Innovation and International Corporate Growth

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R&D, Innovation and Growth: Performance of the World's Leading Technology Corporations

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1 R&D, Investment and Growth

Research and development (R&D) and Innovation are the drivers of change and the key determinants of growth in many industries and service sectors. The Industrial R&D Investment Scoreboard commissioned by the European Union provides data for the 2000 largest R&D spenders in Europe, North America and Asia.[1] World industrial spending for R&D has reached a level of € 373 billion and is expected to grow continuously, in spite of the financial turmoil and restructuring of the world economy after 2008.

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[1] European Commission (2008), The 2008 EU Industrial R&D Investment Scoreboard, Seville and Luxembourg.

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Table 1 The World's leading R&D industries 2007

Industry	R&D expenditures 2007 (Mio €)	R&D as % of sales 2007	R&D growth over last 4 years (%)
1. Pharmaceuticals & Biotechnology	71430	16.1	33.0
2. IT-Hardware & Equipment	68191	8.5	23.6
3. Automobiles & Parts	63234	4.2	8.8
4. Software & Computer Services	26624	9.7	27.7
5. Electronics & Electrical Equipment	26094	4.1	10.2
6. Chemicals	16428	2.8	1.5
7. Aerospace & Defence	15109	4.4	25.8
8. Industrial Engineering	11004	2.7	24.1
9. General Industrials	8129	2.1	11.7
10. Healthcare Equipment & Services	6552	6.5	32.3

Source: R&D Scoreboard (BERR, 2008), INTERIS Database University of Hohenheim 2009

As can be seen in Table 1, R&D expenditures are strongly concentrated within a few technology-intensive industries, with the top-five sectors accounting for more than two thirds of global R&D spending: (1) Pharmaceuticals and Biotech, (2) IT Hardware and Equipment, (3) Automobiles and Parts, (4) Software and Computer Services and (5) Electronic and Electrical Equipment. Within each sector, a few large firms with powerful R&D portfolios and strong innovation management capabilities account for the lion's share of resources. R&D and innovation activities of large firms address three types of strategies in mixed combinations: incremental innovation, dynamic growth strategies and industry creation.

1. *Incremental, piecemeal innovation*. In many industries, considerable R&D is required just to keep business going, to continuously renew products and processes and to defend market shares. This is particularly the case in well-established and mature industries. European firms in manufacturing industries often follow such incremental, more defensive types of strategies.
2. *Dynamic growth strategies.* Other industries are characterized as dynamic, fast-growth and high-tech. Firms in these industries need to adapt their portfolio of products and master breakthrough innovation persistently. As a result, the largest part of investment is directed towards new activities, mainly R&D and product development.

3. *Industry creation.* A third component of R&D spending is directed towards the creation of new industries, often a matter of long-term, high-risk investment involving venture capital and corporate diversification. Some of the fastest growing companies among the top R&D spenders did not exist before 1990, and the type of business they are in has been "created from scratch".[2]

European corporations have most strongly emphasized structure-enhancing, incremental R&D activities in established industries such as Automobiles, Chemicals, Electrotechnical Equipment and Industrial Engineering. These are often not the dynamic sectors and not the ones characterized by large increases in R&D spending. Still, these sectors are being transformed continuously and corporations need to be smart in adapting to new technologies, which are often generated in other, more dynamic high-tech sectors.

The strongest increase in R&D spending over the last ten years has occurred in *dynamic, high-tech growth industries*. Growth rates can attain 15–30% per annum, with above-average profitability. In order to participate in these dynamic industries, corporations must invest between 10 and 20% of annual revenues for R&D and the name of the game is speed in product development and efficient innovation management. As a result, the following dynamic industries have made rapid increases in R&D spending and have attracted the awareness of financial investors.

- Pharmaceuticals and Biotechnology,
- IT Hardware and Equipment,
- Software & Computer Services,
- Electronics & Electrical Equipment,
- Healthcare Equipment and Services.

