39	31	38
Germany	2	3	2	2	2	11	21	20	24	23
U.S.	*7*	*3*	*2*	*3*	*1*	*74*	*31*	*21*	*26*	*16*
France	0	0	0	1	2	0	0	0	5	12
Australia	0	1	0	0	1	0	7	0	0	6
U.K.	1	1	1	1	1	5	12	9	7	0
Netherlands	0	0	1	1	0	0	0	5	7	0
Luxembourg	1	0	1	0	0	5	0	5	0	0
Non-ferrous metals										
Germany	1	1	2	2	4	8	10	15	18	29
U.S.	*8*	*5*	*3*	*3*	*2*	*63*	*39*	*22*	*21*	*16*
Japan	0	0	1	1	2	0	0	8	7	16
Canada	2	2	3	2	1	22	18	21	14	12
France	1	2	1	1	1	7	19	17	16	10
U.K.	0	2	1	1	1	0	14	10	11	10
Switzerland	0	0	1	1	1	0	0	6	7	6
Belgium	0	0	0	1	0	0	0	0	6	0
Non-electrical machinery (industrial and farm equipment)										
U.S.	*5*	*6*	*5*	*5*	*4*	*37%*	*51%*	*41%*	*41%*	*27%*
Japan	0	1	2	1	3	0	7	12	6	20
Germany	4	3	2	2	2	42	28	27	23	20
S. Korea	0	0	0	1	1	0	0	0	9	17
U.K.	0	1	1	1	1	0	7	5	5	9
France	1	0	1	1	1	7	0	9	12	6
Canada	1	1	1	1	0	8	6	7	5	0
Sweden	1	0	0	0	0	6	0	0	0	0
Total	12	12	12	12	12	100%	100%	100%	100%	100%
Paper and paper products										
U.S.	*10*	*9*	*8*	*8*	*9*	*86%*	*81%*	*63%*	*66%*	*82%*
Germany	0	0	1	1	1	0	0	10	10	9
U.K.	1	2	2	2	1	8	14	19	17	5
Japan	0	0	0	0	1	0	0	0	0	5
Sweden	0	0	1	1	0	0	0	7	7	0
Canada	1	1	0	0	0	6	5	0	0	0
Petroleum products										
U.S.	*10*	*10*	*8*	*7*	*7*	*77*	*78*	*69*	*61*	*59*
Netherlands	1	1	1	1	1	17	16	15	15	18
U.K.	1	1	1	1	1	6	6	8	9	11
Italy	0	0	1	1	1	0	0	4	5	6
France	0	0	1	1	1	0	0	4	5	5

Table 1. (Continued).

Industry and headquarters country of firms	Number of firms in 'top 12'					Percentage of sales of 'top 12'				
	1960	1970	1975	1980	1986	1960	1970	1975	1980	1986
Brazil	0	0	0	0	1	0	0	0	0	4
Venezuela	0	0	0	1	0	0	0	0	4	0
Pharmaceuticals										
U.S.	*10*	*9*	*8*	*6*	*8*	*87*	*70*	*64*	*54*	*63*
Switzerland	2	3	3	3	3	13	30	31	31	31
Germany†	0	0	1	2	0	0	0	6	12	0
U.K.	0	0	0	1	1	0	0	0	5	6
Textiles										
U.S.	*7*	*5*	*5*	*4*	*5*	*58*	*44*	*37*	*31*	*39*
Japan	1	5	4	3	3	7	32	33	23	25
U.K.	2	2	3	2	2	19	23	31	24	22
S. Korea	0	0	0	1	1	0	0	0	8	11
France	0	0	0	1	1	0	0	0	5	5
Turkey	0	0	0	1	0	0	0	0	9	0
Netherlands	1	0	0	0	0	10	0	0	0	0
Italy	1	0	0	0	0	6	0	0	0	0
Tires and Rubber (*n*=9) (*n*=10)										
U.S.	*6*	*5*	*7*	*7*	*6*	*76*	*69*	*64*	*50*	*50*
Japan	0	1	2	2	3	0	3	7	10	18
France	1	1	1	1	1	6	8	11	18	16
Italy‡	1	1	1	1	1	7	9	16	18	11
U.K.‡	1	1			0	11	9			0
Germany	0	1	1	1	1	0	3	3	4	5

* Includes only chemical products sales of DuPont and excludes the sales of acquired Conoco. Petroleum and coal sales of $11.32bn were subtracted from DuPont's $27.15bn total when computing 'world chemical industry' sales totals.
† Pharmaceuticals divisions only of Bayer and Hoechst.
‡Dunlop/UK and Pirelli/Italy sales were consolidated in 1975 and 1980.

for by U.S. banks, but the number of U.S. banks on the top 12 list declined from six to three between 1970 and 1980, and to only one by 1986.

The early 1980s have seen few indications of improvement in the global position of U.S. firms. In pharmaceuticals and paper U.S. firms have done better than hold their own. But American companies in electrical equipment and electronics, steel, non-electrical machinery, non-ferrous metals, petroleum and banking all continued to lose world market share between 1980 and 1986.

The seeming stability in U.S. firms' positions in tires and rubber in the early 1980s was belied by subsequent events. By mid-1988 Continental of Germany had acquired the tire operations of General (Fisher, 1987), Bridgestone of Japan had purchased Firestone (*New York Times*, 1988: D5), Uniroyal had essentially disappeared as a corporate entity (Buchan, 1987), and Pirelli of Italy had acquired Armstrong's tire business (*Value Line*, July 24, 1988: 126).

The improvement in the already dominant U.S. company position in aerospace was concentrated among the defense-contracting beneficiaries of the (temporary?) defense boom of the Reagan years, notably Lockheed, General Dynamics and

Northrop, all firms dependent on the U.S. government for more than three-quarters of their sales revenues.

The improvement in the percentage of 'the world's auto and truck business' accounted for by Detroit's Big Three between 1980 and 1986 (from 42 to 50 percent) may be due to a combination of protection of the U.S. domestic market, the disappearance from the top 12 firms of Britain's Leyland/Rover Group, and the travails of Renault of France (including Renault's withdrawal from AMC in the U.S.). But there remains a hint that a turnaround may prove to be more than Ford and Chrysler advertising hyperbole.

Although U.S. firms still have a massively dominant position in computers and office equipment, a continuous erosion at the hands of the Japanese has continued unabated. Moreover, contrary to much-vaunted images of U.S. small-company dynamism, smaller U.S. firms have not 'picked up the slack'. Expanding the data set to the top 20 firms in 1980 and 1986 shows a U.S. decline from 82 percent to 78 percent of the 'total world market' between those two years.

A JAPANESE OR GLOBAL CHALLENGE TO U.S. INDUSTRY?

During the two-decade period 1960–80, the challenges to the U.S. global business position were, far more frequently than generally recognized, European as well as Japanese. The Airbus; the growth of the German auto, truck, chemicals, pharmaceutical and steel companies; the French radial challenge in tires and Swiss dominance of notable segments of the world pharmaceutical industry are all reflected in Table 1, as are the thrusts of the Japanese.

The early 1980s, however, have in general seen stable world market share positions for most European firms. The current decade has begun as one of continued, sometimes spectacular, Japanese advance in banking, autos, electrical equipment and electronics, tires, steel and non-electrical machinery. In addition, companies from a new Asian competitor, South Korea, have begun obtaining notable shares of world markets in non-electrical machinery, electronics and textiles (as well as in other industries not surveyed in Table 1).

The data on global competitive performance summarized in Table 1 thus suggest two fairly firm conclusions, and one tantalizing question.

First, as has been occasionally but infrequently noted, there is a good deal of evidence that the decade of the 1960s was in fact not one of a generalized 'American challenge'. Indeed, as was pointed out in a too-little-remarked work of the time, a large part of the upsurge in American foreign direct investment in Europe during that decade was primarily a defensive corporate response aimed at maintaining some position in markets where local and non-U.S., third-country competitors were rapidly gaining ground on the once-dominant American global position (Hymer and Rowthorn, 1970; see also Droucopoulos, 1981 and sources cited therein). Contrary to the *hubris* of the times, U.S. multinational direct investment was accompanied by a shrinking, not expanding, share of global markets.

Secondly, it is evident that the 1970s saw a continued erosion in the global position of U.S. enterprise, and that the early 1980s have seen the continuation of the same trend in many, if not all, industries.

The tantalizing question is, of course, whether there is any basis for thinking that the slight upturn in a number of indicators of the U.S. firms' positions signals an end to—or even a reversal in—the erosion of the global position of American firms in such industries as autos, chemicals and pharmaceuticals; or whether a change in corporate practice or strategies could produce U.S. global advances as well as declines.