Investments in these dynamic, R&D-intensive industries were mostly dominated by U.S. corporations, and were also targeted by corporations in Asian countries. In many of the most dynamic fields, European investors, with a few exceptions, were not among the high performers and have often lost out to their American and/or Asian rivals. This was particularly the case in Pharmaceuticals and Biotech, in IT Hardware and Equipment, in Semiconductors, as well as in Consumer Electronics.

European corporations have concentrated their R&D efforts in traditional manufacturing industries including Automobiles and Parts, Chemicals, Industrial Engineering and General Industrials. R&D intensities in these sectors tend to be in the range of 2–5% (R&D as percent of revenues). R&D and innovation activities tend to be less dynamic, and annual average rates of growth of R&D are more or less in the range of output growth. Temporary exceptions have been noticed

[2] Take as a prominent example Google, a start-up firm established in the late '90s. This newly created firm is today one of the most valuable American corporations and No. 59 on the list of the world's largest R&D spenders.

in Automobiles and Machinery, where firms had to increase their R&D spending for the absorption of Advanced Electronics, IT and Software. In the fields of Pharmaceuticals, Biotechnology and Healthcare, European firms have increased their efforts, but R&D investments have been concentrated increasingly in North America.

2 When does Innovation Lead to Sustainable Growth?

High-performing innovators effectively manage the full cycle of idea generation, project selection and execution, and they effectively address growth targets in their existing industries or in new, more dynamic market environments. *Innovation excellence* is more than innovation management, involving constant rejuvenation and effective market creation activities, year after year. Some companies have been successful in introducing new products to the market in one generation, but were unable to remain at the leading edge over a longer period of time.[3] Only those companies that continuously invest considerable amounts in R&D, that persistently expand their base of technological capabilities, and that remain at the forefront of new product introductions for successive generations will attain stable growth and strong financial performance. They need to maintain a repetitive cycle of innovation as described in Fig. 1. High margins and above-average returns are fed back into the pipeline, to invest more for R&D than rival firms, and to manage the new product development pipeline effectively year after year.

Innovation-excellent companies have a strong track record of turning innovation inputs (R&D expenditures, ideas and managerial inputs) into strong *innovation competence*. However, innovation competence is a necessary, but non sufficient

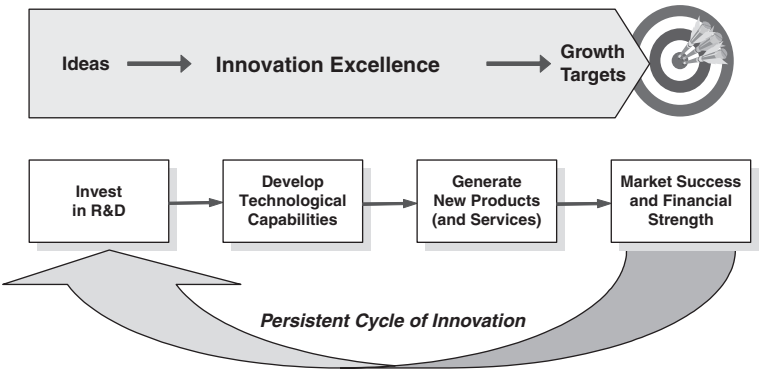

Fig. 1 Innovation excellence: Managing the dynamic cycle of innovation

[3] The term "Innovation excellence" was coined by Arthur D. Little to describe corporations that are persistent high performers in innovation management within their industry. See ADL (2005a,b).

condition for long-term growth and for persistent market success and financial performance. Some important complementary factors, such as strategic direction, organizational capabilities and dynamic interaction with other firms as well as standard-setting activities, are required to effectively attain strong and lasting innovation performance. The whole set of complementary factors can be defined as *dynamic capabilities*, and these are described more precisely below.

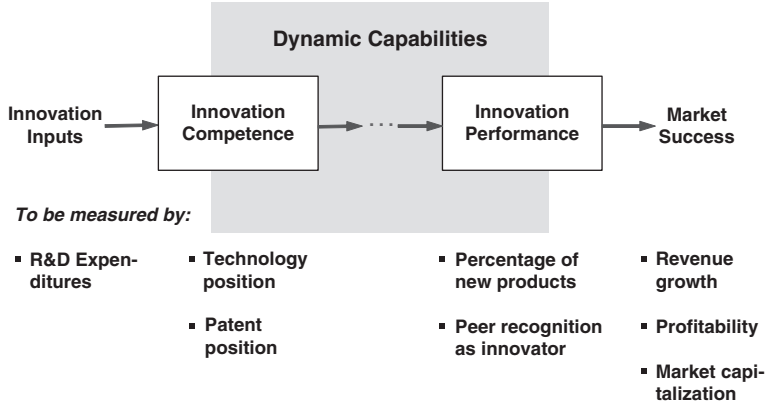

Fig. 2 Dynamic capabilities help to transform innovation competence into market success

Dynamic capabilities within innovation-excellent companies build on strong managerial capabilities at the corporate as well as the business unit level.[4] Innovation is strongly emphasized by corporate strategy and investment policies support expensive and often risky R&D projects. Superb performers have developed effective innovation routines, a strong new product pipeline and the ability to evaluate and absorb risks better than rival firms. Dynamic capabilities must be supported through innovation-enhancing organizational structures, allowing for the effective integration of corporate research as well as R&D performed within the major business units. Corporate capabilities are directed towards promising growth targets and this requires a balancing of priorities between short-term (often financial) objectives and long-term projects. Effective *intra-corporate innovation management* builds on excellence at three simultaneous stages:

1. Excellence in the idea generation and selection process, i.e. the continuous transformation of promising ideas and concepts into sound projects.
2. Excellence in project development and execution and the appropriate balancing of a large number of diverse projects, often attained through effective portfolio management.

[4] See ADL (2005a, 2006), Teece (2007) and Eisenhardt and Martin (2000) for an excellent description of dynamic capabilities within top innovation performing firms.

3. Excellence in turning projects into commercial ventures, in managing business scale-up activities and in generating strong new business units based on internally-generated innovation projects.

Some companies may be strong in idea generation and selection, but they often miss the subsequent stages. Due to failures in project development and portfolio management, they are unable to focus, thus taking on too many projects at a subcritical level. Other companies effectively manage project development and use sophisticated R&D portfolio techniques, but have a rather weak track record for turning completed projects into growing business units. Strong launch and business scale-up capabilities are just as important as excellence in R&D and product development. All three types of competences described by the shaded boxes in the upper part of Fig. 3 need to be developed and implemented simultaneously. Excellence in intra-corporate innovation management requires managing the full cycle of idea generation and selection, R&D project development and portfolio management, as well as a systematic business development and scale-up process.

The most admired innovation performers have implemented an integrated innovation process as an effective routine. Stage-gate processes and firm-specific innovation management routines have been developed extensively over the last ten years. These techniques have often become "standard operating procedures" for many companies and are highly promoted by many management consulting firms.[5]