The answer surely depends on responses to two further questions: First, were all U.S. firms in each sector in fact 'underperforming', or was there a wide range of U.S. corporate performance which would allow for a reversal in average trends? Secondly, if the key differences between high- and low-performing firms were not only, or not mainly, 'national' characteristics, what were they, and how could they be verified?

VARIATIONS IN COMPANY PERFORMANCE

All U.S. firms do not in fact grow—or lag—alike. The nation-by-nation categorizations of Table 1 do not tell of the wide, sometimes extraordinarily wide, variation in the performance of individual firms within national or regional headquarters groupings. The story of the notable variation among U.S. (and European) company performance is summarized in Table 2, which relates averages and ranges of average annual compound corporate growth rates (AACGRs) between 1970 and 1980 for U.S., Japanese and European companies.

In four of the five manufacturing industries in which more than one Japanese firm was among the leading competitors, i.e. in autos, steel, non-electrical machinery and textiles, the range of growth performance of U.S. firms was far wider than was that of their Japanese competitors (around their higher means). In a fifth industry, electrical equipment and electronics, there was a nearly identical 10 percentage-point spread between the growth rates of the highest- and lowest-performing U.S. and Japanese firms, albeit the latter had a mean AACGR nearly double that of the former (giving a standard deviation of 24 percent for the Japanese firms versus 32 percent for the U.S. companies).

The range of AACGR performance for European companies taken as a group was, in general, wider still. Even national generalizations within Europe tended to break down when differences between, e.g. high-performing Siemens (with a 1970–80 AACGR of 18.6 percent) and low(est)-performing AEG (11.2 percent) were noted.

In so far as formal statistical tests have meaning when applied to small, within-industry, non-random samples, analyses of variance suggested that the variation between the Japanese and U.S. groups was 'significant' at the 95 percent level in autos and steel, and nearly so in electrical equipment and electronics. From a strategic managerial point of view, however, the issue is arguably less 'does Japanese-ness count', than 'if it does, what were they doing', and perhaps even more, 'why is it that in some sectors, *some* U.S. and European companies were doing as well or better than their Japanese challengers?' For indeed, in eight sectors, including six of generalized 'U.S.' decline, at least one large U.S. firm's growth performance during the decade of the 1970s approximately equaled or even exceeded that of the average performance of its principal non-U.S. competitors. Table 2 shows that at least one U.S. firm did better than the average performance of its foreign challengers not only in computers and aerospace, but also in electrical equipment, chemicals, pharmaceuticals, non-electrical machinery, and even in textiles and steel.

The U.S. firms on the list of high-growth performers during the 1970s relative even to foreign competition included Hewlett-Packard, DEC, United Technologies, Texas Instruments, Dow, SmithKline, Johnson and Johnson, Eli Lilly, Armco, and Deere. A number of these firms have been justly celebrated for their excellence in the U.S. management literature. Yet, apart from the fact that some non-U.S. firms have done better than have some of these companies, tangible, measurable and verifiable specifics on just what it is that has led a few U.S. firms to perform well, while many others have lagged behind, are few and far between. (The work of Rumelt (1974) remains the principal exception to this generalization. But it, and the work of the limited number of authors who have built on it, examines the relationship between corporate strategy, sturcture and performance in mono-national contexts only.)

Nor has there yet been a systematic examination of non-U.S. firms' performance, and the determinants thereof relative to their closest U.S. competitors. The literature has tended to concentrate on anecdotal cases focusing on the organizational processes of 'how things are done' in 'successful' firms, where 'success' is not explicitly measured and is rarely considered in a global context. Less is known about differences in *what* things are done, and about the influence corporate allocative or structural decisions may have on global competitive performance.

IMPLICATIONS FOR EMPLOYMENT AND SHAREHOLDER RETURNS

The question 'which companies are winning, losing and why in global competition', moreover warrants systematic examination on grounds that go far beyond those of casting additional light on 'the U.S. competitiveness problem'. It is not the purpose of the present article to examine the precise nature of the linkages between corporate growth performance, and employment creation and shareholder returns, but linkages clearly exist. Medium- and long-term performance matters greatly both to employees and to shareholders.

As the tests of significance summarized in Table 3, 'Employment change and company

Table 2. Growth in sales of the world's 231 leading companies, 1970–80: national/regional average annual company compound growth rates (ACGRs) and ranges of compound growth rates by industry

Industry		Average ACGR (%)	Range (%)	
Aerospace				
U.S.	(10)	16.5	14.0%	(3.8–17.8%)
Europe	(2)	16.8		(16.3–17.2)
Autos and trucks				
U.S.	(4)	8.2	9.6	(2.3–11.9)
Japan	(3)	20.0	3.1	(18.3–21.4)
Europe	(6)	18.5	21.3	(10.6–23.8)
Banking				
U.S.	(10)	14.1	5.9	(10.9–16.8)
Japan	(7)	22.9	7.0	(21.5–28.5)
Europe	(8)	21.6	12.9	(14.9–27.8)
Canada	(2)	16.8	1.2	(16.2–17.4)
Chemicals				
U.S.	(9)	12.7	13.4	(5.3–18.7)
Europe	(7)	15.6	8.0	(12.2–20.2)
Computers and office equipment				
U.S.	(9)	16.5	23.8	(8.9–32.7)
Europe	(2)	14.9	3.5	(13.2–16.6)
Japan	(1)	19.5		
Electrical equipment and electronics				
U.S.	(9)	10.8	10.3	(7.0–17.3)
Japan	(5)	17.5	10.0	(14.9–24.9)
Europe	(6)	17.9	12.4	(11.3–23.7)
Food and beverage products				
U.S.	(16)	11.8	9.0	(9.4–18.4)
Europe	(3)	15.7	7.0	(13.1–20.1)
Iron and steel				
U.S.	(7)	10.0	10.0	(3.7–13.7%)
Japan	(5)	13.7	3.8	(12.1–15.9)
Europe	(4)	13.7	10.9	(6.9–17.8)
Non-ferrous metals				
U.S.	(6)	11.2	7.8	(6.0–13.8)
Europe	(6)	16.8	9.9	(12.8–22.7)
Non-electrical machinery				
U.S.	(6)	13.1	8.0	(9.0–17.0)
Japan	(2)	14.0	3.2	(12.4–15.6)
Europe	(5)	13.4	9.8	(8.5–18.3)
Paper and paper products				
U.S.	(10)	11.5	9.6	(5.7–15.3)
Europe	(2)	14.9	8.6	(10.6–19.2)
Canada	(1)	12.3		

Table 2. (Continued).

Industry		Average ACGR (%)	Range (%)	
Petroleum products				
U.S.	(11)	20.7	9.1	(16.4–25.5)
Europe	(5)	27.6	9.4	(21.7–31.1)
Pharmaceuticals				
U.S.	(11)	13.5	8.1	(9.7–17.8)
Switzerland	(3)	14.9	4.4	(12.1–16.5)
Japan	(1)	14.3		
Textiles				
U.S.	(10)	8.3	25.5	(−1.7–23.8)
Japan	(4)	8.9	5.2	(5.8–11.0)
U.K.	(2)	9.0	1.4	(8.3– 9.7)
Tires and Rubber				
U.S.	(7)	8.3	5.7	(4.6–10.3)
Europe	(3)	15.0	5.6	(12.2–17.8)
Japan	(1)	19.5		

Figures in parentheses show no. of companies for which data are available.

growth: world's largest companies, 1975–80', show, growth companies, not growth 'sectors', create employment. Poorly performing companies, of whatever nationality, are the *foci* of employment decline. (Whether companies can 'restart' growth through increasing productivity via a 'temporary' decrease in employment is an interesting but separate, and probably shorter-term, question.) When the majority of the poorly performing companies are of one nationality, and when these companies perform poorly even during a time of favorable exchange rate and macroeconomic conditions, poor corporate strategic performance has evident social consequences. The examples of the poor performance of some, but not all, firms in the U.S. electronics and tire industries are cases in point. The obvious corollary would seem to be that corporate performance, and the factors that improve or impede it, ought to be of concern to employees and unions, and not only to corporate strategists and consultants.