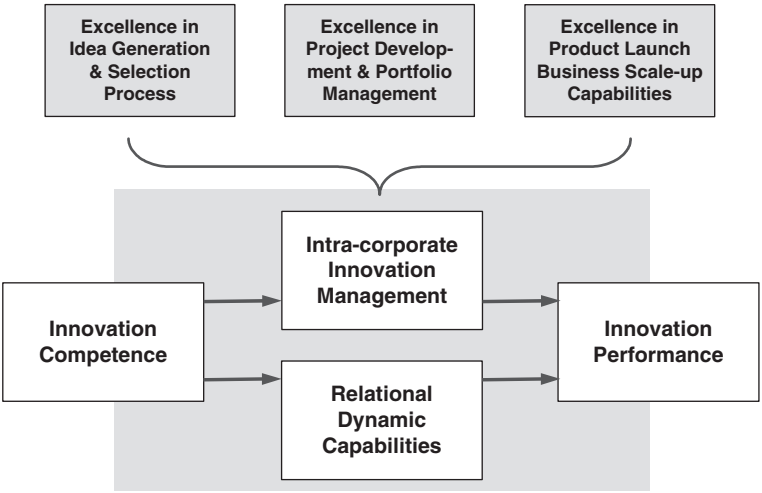

Fig. 3 Intra-corporate dynamic capabilities based on internal innovation management

[5] In a private conversation, Mr. Jaworski, managing director of 3 M in Germany, pointed out "that you can find at least 10 consultants in the neighborhood of Düsseldorf that are ready to implement a new structured innovation process within six months".

As a result, these techniques of innovation process management have turned into a "base competence", a type of "hygiene factor" required to stay in business, but they rarely serve as a differentiator for explaining above-average innovation performance.[6] Managing external relationships and relational dynamic capabilities are often much more difficult to master, as will be described in Sect. 4.

3 Which Companies are the Top Performers in Innovation?

Top performers in innovation are those corporations that manage a persistent stream of new products and services over a longer period of time. They often push the frontier and are considered innovation leaders in their industry. However, the balance between financial performance indicators and innovation-oriented investment projects needs to be mastered. Overstretched R&D budgets can be as bad as underinvestment in new product development.[7] Unfortunately, there are not many systematic studies on the relationship between R&D investment, corporate growth and financial performance. Some specialized consulting companies as well as university-based research centers have developed assessments of corporate innovation performance, however these are often incompatible with respect to the chosen evaluation technique.

- The Boston Consulting Group (BCG) has developed a senior management survey which is published annually. As part of the survey based on subjective assessments, the company asks top managers: "Which three companies do you consider the most innovative and why". As one of the results, BCG publishes a list of the top 50 most innovative global companies.[8] This is based exclusively on extensive in-house research attempting to unveil the innovation-to-cash process.
- Arthur D. Little (ADL) has promoted the concepts of Innovation Excellence and the Innovation Premium. In an earlier study on the Innovation Premium, Jonash and Sommerlatte (1999) analyzed the link between innovation performance and financial performance. ADL has since then published several studies on Innovation Excellence, including a ranking of the most admired innovators (ADL, 2005a,b).
- Booz & Company publishes an annual survey of the 1000 largest R&D spenders, has developed a detailed performance metric and identifies the high-performers among the large R&D spenders in the world. See Jaruzelski and Dehoff (2008, 2007).

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[6] In their study on successful breakthrough innovation in 32 companies, Cotterman et al. (2009) come to a similar conclusion: Stage-gate processes are important but they do no longer serve as a differentiating factor.

[7] See Knott (2009, 2008) for a more recent study on the ambivalent influence of R&D on financial performance indicators.

[8] For the latest ranking see BCG (2009a,b). This study as well as earlier versions (BCG 2008, 2007) can be accessed via the internet.

- Research at the Center for International Management and Innovation at Hohenheim University has led to innovation auditing and innovation performance measurement for the world's largest R&D spenders. The Center tracks the evolution of the Top 100 R&D spenders over time and analyzes the relationship between R&D, sales growth and market capitalization.

In the following, we will analyze R&D investments and innovation performance for the period 1997 to 2007. The R&D expenditures of the top 100 R&D corporations have been increased consistently at an average annual growth rate of 7% over the last 10 years. R&D growth was considerably higher than revenue growth during that period, and was not seriously affected by the recession in 2001/2002. The top 100 firms spent $ 327 billion on R&D in 2007, representing 60% of total business expenditures on R&D.

During the period under investigation, firms from very dynamic high-tech sectors were responsible for large increases in R&D spending, e.g. Software and IT services (386% compound growth between 1997 and 2007), Semiconductors (+291%), Consumer Electronics (+170%) and Pharmaceuticals and Biotechnology (+158%). Firms from these dynamic sectors have significantly improved their position in this ranking. As an example, Microsoft is now No. 1 on the list of leading R&D spenders with an $ 8.2 billion R&D investment budget in 2007. Several dynamic firms which were much further back on the list in 1997, now appear among the top 100. Dynamic Schumpeterian competition drives the quest for R&D and innovation. Large incumbent firms such as ABB, AT&T, Saint Gobain, 3 M and Xerox are no longer on the list of the top 100 R&D spenders in 2007. New entrants in newly created business (Internet services, Network equipment and Biotech companies) have risen to the top, including Amgen, Cisco, Google and Yahoo.

Innovation performance cannot be based solely on growth in R&D spending, however. Reliable evaluations of corporate innovation performance need to take the following into account:

- Long-term and stable investments into most promising R&D projects,
- the build-up of unique pools of knowledge and strong patent positions,
- stable and above-average growth in revenues,
- high percentage shares of new products (introduced during the last 5 years),
- growing market shares and above-average profit margins,
- and, last but not least, considerable increases in market capitalization.

Unfortunately, only a few consistent econometric studies linking these variables have already been published. Investment analysts and industry-specific research organizations certainly use data uncovering these relationships, but exclusively in-house or for their client relationships.[9] As a result, publicly accessible rankings of

[9] Probably the most extensive benchmark studies on R&D performance and "pipeline studies" are carried out in Pharmaceuticals.

the world's most innovative corporations are often based on subjective evaluations, and are typically results of surveys among top managers. These tend to be biased in favour of highly visible firms, often high-tech consumer good producers and, last but not least, on US-based corporations. As an example, the BCG 2008 list of the most innovative corporations in the world contains 35 companies that can be considered as manufacturing firms with heavy involvement in R&D. In addition, the BCG list also contains 15 companies which are service providers investing in innovation, but rarely for dedicated R&D projects. Surprisingly, this last group contains