Longer-term corporate performance also matters to shareholders. The correlations between total returns to shareholders (dividends plus stock price appreciation, before taxes) and the growth rates of U.S. companies for the period 1970–80 shown in Table 4 indicate that long-term corporate performance does affect shareholder returns, and that it is not fully discounted in advance by an all-foreseeing, strongly efficient securities market. (Comparable data are not available for non-U.S. companies. The fact that total returns to shareholders in non-U.S. markets generally exceeded those in the U.S., at the same time as leading non-U.S. firms companies were outperforming U.S. firms in the battle for world market share, is, however, consistent with the notion that superior long-term corporate growth relative to competitors creates shareholder value.) For company managements the message is clearly that shareholder value can indeed be enhanced by high-growth, longer-term strategic performance—or destroyed by poor performance, as the extraordinarily wide range of returns to shareholders among companies *within* individual industry sectors clearly shows.

What, then, may be the tangible, distinguishing characteristics of high- *versus* low-growth firms, of those gaining *versus* those losing world market share?

The following section discusses one possible determinant of global corporate performance: research and development (R&D) spending and

Table 3. Employment, change and company growth*, world's largest companies, 1975–80 (Correlations and regressions of company employment change and average annual compound company sales growth rates, 1975–80)

		Ranges (%)		Correlation coefficient			
Industry	Number of firms	Sales growth (annual)	Employment change (total)	R	R^2	Regression 't' statistic	Significance level (%)
Aerospace	15	25.8	108.1	0.53	0.28	2.27	96
		2.1	−23.7				
Computers and office equipment	15	42.7	336.4	0.83	0.69	5.37	99.99
		9.5	−5.6				
Chemicals	20	18.7	478.8	0.43	0.19	2.04	94.3
		2.3	−53.5				
Electrical equipment and electronics	25	23.9	60.1	0.68	0.46	4.45	99.98
		5.4	−33.4				
Food processing	29	23.7	179.7	0.56	0.32	3.56	99.9
		5.2	−53.2				
Pharmaceuticals	20	25.1	54.7	0.74	0.55	4.67	99.98
		6.7	−26.5				
Tires and rubber	11	21.7	20.4	0.91	0.83	6.67	99.99
		1.0	−38.9				

* Adjusted for significant acquisitions and mergers.

Table 4. Total returns to shareholders and company growth largest U.S. companies, 1970–80 (Correlations and regressions of total returns to shareholders (dividends plus capital gains, before taxes*) at average annual compound rates, 1970–80 and average annual compound company sales growth rates, 1970–80—U.S. companies only)

		Ranges (%)		Correlations coefficient			
Industry	Number of U.S. firms	Sales growth (annual)	Average annual return	R	R^2	Regression 't' statistic	Significance level (%)
Aerospace	13	17.8	28.1	0.45	0.20	1.66	88
		5.6	1.7				
Computers and office equipment	10	57.3	25.3	0.76	0.58	3.33	99
		8.9	1.2				
Electrical equipment and electronics	8	17.2	25.8	0.80	0.64	3.24	98
		7.0	−0.6				
Food processing	19	20.3	26.5	0.49	0.24	2.34	97
		5.7	0.1				
Pharmaceuticals	13	17.6	23.7	0.73	0.53	3.55	95
		10.0	−1.8				
Tires and rubber	7	10.2	4.7	0.71	0.50	2.23	92
		4.6	−7.5				

* As computed by *Fortune* for the period 1970–80. Source: the *Fortune* '500' list for 1980; *Fortune*, May 1981.

intensity.[2] Its findings are based on an investigation of the relationship between corporate R&D intensity and the growth of world-wide consolidated sales during the decade 1970–80.

THE R&D FACTOR IN WORLD-WIDE CORPORATE PERFORMANCE

Our examination of the R&D factor in world-wide corporate performance is based on an analysis of a subset of our corporate 'universe' of the firms included in the construction of Table 1, which consists of the 83 largest companies in six industries: aerospace, electrical equipment, business machines and computers, chemicals, pharmaceuticals and tires and rubber. (Appendix 2 provides a complete listing of companies included in the correlation, regression and graphic analyses presented below. All firms that had ever appeared in the 12 largest in their industry between 1970 and 1980 *and* for which R&D data were available were included in the regressions. In order to have adequate statistical degrees of freedom for multiple regression analyses reported below, the sample for the electrical and electronics industry was expanded to include firms among the largest 25 in that industry.)

These sectors can be analyzed in some depth since the available data allow for reasonably comprehensive comparisons of both R&D spending and performance among major competitors headquartered in different countries during the decade 1970–80. Data availability do not allow systematic statistical testing of R&D and performance relationships in the world motor vehicle and steel industries. However, broadly similar R&D and performance patterns characterize an additional 24 firms examined in these sectors.

Why the commercial R&D factor?

The rationale for testing the relationship between corporate R&D intensity and subsequent sales growth, and thence gains or losses in world market share, derives as much or more from the econometric literature on aggregate economic growth, and from industrial organization economics as it does from that of business policy and corporate strategy. There is a direct path to the notion that corporate R&D matters, if one accepts the key conclusion of investigators of the economic growth processes of industrialized nations, i.e. that technological innovation (and by extension or proxy, business investment in R&D) is *the* leading determinant of economic growth in the twentieth-century industrialized world (Schumpeter, 1934; Denison, 1967; Carré, Dubois and Malinvaud, 1975; Harberger, 1984). If technology is the principal driving force of the growth of industrialized countries, it should also drive the growth of the individual industrial firms based in those countries.

The link between corporate R&D and subsequent firm sales growth has been tested occasionally in the industrial organizations literature, both across and within industries. Results have typically shown both an association between measures of R&D input (or, more rarely, given data availability constraints, patent or innovation output) and firm growth, and a lagged relationship strongly suggestive of a causal relationship going from R&D to growth, and not vice-versa (Scherer, 1976; Mansfield, 1968; Leonard, 1971; Branch, 1973; Odagiri, 1983; Jarrell, 1983; Comanor, 1986). The existing tests, however, all are based on mono-national U.S. (and in one case Japanese) samples. They thus have not been directly related to the question of world-wide, international corporate competition.

In contrast to the direct link posited in the literature of growth and industrial economics, the conceptual frameworks of business policy and strategy tend to treat the role of technology as only one possible influence among many in determining competitive advantage. In the predominantly normative, and especially in the more 'how-to' expositions of the art of business strategy, technology is subsumed or subdivided among many categories. It may be listed as a corporate strength (or weakness), as an element of 'distinctive competence', as a basis for cost leadership or product differentiation, as a barrier to entry facing potential competitors, or as one element among many influencing experience effects which in turn may provide cost advantages and barriers to competitive entry (Porter, 1979, 1980, 1985; Harvard Business School, 1976).

Further subjective categorical distinctions derive from these taxonomies, such as the *a*

[2] A companion piece to this article (Franko, 1989) discusses the (negative) relationship between corporate unrelated diversification strategies and global corporate performance.

priori reasonable, but in practice difficult-to-measure, distinction between process R&D oriented toward cost leadership, and product R&D aimed at differentiation. (Process R&D, for example, may lead to more reliable, accurate manufacturing, and thence to greater product quality and durability that then becomes an element of differentiation, *viz.* Michelin and radial tire development.) Moreover, much strategy conceptualization, and even testing of 'factors leading to corporate success', has focused on competitive conditions facing individual product markets, and thence on managers of corporate subunits such as divisions and SBUs, rather than on *corporate* resource allocation decisions, such as whether to spend or invest more on R&D relative to competition, and their strategic consequences, if any (PIMS, 1979–82). Finally, product or corporate 'success' has perhaps too often been identified with financial return (return on assets or equity) over short time periods, whereas long-term growth and gains in world market share may not only be more appropriate measures of strategic success, but may also lead and determine long-term financial results. (For a review of the literature on the relationship between market share and profitability, see Gale and Buzzell, 1987.)

The results presented below argue that corporate-level resource allocation with respect to R&D does indeed matter, to the point that it is one of the most important factors underlying recent changes in shares of world markets by the world's leading firms. R&D clearly plays no mono-causal role in corporate performance, however, and the richness of clinical and case analysis can provide the 'flesh and blood' around the 'skeleton' of large-sample research.