Table 2 Ranking of the World's 100 largest R&D corporations

	Company	R&D expenditures 2007 ($ million)	CAGR 1997–2007 (in %)	Former rank R&D 1997		Company	R&D expenditures 2007 ($ million)	CAGR 1997–2007 (in %)	Former rank R&D 1997
1	Microsoft	8 164	14.0	32	51	Denso	2 505	7.1	59
2	General Motors	8 100	–0.1	1	52	BT	2 492	16.1	109
3	Pfizer	8 089	13.9	31	53	NTT	2 435	–0.4	19
4	Toyota Motor	7 974	7.8	6	54	Philips Electronics	2 345	1.4	28
5	Nokia Finland	7 721	20.3	68	55	Hyundai Motor	2 343	24.7	201
6	Johnson & Johnson	7 680	12.3	26	56	Fujitsu	2 274	–1.6	13
7	Ford Motor	7 500	1.5	2	57	Texas Instruments	2 155	3.1	41
8	Roche	7 325	12.5	29	58	SAP	2 132	15.1	112
9	Volkswagen	7 198	10.3	20	59	Google	2 120		
10	Daimler	7 147	7.7	8	60	Procter & Gamble	2 112	4.6	53
11	Sanofi-Aventis	6 671	5.6		61	BASF	2 046	3.4	46
12	Samsung Electronics	6 489	21.8		62	Volvo	2 029	5.8	61
13	GlaxoSmithKline	6 461	11.8	34	63	Sun Microsystems	2 023	8.5	78
14	Novartis	6 414	8.8	18	64	Delphi	2 000		
15	Intel	5 755	8.5	21	65	AMD	1 847	13.3	110
16	IBM	5 747	2.6	4	66	Qualcomm	1 829	20.4	178
17	Robert Bosch	5 205	10.0	36	67	LG Electronics	1 802		
18	Matsushita Electric	5 175	4.0	7	68	EMC	1 767	20.8	187
19	AstraZeneca	5 042	7.9		69	Takeda Pharmaceuticals	1 730	10.9	98
20	Honda Motor	4 940	8.9	30	70	Nortel Networks	1 723	–2.0	
21	Alcatel-Lucent	4 924	9.4		71	Infineon Technologies	1 709		
22	Siemens	4 921	0.7	3	72	STMicroelectronics	1 705	10.8	
23	Merck	4 883	10.1	38	73	Sharp	1 699	5.3	70
24	Sony	4 869	7.6	24	74	United Technologies	1 678	3.2	58
25	BMW	4 597			75	Nestle	1 656	10.8	102
26	Cisco Systems	4 499	12.7	57	76	Merck	1 642	12.8	117
27	Motorola	4 429	4.4	12	77	Fuji Film	1 584	9.5	94
28	Ericsson	4 256	3.0	10	78	NXP	1 547		
29	Nissan Motor	4 161			79	Daiichi Sankyo	1 527	17.2	167
30	EADS	3 949			80	Astellas Pharma	1 503	8.0	
31	Bayer	3 867	5.2	23	81	Honeywell	1 459	11.3	113
32	Boeing	3 850	6.5	33	82	Novo Nordisk	1 457	12.4	127
33	Hitachi	3 693	–0.5	5	83	Caterpillar	1 404	9.3	104
34	Hewlett-Packard	3 611	1.4	9	84	Broadcom	1 349		
35	Renault	3 600	8.2	42	85	DuPont	1 338	–5.9	16
36	Toshiba	3 527	2.9	17	86	France Telecom	1 307	3.5	73
37	Eli Lilly	3 487	8.7	49	87	Dow Chemical	1 305	4.7	81
38	Canon	3 296	8.7	50	88	Safran	1 297		
39	Bristol-Myers Squibb	3 282	8.1	47	89	Medtronic	1 275	14.7	161
40	Amgen	3 266	16.1	89	90	Unilever	1 269	3.2	72
41	Wyeth	3 257	7.6		91	Continental	1 231		
42	Peugeot (PSA)	3 032	10.5	66	92	Telstra	1 231	36.2	
43	General Electric	3 009	6.6	43	93	Lockheed Martin	1 206	3.9	80
44	NEC	2 995	1.0	14	94	Royal Dutch Shell	1 201	5.5	87
45	Schering-Plough	2 926	11.9	75	95	Yahoo!	1 195	59.6	
46	Finmeccanica	2 858			96	Mitsubishi Electric	1 188	–1.9	44
47	Oracle	2 741	15.6	97	97	Valeo	1 155	11.7	137
48	Fiat	2 545	6.8	54	98	Electronic Arts	1 145	25.5	
49	Boehringer Ingelheim	2 529	10.5	76	99	Applied Materials	1 142	5.6	90
50	Abbott Laboratories	2 506	6.1	51	100	UCB	1 142		

Table 3 BCG Ranking of the Most Innovative Global Companies

Company		Rank R&D expenditures 2007	Primary reason for selection
1	Apple	124	Breakthrough products
2	Google	54	Unique customer experiences
3	Toyota Motor	4	Innovative processes
4	General Electric	43	Innovative processes
5	Microsoft	1	Breakthrough products
6	Tata Group	295	Breakthrough products
7	Nintendo	272	Breakthrough products
8	Procter&Gamble	60	Innovative processes
9	Sony	24	Breakthrough products
10	Nokia	5	Breakthrough products
11	Amazon	114	Unique customer experiences
12	IBM	15	Innovative processes
13	Research in Motion	261	Breakthrough products
14	BMW	25	Unique customer experiences
15	Hewlett-Packard	34	Innovative processes/new business models/Unique customer experiences
16	Honda Motor	20	Breakthrough products
17	Disney		Unique customer experiences
18	General Motors	2	Breakthrough products
20	Boeing	32	Breakthrough products
22	3 M	138	Breakthrough products
26	Samsung Electronics	12	Breakthrough products
27	AT&T	107	Unique customer experiences
29	Audi		Breakthrough products
31	Daimler	10	Breakthrough products
35	Cisco	26	Breakthrough products
38	Siemens	22	Breakthrough products
42	Exxon Mobil	135	Innovative processes
44	BP	173	Innovative processes
45	Nike		Unique customer experiences
46	Dell	166	New & differentiated business models
47	Vodafone	205	New & differentiated business models
48	Intel	15	Breakthrough products

Source: BCG Senior Executive Innovation Survey (2008, 21)

strong innovators based on the opinion survey completed shortly before the financial turmoil (such as Goldman Sachs, Bank of America, ING and HSBC).[10]

Almost two thirds of the manufacturing firms in the BCG 2008 list also appear on the list of the top 100 R&D spenders. Typical names that tend to have "high visibility" as innovators include Apple, Google, Nokia and 3 M. Big R&D money also

[10] Maybe the quest for innovation in financial derivatives has led some of these firms to accept risks that later resulted in the financial domino game. The most recent ranking published by BCG in April 2009 has thus excluded Goldman Sachs, Bank of America and ING from the list of the most innovative corporations.

supports high innovation as is the case for GE, Toyota, Procter & Gamble, Boeing, Samsung and a number of other big R&D spenders. A few German corporations with brand names are mentioned (BMW, Audi, Daimler and Siemens) on the BCG list. To summarize, this list tends to focus on US-based corporations and a few Asian firms with strong inroads into the U.S. market.

4 Managing Relational Dynamic Capabilities

Successful innovators are often active in turbulent market environments and need to be strong in their adaptive skills as well as in their abilities to deal effectively with other market participants. They must develop and maintain strong external as well as internal capabilities.

> Dynamic capabilities include difficult-to-replicate enterprise capabilities required to adapt to changing customer and technological opportunities. They also embrace the enterprise's capacity to shape the ecosystem it occupies, develop new products and processes, and design and implement new business models. It is hypothesized that excellence in these 'orchestration' capacities undergirds an enterprise's capacity to successfully innovate and capture sufficient value to deliver superior long-term financial performance (Teece, 2007, 1319f).

The power to shape the ecosystem of innovation and the ability to orchestrate and deal effectively with other innovation partners,[11] will be summarized under the term *relational dynamic capabilities*. Innovation excellence builds strongly on these relational capabilities, including the ability to sense, anticipate and influence trends and investment patterns. David Teece (1986) originally emphasized these external or relational innovation success factors, and recently elaborated on this framework (Teece, 2007). Three major factors are most critical for attaining benchmark performance in highly dynamic market environments.

1. The ability to participate and actively influence standard-setting processes and the major evolutionary pattern of a new product, a new technological field or a new business model.
2. The ability to absorb and control intangible assets to create value in environments where these assets are co-produced and distributed. Managing the dynamics of the appropriation game for intellectual property (IP), and effectively coordinating with other owners of tangible assets have become most critical for success and high performance in new product (or service) markets.
3. Finally, success in markets is often dependent on a number of complementary goods or complementary assets. Strategic control of complementary assets and

[11] This includes the whole set of relevant "co-producers" of a complex innovation, including lead customers, innovative suppliers, service providers, regulators, competitors, research centers and universities.