The conclusions are these

The R&D intensity of individual firms (measured in terms of firms' own-funded R&D spending as a percentage of sales revenues at the beginning of the period(s) covered) is positively and significantly related to subsequent relative worldwide corporate sales growth, and thus to company gains in world market share. This relationship is observable across a broad, and seemingly heterogeneous, range of industries (see Table 5: R&D and corporate performance during the decade 1970–80). The correlations presented in Table 5 test relationships between mid-1970s R&D levels and intensities, and corporate sales growth rates for two periods: the whole 1970–80 decade and the 5-year period 1975–80. Ideally, all tests would relate R&D measures at the beginning of a period to subsequent 5–10-year growth rates in order to test the hypothesis that R&D intensity indeed *leads* growth rather than vice-versa, the argument that something (sales growth) that followed a particular state (R&D intensity) cannot have caused the initial state. The 5-year tests are of this form. Indeed, using 1975 values for R&D intensity rather than 1975–78 averages, a procedure employed to 'smooth' possible business cycle fluctuations in the sales denominator of the fraction, does not materially alter the results. Unfortunately, a comprehensive, comparable set of R&D data is not available for the very beginning of the 1970s, especially for non-U.S. firms. If it can be assumed that ordinal rankings of R&D intensities across firms were as stable in the early part of the 1970–80 decade as they were in its latter half, i.e. that high R&D firms in 1975 were also high R&D firms in 1970, an assumption that appears eminently reasonable both on the basis of the fragmentary data available and subsequent 1975–80 behavior (see Appendix 2 and comments below), then the relationships between mid-1970s R&D indicators and 1970–80 corporate growth rates are also suggestive of a causal link between 'R&D in' and 'corporate growth out'.

R&D spending *relative* to sales is generally much more closely related to growth performance than are *absolute* levels of corporate R&D spending (see Table 6). This in turn suggests that the eventual product or process output of R&D activity is not just a matter of 'dollars or yen spent', but also of how highly firms value R&D activity *relative* to other claims on their resources. This finding is consistent with the assertions of observers of corporate culture to the effect that R&D is not just something one 'does'. Rather, it is a part of the internalized values of people in successful organizations.

In sectors where American firms experienced major losses of world market share during the decade of the 1970s, U.S. firms' R&D intensity was low relative to European *and* to Japanese competitors. This was especially true in the electrical equipment, chemicals and tire and rubber industries (see Table 6). European, but

Table 5. R&D and corporate performance during the decade 1970–80: correlations between worldwide growth and measures of R&D intensity and spending

	Correlation of self-financed R&D as a percentage of sales 1975–78 averages, with				Correlations of absolute R&D spending, 1975, with	
	1970–80 growth		1975–80 growth		1970–80 growth	1975–80 growth
Aerospace	0.65** (10)		0.67** (10)		0.78** (10)	0.78** (10)
Computers and office equipment	0.73** (11)		0.65** (12)		−0.22 (11)	−0.26 (12)
		R&D and 1975–79 Growth				
Chemicals	0.53** (16)		0.75** (16)	0.36 (16)	0.67** (12)	0.49 (16)
Electrical equipment	0.45** (20)		0.27 (20)		0.15 (13)	−0.06 (13)
			0.53**[a] (19)			
Pharmaceuticals	0.47 (15)		0.46 (15)		0.28 (15)	−0.03 (15)
	0.74** (14)		0.56**[b] (14)			
Tires and rubber	0.47 (10)		0.47 (10)		0.47 (9)	0.53 (9)

Figures in parentheses indicate no. of companies.
[a] Excluding AEG.
[b] Excluding Hoffman-LaRoche.
* Statistical significance at the 90 percent level.
** Statistical significance at the 95 percent level.

not Japanese, competitors were more R&D-intensive on average than were U.S. firms in the pharmaceuticals industry. Some of the observed differences in firms' R&D intensities are influenced by different definitions of what exactly constitutes R&D, as well as by different product mixes. Nonetheless, the tangible statistical fact of frequent U.S. underspending on R&D is consistent with the loss of world market share experienced during the 1970s by US-based companies in these sectors. While a number of US firms materially increased their R&D efforts during the early 1980s, the general pattern of US followership in chemicals, electrical equipment and pharmaceuticals has persisted (see Table 6, 1982 data).

U.S. averages, both of firms' R&D intensity and world market growth, obscure important variations in the R&D allocation practices and market performance of U.S. companies. The variation in U.S. growth performance and R&D intensity is especially large in aerospace, pharmaceuticals and electrical equipment, but is also noticeable in chemicals and office equipment.

Extreme variations in U.S. performance and practice also characterize the motor vehicle and steel industries, even though the data do not allow comprehensive statistical comparisons. Some American firms with poor performance records during the 1970s, such as Chrysler and U.S. Steel, had notoriously low R&D intensities relative to both more successful foreign *and* domestic competitors.

Corporate versus government-funded R&D

Results from the electrical equipment, computer, and even the aerospace industry for the 1970–80 decade argue that it is *corporate*-funded and *commercially* oriented R&D that matters for

Table 6. R&D intensity of U.S., European and Japanese firms, 1975–82 company averages and ranges of own-funded R&D to sales ratios, world's largest firms in the electrical equipment, chemicals, pharmaceuticals and tire and rubber industries (percentage)

	1975		1980		1982	
Industry	Average	Range	Average	Range	Average	Range
Electrical equipment and electronics						
U.S. (8)	2.7	1.9/5.7	3.2	2/6.4	4.0	2.2/9.4
Europe (6)	7.7	4/10	7.2	3.6/10.3	6.8	3.7/8.6
Japan (5)	4.4	3.6/5.9	4.0	3.5/4.8	4.6	4.1/5.0
Chemicals						
U.S. (9)	2.7	0.8/4.6	2.6	0.7/4.3	3.5	1.0/5.3
Europe (8)	3.9	2.5/4.9	3.9	2.2/4.6	4.0	2.6/4.8
Pharmaceuticals						
U.S. (11)	5.5	2.5/8.9	5.5	2.7/8.7	6.7	3/10.7
Switzerland (3)	9.6	8/12	9.2	7.9/11.8	9.9	8.2/13
Japan [Takeda]	4.6		5.3		5.3	
			1978			
Tires and rubber						
U.S. (7)			1.5	1.2/2.3		
France [Michelin]			4.0			
U.K.–Italy [Dunlop-Pirelli]			0.5			
Japan [Bridgestone]			2.4			

Figures in parentheses show no. of companies for which data are available.
Source: For non-U.S. firms: *Annual Reports* and Brokerage Reports. For U.S. firms: *Annual Reports*, Brokerage Reports and *Business Week* 'R&D Scoreboard', various annual issues.

global corporate performance. U.S. companies' total R&D activity in these sectors, including governmentally funded projects, sometimes reaches two to three times the levels that are privately funded. Yet world growth performance was consistent with levels of corporate funding: commercially funded and oriented R&D correlates with commercial results.

A considerable body of literature exists which expresses skepticism about the civilian value of possible 'spinoffs' from governmentally funded R&D (Levin, 1982; Lichtenberg, 1986; Melman, 1983; Morse, 1985; Nelson, 1982; Fishlock, 1987; Rowe, 1984). Although much of the debate over the value—or lack therefore—of civilian spinoffs from military R&D is political and polemical, many case-by-case studies suggest that, while linkages between defense and space R&D and commerical output undeniably existed in the initial post-World-War Two period, reliance on government funding has increasingly proved a distraction from commercial markets to the predominantly U.S. (and British) firms relying on it (Nelson, 1982). Case evidence suggests that engineers employed primarily on military projects in an environment dominated by technical specifications and cost-plus contracts have difficulty in operating in commercial environments where product reliability, durability and cost are of greater import (Melman, 1983). Studies of the aerospace industry suggest that linkages between ballistic missile projects and the transport of people and goods are many fewer than were those between bomber and civil aircraft. Moreover, the histories of commercial projects with a 'military' lineage, such as the Boeing 747, an aircraft partly based on a (failed) competition design for what became the Lockheed C-5A military transport, note that vast amounts of private sector R&D funds were required to achieve commercial success (Monery and Rosenberg, 1982: 145).

Studies of global competition in the semiconductor industry are even more categoric: they argue that reliance on military demand and R&D funding by U.S. firms biased these companies toward so-called 'professional' markets and cost-plus contracts, and away from the demands of consumer electronics producers and the rough-and-tumble price-competitive marketplace faced by more commerically successful Japanese firms (Levin, 1982).

Our findings here are consistent with the view that government R&D funding does not provide a solid basis for long-term corporate strategic success. Even among the U.S. aerospace firms, the companies that grew rapidly during the 1970s (prior to the temporary early-1980s U.S. defense build-up) were Boeing and United Technologies, firms that invested the highest proportion of their own funds in R&D, while the R&D activity of low-growth firms such as Lockheed and Grumman depended to a far greater extent on government funding. (Boeing and UT, with 35 percent and 25 percent respectively of their sales coming from government contracts in 1980 were also far less dependent on government markets than were Lockheed, with 81 percent and Grumman with 79 percent.) Among leading *non*-U.S. competitors in computers and electrical equipment and electronics, it is clear that the high-growth gainers of world market share were also those firms that devoted a high proportion of their own resources to R&D (relative to competitors), and not the 'national champions' force-fed on government funds such as ICL (International Computers of the U.K.) or CII–Bull of France.

These firm-level comparisons are consistent with data on *nations*' R&D and economic performance. High-performing Japan has the second-highest proportion, after Switzerland, of *business* funding of total national R&D in the OECD, contrary to one current image of the Japanese government's role in Japanese business. Business in the low-performing U.K. and U.S. funds a relatively low proportion of these nations' R&D efforts (see Table 7).

One characteristic of corporate R&D resource allocation held true for the great majority of the 83 firms from all countries represented in these six industries between 1975 and 1980: R&D/sales levels were remarkably stable over time (see Appendix 2). Ordinal rankings of R&D/sales ratios of firms within industries were even more stable. Notable increases by NCR, Sperry and CDC in computers, a more general move upward among U.S. aerospace firms, and a visible decrease in R&D-to-sales levels by DuPont over the 1970–80 decade were among the exceptions to the rule. This constancy suggests that many managements were setting R&D spending levels more as a function of what they did in the past, rather than setting levels relative to competition, objectives for growth, internationalization, market share, or even reported profit.

Japanese firms' R&D, at least in the electrical equipment and tire industries, appears to be unusually 'productive' in terms of associated growth rates, relative to either the low-spending U.S. firms or to the often higher-spending Continental Europeans. This is in part due simply to the higher overall growth rate of the Japanese home market, and of Asian and other LDC export destinations and production sites during this period, and the great stake of most Japanese firms therein. This 'tailwind boost' to the growth of Japanese firms from the high overall growth of the Japanese market is confirmed by the

Table 7. National data on research and development expenditures, 1975, 1979 and 1983

	Gross R&D expenditures as a percentage of GDP			Of which percentage funded by business		
	1975	1979	1983	1975	1979	1983
U.S.	2.3	2.4	2.7	43	48	49
Switzerland	2.2	2.4	2.4	77	77	77
Germany	2.1	2.3	2.6	53	53	58
U.K.	2.1	2.2	2.2	41	52	42
Netherlands	1.9	1.9	2.0	54	55	46*
France	1.8	1.8	2.1	40	44	42
Sweden	1.8	1.9	2.5	57	57*	61
Japan	1.7	2.0	2.6	65	70	65
Canada	1.0	1.1	1.4	33	42*	39
Italy	0.9	0.8	1.1	55	49*	45

Source: OECD, 1980 and 1987, especially pp. 78 and 79, Technical Annex Tables 1 and 4.
* 1981.

multiple regression results reported in Tables 8 and 9, where both R&D intensity and home market growth rates emerge as significant explanatory variables of the growth of the world's leading electrical equipment and electronics firms. French companies also received a boost from their primary location in a relatively fast-growth market. The unusual 'productivity' of Japanese R&D may also be due to the lower salaries paid to proportionally more numerous R&D personnel in Japan, or to more efficient worldwide technology scanning, licensing and import policies pursued by Japanese firms.

Especially high Japanese (and French) electrical and electronics company growth may also be related to what were extraordinarily high rates of 'capital deepening', or increases in the net fixed capital (NFK) used per employee during the decade, especially between 1975 and 1978. The change in Japanese electrical firms average NFK/employee level, which was $7200 in 1975, to an average of $15,600 by 1980 (versus U.S. average levels of $9300 in 1974 and $14,600 in 1980) provide both a massive boost in the capital stock available to each Japanese worker and, perhaps more importantly, it allowed an extraordinary degree of 'embodiment' of process-oriented R&D results into new plant and equipment. Table 9 shows the very high degree of significance in the correlation between such capital deepening during the latter half of the 1970s and company growth performance in the world electrical and electronics industry.

Analysis of 'outliers'

Other explanations for especially high or low R&D 'productivity' emerge from an examination of the particularly 'over'- and 'under'-performing firms noted on Figures 1 through 6.

In computers and office equipment (Figure 2), the principal 'underperformer' in terms of sales-growth-results for R&D-effort-in was France's CII-Honeywell-Bull. Apart from an upward distortion in that firm's growth figures introduced by French government purchasing preferences,

Table 8. Electrical equipment industry: company growth, R&D intensity and home-market growth (multiple regression of sales growth with R&D intensity and home-market growth rates, world's 20 largest electrical equipment firms)
y = Variable 3 = Company average compound growth rate, 1970–80
$x1$ = Variable 1 = R&D/sales, 1975–78 average
$x2$ = Variable 2 = Home country compound growth rate, 1970–80

Correlation matrix			
1	1.00		
2	−0.347	1.000	
3	0.453**	0.301	1.000
Multiple correlation = 0.444			
Analysis of variance			
Source/DF SS	MS	*F*	
Total 19 499.3			
Reg. 2 221.9	111.0	6.8	
X[1] 1 102.5	102.5	6.3	
X[2] 1 119.4	119.4	7.3	
Resid. 17 277.4	16.3		
Coefficients			
I	B[I]	Variance	*T*-Value
0	−0.286		
1	1.567	0.227	3.290**
2	2.341	0.749	2.705*

* Significant at the 5 percent level.
** Significant at the 1 percent level.

Table 9. Electrical equipment industry: company growth, R&D intensity, capital deepening and home country growth (Multiple regression of sales growth with R&D intensity, percentage change in net fixed capital per employee, 1975–80, and home market growth, 11 of the world's largest electrical firms, four Japanese, four American and three European)
y = Variable 4 = Company average compound growth rate, 1970–80
$x1$ = Variable 1 = R&D/sales, 1975–78 average
$x2$ = Variable 2 = % Change in net fixed capital per employee, 1975–80
$x3$ = Variable 3 = Home country average compound growth rate, 1970–80

Correlation matrix				
1	1.000			
2	0.114	1.000		
3	−0.220	0.110		
4	0.591*	0.692**	0.307	1.000

Multiple correlation = 0.876***

Analysis of variance			
Source/DF SS		MS	F
Total	10 187.1		
Reg.	3 164.0	54.7	16.5
X[1]	1 65.3	65.3	19.7
X[2]	1 73.8	73.8	22.3
X[3]	1 24.8	24.8	7.5
Resid.	7 23.2	3.3	

Coefficients			
I	B[I]	Variance	T-Value
0	0.576		
1	1.335	30.092	4.407***
2	0.022	0.000	4.293***
3	1.584	0.335	2.738**

* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

the impact of CII's technical effort appears to have been blunted by a government-influenced strategic decision to face IBM head-on in the large mainframe, central processing unit segments of the computer market (Doz, 1983). The very substantial R&D intensity of the firms that did grow most rapidly in the industry, notably DEC and Hewlett-Packard, were linked to the identification of new, commercially viable applications and market segments (minicomputers and scientific applications) ignored or underemphasized by IBM and its closes imitators. Once again, the role of the relative *commercial* orientation of a firm's R&D effort is highlighted.

In electrical equipment (Figure 3), the main deviations from the norm are Japanese 'overperformers' due to the factors mentioned earlier, and the underperformance of high-R&D Philips of the Netherlands, AEG of Germany and America's Western Electric, ATT's telecommunications-equipment affiliate. Explanations for Philips' results include its highly complex and 'viscous', nation-and-product matrix organization which long inhibited market-to-laboratory communication, as well as its limited participation in the fast-growing markets and low-cost production sites of the newly industrializing countries (NIC's) in the less developed world (*Business Week*, 30 March, 1981; Franko, 1976, Chapter VIII; Franko, 1983, Chapter V).

AEG's underperformance in the marketplace, and its subsequent disastrous financial results, were related to a combination of overdependence on a product portfolio weighted toward mature, price-competitive consumer goods, a geographical orientation highly biased toward the firm's low-

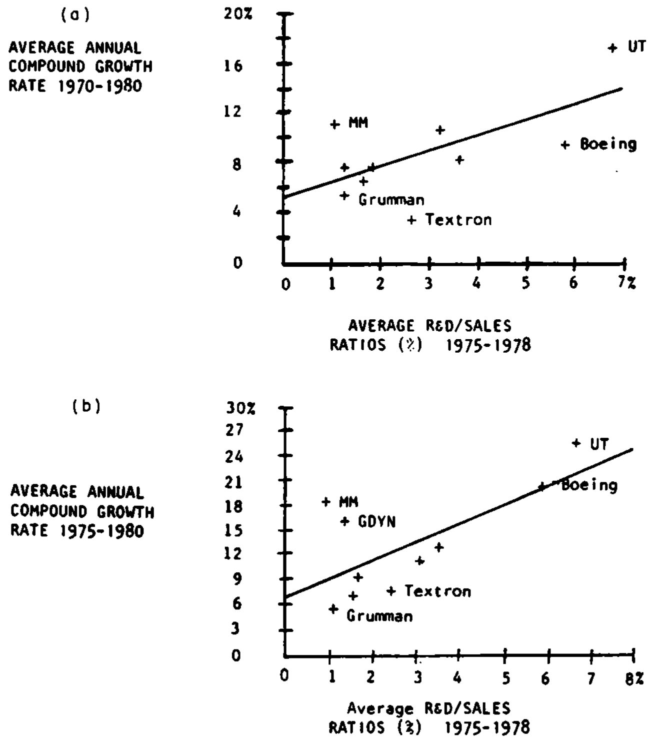


Figure 1. (a) R&D Intensity and growth, 1970–80, Aerospace companies (r=0.65; (b) R&D Intensity and growth, 1975–80, 10 aerospace companies (r=0.67) (Statistically significant at the 95 percent level of confidence.)

growth domestic market and to high-cost German production sites, and a heavy reliance on government R&D funding for nuclear energy projects whose amount, however, was not broken out in the corporate accounts. (This incomparability in the data, i.e. the unavailability of commerical R&D spending for AEG specified separately, is the reason why a separate correlation excluding that firm is reported on Table 5 and Figure 3.) The slow growth of Western Electric was due to its 100 percent ownership by ATT and to it focusing until 1978 solely and exclusively on ATT's slow-growing domestic U.S. needs.

In the chemical industry (Figure 4) major deviations from the norm, as well as the apparent weakening in the relationship between R&D and growth during the last half of the 1970–80 decade, were almost entirely due to the interaction of the second oil price shock of 1980 with certain chemicals companies' diversification into oil production and refining. 'Overperformers' Dow, Allied and BASF benefited handsomely, if temporarily, from increases in sales revenues due to price increases affecting their positions in oil and oil services, approximately 20, 32 and 22 percent of their product portfolios respectively in 1980. Conversely, France's Rhone-Poulenc and AKZO of the Netherlands, both highly R&D-intensive firms, suffered deeply and suddenly both from the recession-induced downturn affecting their significant exposure in the maturing synthetic fiber sector, and from the fact that their fiber and other chemical production depended on suddenly higher-cost naphtha (i.e. oil)-based feedstocks. These firms' American competitors were made less vulnerable to oil shocks by their use of natural gas feedstocks (price-controlled in the U.S.) or by their ownership of sources of oil (see also Franko, 1983, Chapter V). The combined importance of R&D intensity and energy in the product portfolio of the world's 16 leading chemicals firms is evident from the multiple regression results summarized in Table 10. R&D intensity and the percentage of company's

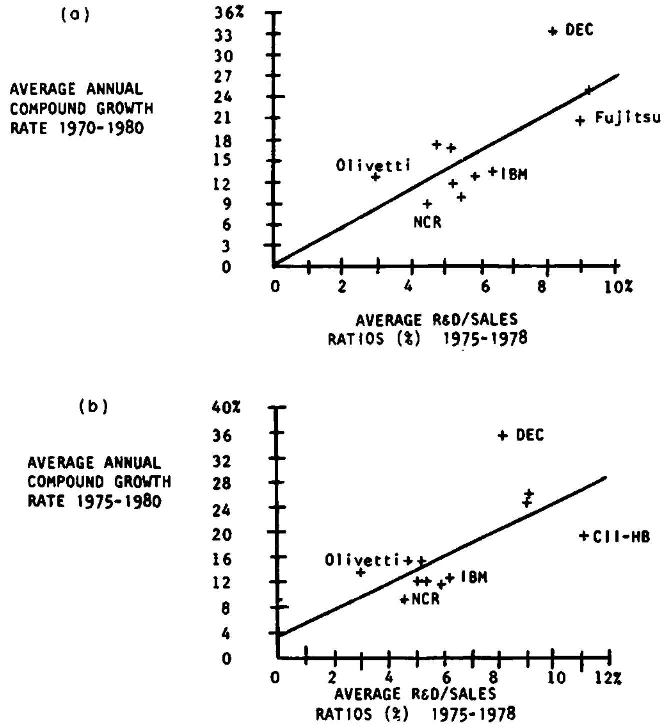


Figure 2. **(a)** R&D Intensity and growth, 1970–80, 11 computer companies (r=0.73); **(b)** R&D Intensity and growth, 1975–80, 12 computer companies (r=0.65) (Statistically significant at the 95 percent level of confidence.)

business in energy are both statistically significant explanatory variables of company growth during the 1970–80 decade (and for the half-decade, 1975–80 as well). It should be further noted that high-performance, R&D-intensive Bayer and Hoechst of Germany have important pharmaceutical divisions whose activities could not be fully assessed separately from the rest of those firms.

In the pharmaceuticals industry *per se*, two major deviants are noteworthy (see Figure 5). One is ultra-high-growth SmithKline which, while having a very high R&D intensity, hit the proverbial jackpot with its anti-ulcer drug Tagamet. The other is low-growth, extraordinarily R&D-intensive Hoffman-La Roche of Switzerland. Roche's *sui generis* performance prompts *sui generis* explanations, of which there are many current in the industry and investment community. Will all this R&D activity some day result in an encore to Roche's once fabulously successful psycho-pharmaceuticals, Librium and Valium, or is it being done just because it has been done that way for a long time? To a certain extent Roche's low performance appears explicable by the same factor as that of Philips: organizational structure. Those familiar with the firm speak of 'national baronies' and of a nation-by-nation 'mother–daughter' structure being used long after supranational marketing communications had become nonetheless clearly desirable. Impermeable organizational barriers also are said to have built up among product groups. The phenomenon of allocating R&D resources to activities which had given a high pay-off in the past, rather than to promising activities for the future, may also have occurred.

In tires and rubber (see Figure 6), the principal 'overperformer' was Bridgestone of Japan, a firm whose growth was boosted by its home-market location in the booming Japanese automotive market. The principal 'underperforming' deviant was Uniroyal, a firm with a middling level of R&D for the industry, but with virtually zero

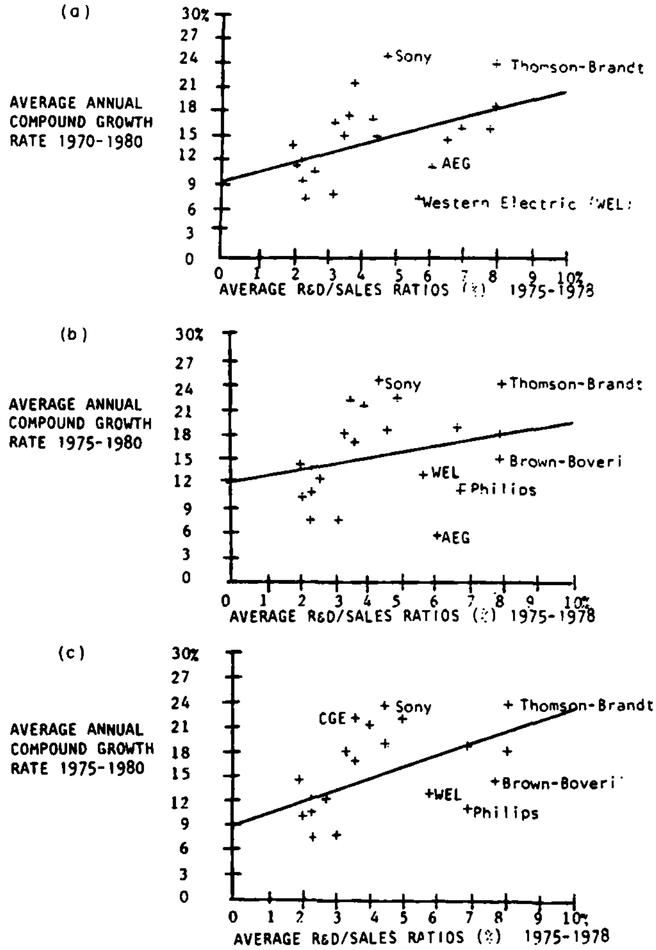


Figure 3. **(a)** R&D Intensity and growth, 1970–80, 20 electrical companies (r=0.45); **(b)** R&D Intensity and growth, 1975–80, 20 electrical companies (r=0.27); **(c)** R&D Intensity and growth, 1975–80, 19 electrical companies (excluding AEG) (r=0.53) (Statistically significant at the 95 percent level of confidence.)

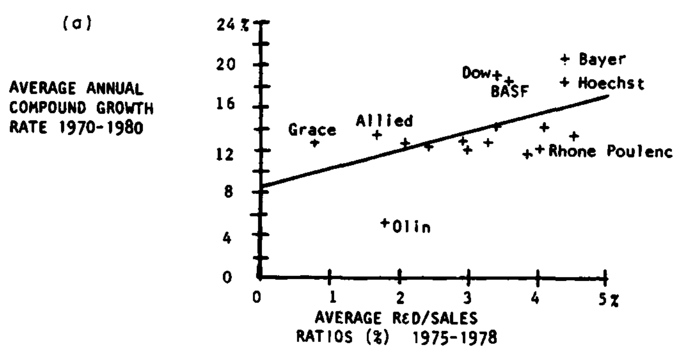


Figure 4. **(a)** R&D Intensity and growth, 1970–80, 16 chemical companies (r=0.53); **(b)** R&D Intensity and growth, 1975–80, 16 chemical companies (r=0.36) (Statistically significant at the 95 percent level of confidence.)

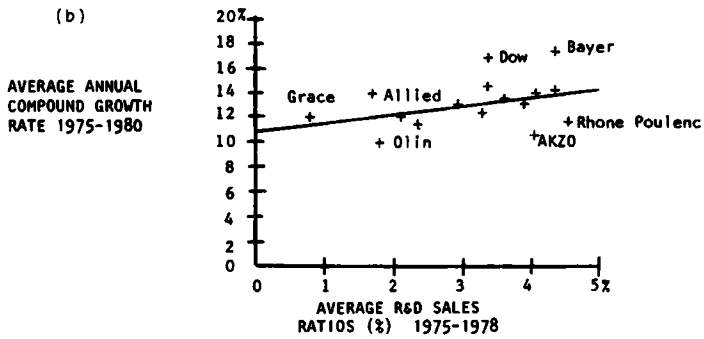


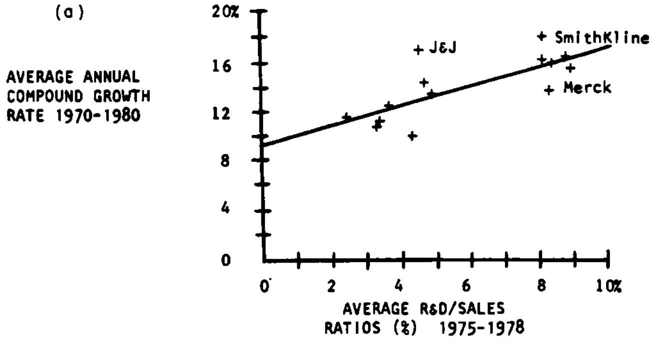
Figure 4. (Continued).

Table 10. Chemical industry: growth, R&D intensity and the influence of oil prices (Multiple regression of sales growth with R&D intensity and the percentage of company sales in oil and oil servcies, 1970–80 and 1975–80, world's 16 largest industrial chemicals firms)
y = Variable 3 = Company average compound growth rate
$x1$ = Variable 1 = R&D/sales, 1975–78 average
$x2$ = Variable 2 = Percentage sales in oil and services, 1980

1970–80 Growth				1975–80 growth			
Correlation matrix				Correlation matrix			
1	1.000			1	1.000		
2	−0.372	1.000		2	−0.372	1.000	
3	0.535**	0.264	1.000	3	0.359	0.338	1.000
Multiple correlation = 0.535**				Multiple correlation = 0.387			
Analysis of variance				Analysis of variance			
Source/DF	SS	MS	F	Source/DF	SS	MS	F
Total 15	192.7			Total 15	65.2		
Reg. 2	103.0	51.5	7.5	Reg. 2	25.2	12.6	4.1
$X(1)$ 1	55.1	55.1	8.0	$X(1)$ 1	8.4	8.4	2.7
$X(2)$ 1	47.9	47.9	6.9	$X(2)$ 1	16.8	16.8	5.5
Resid. 13	89.7	6.9		Resid. 13	40.0	3.1	
Coefficients				Coefficients			
I	B(I)	Variance	T-value	I	B(I)	Variance	T-value
0	5.290			0	8.885		
1	2.344	0.423	3.604***	1	1.044	0.189	2.403**
2	0.188	0.005	2.634**	2	0.112	0.002	2.338**

** = Significant at the 5 percent level.
*** = Significant at the 1 percent level.

growth (indeed negative growth in real, inflation-adjusted terms) during the 1970–80 period. The direct cause of Uniroyal's 'zero growth' was an extensive program of divestment that commenced around 1977, in which the firm disposed of 'businesses with combined sales of more than $1 billion, including nearly all tire operations outside North America and most of its footwear unit' (*Business Week*, 1983: 116). A more fundamental reason for the firm's poor growth, and ultimately its financial losses by the end of the decade, was the dispersion of resources, including the already limited R&D effort, into a great array of unrelated activities. In the mid-1970s the com-



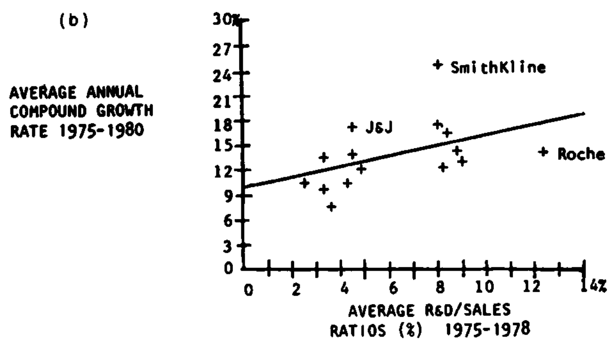


Figure 5. (a) R&D Intensity and growth, 1970–80, 14 pharmaceutical companies (r=0.74) (excluding Hoffman LaRoche); (b) R&D Intensity and growth, 1975–80, 15 pharmaceutical companies (r=0.46) (Statistically significant at the 95 percent level of confidence.)

pany's activities ranged from tires, chemicals and footwear to a 'bevy of businesses' including golf balls and industrial protective clothing. A Uniroyal director was quoted in the early 1980s as saying: 'We were in too many kinds of businesses that required too much management time, and it was a tremendous financial strain' (*Business Week*, 1983: 114).

In contrast to Uniroyal's negative growth, drastic decline in world market share (including withdrawal from the tire business outside of the U.S. altogether), negative returns on assets and equity by 1979, and a brush with bankruptcy in 1980, more focused industry R&D leaders, such as France's Michelin and Japan's Bridgestone, went from strength to strength.

CONCLUSION

Commercially oriented R&D activity, funded out of corporations' own resources, is an important determinant corporate strategic performance relative to competition in a broad range of industries. Relative R&D intensity is thus an important driving force, and predictor of corporate growth. Corporate R&D intensity also emerges as a principal, perhaps *the* principal, means of gaining market share in a global competition.

To be sure, R&D intensity is not the only tangible allocative or structural corporate characteristic associated with global competitive success or failure. Several other candidates for additional research have already emerged above, including firms' geographical market location and orientation, product-portfolio characteristics such as focused versus unrelated diversification strategies, capital deepening and expenditure relative to competitors, and organizational structure. Notwithstanding, a re-emphasis on R&D and technology may be a good place for strategic management of companies desiring to survive global competition to begin.

In five of the six industries examined in detail in this study, the erosion of the world market

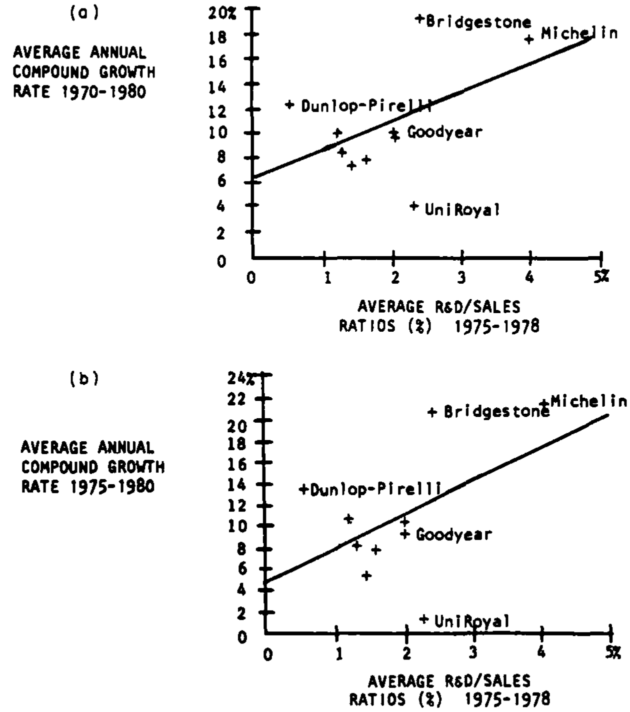


Figure 6. (a) R&D Intensity and growth, 1970–80, 10 tire and rubber companies (r=0.47); (b) R&D Intensity and growth, 1975–80, 10 tire and rubber companies (r=0.47).

share of U.S. firms during the decade of the 1970s is traceable in large measure to the greater intensity and commitment to R&D on the part of a number of Japanese and European competitors. The U.S. firms that *have* survived, or even flourished, in the face of global competitive challenge have been those making a similar or greater commitment.

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APPENDIX 1: THE INTERNATIONAL COMPETITIVE ANALYSIS DATA BASE

The data base underlying the International Competitive Analysis (ICA) research effort includes quantitative and qualitative information for the period 1960–86 on the world's largest corporations in 15 broadly defined industries headquartered in the U.S., Europe, Japan, and other Asian countries.

The units of analysis in this work are firms. Firms based in the same industry and country frequently have widely differing levels of growth and financial performance. Generalizations about nations' 'competitiveness' should be treated with caution: one of the most striking facts to emerge from the data base is its demonstration that gross generalizations about 'U.S.' or 'German' or 'Japanese' industry are excessively simplisitic.

Although many of the world's largest firms have diversified product lines, the bulk of this diversification is 'related' and thus does not obscure major trends. This is particularly the case if firms' product mixes have remained relatively stable over time. In the case of unrelated diversification moves, the choice of such strategies can be examined as a variable explanatory of corporate performance. Corporations are legal, institutional and managerial entities—and report as such. Global corporate competition involves more than what occurs at company subunit (divisional or 'SBU') level, and deserves investigation as such.

The ICA data base focuses on measures and determinants of strategic performance, i.e. success over 5–10-year periods. The data base includes information on companies' growth and financial performance, R&D spending, product portfolios, geographical location profile, organization structures, and capital investment per employee during the period 1970–86. Data sources include *Fortune* U.S. and non-U.S. rankings, *Moody's*, Annual Reports, *Business Week* R&D Scoreboards, and brokerage reports. Special emphasis is placed on compiling data on non-U.S. firms.

Sales, sales growth and market share data summarized in Tables 1 and 2 are based on consolidated, world-wide corporate figures expressed in current U.S. dollars and converted at the exchange rates of the years indicated. This practice might distort 'real' comparisons over short time periods or among purely national companies. (One reason for presenting 1986 figures, in addition to their being recent, is that the effects of an arguably 'overvalued' dollar of 1985 are minimized.) Such is much less likely to be the case with the periods or the firms considered here. Virtually all of the firms covered do (or have the capability to) sell and produce in many currencies, and they use their base currency largely as a *numeraire*. Swiss pharmaceutical companies, for example, keep their accounts in Swiss francs, but some 50 percent of their sales and earnings are dollar-linked, and only 10 percent are in Swiss francs.

APPENDIX 2. R&D-TO-SALES RATIOS OVER TIME

Industry and company	Range of companies' own-funded R&D/sales ratios (%) 1875–80	Trend, 1975–80
Aerospace (*n*=10)		
Rockwell (U.S.)	0.6–3.0[a]	+
United Technologies (U.S.)	5.4–8.3	–
Boeing (U.S.)	4.9–8.1	+
McDonnell Douglas (U.S.)	3.0–4.1	–
Lockheed (U.S.)	1.6–1.7	
Textron (U.S.)	2.0–3.0	+
General Dynamics (U.S.)	0.9–2.3[a]	+
Northrop (U.S.)	2.0–5.6[a]	+
Martin-Marietta (U.S.)	0.4–1.6	
Grumman (U.S.)	0.4–1.7[a]	+
Computers and office equipment (*n*=12)		
Fujitsu (J)	8.0–8.5	
Olivetti (I)	2.5–3.4[a]	
CII-H-Bull (F)	8.1–11.9	–
IBM (U.S.)	5.8–6.6	–
Xerox (U.S.)	4.9–5.4	+
Honeywell (U.S.)	5.0–6.0[a]	+
Sperry (U.S.)	5.0–6.2[b]	+
NCR (U.S.)	3.9–6.0	+
Burroughs (U.S.)	5.8–6.7[a]	
Hewlett Packard (U.S.)	8.4–9.7	–
CDC (U.S.)	4.0–6.6	+
DEC (U.S.)	7.5–9.1	
Electrical equipment (*n*=20)		
Philips (NL)	7.0–7.3	
Siemens (D)	8.0–10.3[b]	
Matsushita (J)	3.5–3.6	
Hitachi (J)	3.7–4.6	–
C.G.d'E (F)	3.6–4.0	
Toshiba (J)	3.4–3.7	
Thomson-Brandt (F)	(9–11)	
AEG (D)	5.7[c]–6.9[c]	+
Brown Boveri (Switzerland)	5.9–9.0	+
NEC (J)	3.0–5.1[b]	+

APPENDIX 2. (CONTINUED)

Industry and company	R&D/sales, 1970	Range of companies' own-funded R&D/sales ratios (%) 1975–80	Trend, 1975–80
Sony (J)		4.3–5.9	+
GE (U.S.)		2.6–3.0[a]	
ITT (U.S.)		1.9–2.7	+
Western Electric (U.S.)		5.4–6.4	+
Westinghouse (U.S.)		2.2–2.3	
RCA (U.S.)		1.9–2.5	
Raytheon (U.S.)		1.9–2.6	+
Texas Instruments (U.S.)		3.7–4.6	+
Motorola (U.S.)		7.5–6.0	
Zenith (U.S.)		3.1–4.0[a]	
Chemicals ($n=16$)	R&D/sales, 1970		
Hoechst (D)	3.6	4.1–4.3	
Bayer (D)	4.9	4.2–4.3	
BASF (D)	4.2	3.5–3.9	
Montedison (I)	2.8	2.0–2.8	
ICI (UK)	3.5	3.2–3.7	
Rhone-Poulenc (F)	4.3	4.2–4.9	
AKZO (NL)	2.8	3.8–4.1	
Dupont (U.S.)	6.9	3.3–4.6[a]	– (to 1979)
Union Carbide (U.S.)	2.6	1.7–2.2	
DOW (U.S.)	4.8	3.0–3.4	
Monsanto (U.S.)	5.0	2.8–3.1	
Grace (U.S.)	1.0	0.7–0.8	
Allied (U.S.)	2.3	1.5–1.9	
Olin (U.S.)	.	1.5–1.9	
American Cyanamid (U.S.)	4.0	3.5–4.1	
Celanese (U.S.)	5.1	2.8–3.4	–
Pharmaceuticals ($n=15$)			
Hoffman-LaRoche (Switzerland)		11.8–13.0	
GIBA-GEIGY (Switzerland)		7.9–8.5	
Sandoz (Switzerland)		8.5–9.0	
TAKEDA (J)		4.4–5.3	
Pfizer (U.S.)		4.7–5.3	+
Merck (U.S.)		7.8–8.7	– (to 1979)
Eli Lilly (U.S.)		7.8–8.5	–
Johnson & Johnson (U.S.)		4.4–4.8	
AHP (U.S.)		2.4–2.7	
Warner-Lambert (U.S.)		3.4–2.9	–
Bristol-Myers (U.S.)		3.4–4.1	
Sterling (U.S.)		3.2–3.4	
Squibb (U.S.)		4.1–4.6	
SmithKline (U.S.)		7.0–8.9	–
Upjohn (U.S.)		8.4–9.0	–
Tires and rubber ($n=10$)			
Michelin (F)		(3.0–4.0)	
Dunlop-Pirelli (U.K.-I)*		(0.6–1.0)	
Bridgestone (J)		(2.4–4.0)	
Goodyear (U.S.)		1.8–2.2	
Firestone (U.S.)		1.4–1.7	
B.F. Goodrich (U.S.)		1.5–2.2	–
Uniroyal (U.S.)		1.6–2.6	–
General (U.S.)		0.8–2.3	+
Armstrong (U.S.)		1.4 2.3	
Cooper (U.S.)		1.1 1.3	

[a] Major step-function increase, 1980.
[b] Major increases 1979 and 1980 from 2.0 to 3.0 range.
[c] Includes substantial, but unknown, government-funded R&D.
[d] Reported as two separate firms in 1970, consolidated in 1975 and 1980.
Note: 'Trends' are indicated when there was a more than 0.5 percent shift over the 6-year period covered.
Figures in parentheses are estimates based on incomplete data.