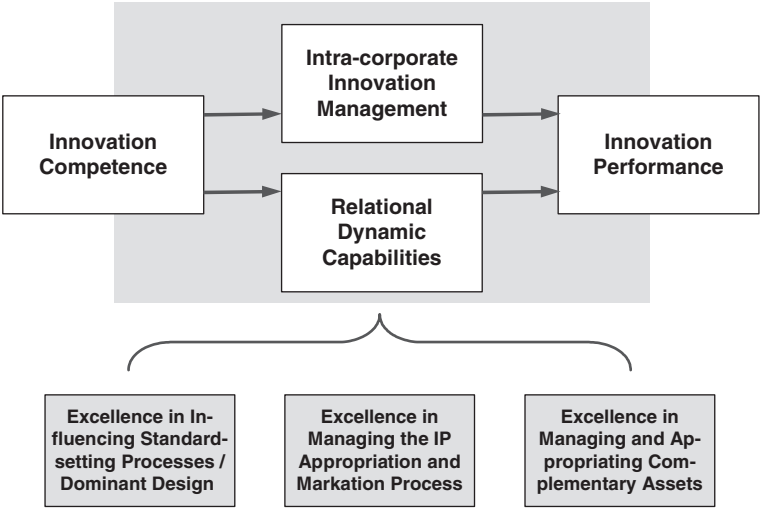

Fig. 4 Success factors related to external dynamic capabilities

the ability to leverage relevant assets owned by other firms often makes the crucial difference between successful and non-successful innovators.

4.1 Standard-Setting Excellence

Most high-tech markets are strongly dependent on the formation of norms and on agreement on standards. In the computer industry, in mobile telecommunication and in factory automation, innovation performance is critically dependent on the ability to influence product standards, interfaces and system configuration agreements. Standards and dominant designs evolve through complex social and political processes. Firms that may be excellent in R&D and technological innovation often lose out by "betting on the wrong horse". This has often been the case for European firms in semiconductors, computers and consumer electronics that were unable to influence the formation process of a strong standard, which, by contrast, was more stringently promoted by corporations in the U.S. or Asia.

Standard setting and R&D activities must be seen as strongly interrelated activities. R&D project selection should be based on criteria such as "likelihood of addressing the winning standard". Successful innovators are thus often forerunners and opinion leaders in informal as well as formal standard-setting consortia. Those who influence winning standards for world markets will attain a much higher market potential and larger sales volumes and will benefit from economies-of-scale, thus enabling themselves to concentrate expensive product-development projects on highly elastic markets allowing for a much higher return on investment.

4.2 Intellectual Property Management

The role of intellectual property in various forms has increased in importance over the last ten years, and markets for intangible assets will be the most important battlegrounds in the future. Pharmaceuticals and Biotechnology are the most outstanding examples where control of patents is often synonymous with blockbuster markets and extremely high profitability. In many other high-tech markets, patents may not be such a powerful weapon, but related forms of IP protection such as trademarks, brands, trade secrets etc. often serve as useful mechanisms for attaining differentiation and innovation success. Various novel forms of IP protection and markation such as labels, domains, internet practices, 3-D brands etc. have been introduced during recent years. As a result, new types of differentiation strategies have evolved and these have extended our repertoire of effective separation mechanisms.

In parallel, Intellectual Property (IP) regulation and litigation in different countries has become a very complicated and often cumbersome process. IP professionals are increasing in numbers (patent attorneys, trademark attorneys and consultants), and this has resulted in secondary markets for IP protection and advice that need to be addressed in parallel to R&D and technology development directed at product markets. As a result, technology-intensive companies must pursue smart IP strategies in combination with their product development efforts. Excellence in managing IP appropriation and markation processes has become the most critical success factor influencing strong innovation performance.

4.3 Managing Complementary Assets

A third, very important approach for managing relational dynamic capabilities builds on interdependencies between products and complementary goods. Successful innovators are smart in leveraging the dynamics of complementary goods. In information technology industries, different building blocs such as servers, PCs, software, various peripheral components as well as networks must be effectively integrated. Firms such as Cisco have grown effectively as solution providers for integrating a whole array of components and complementary assets often provided by other market participants. Another example is the market for Industrial Automation and Manufacturing. The integration of machine-tools requires effective coordination between factory automation systems, hardware, controls, field buses, software, sensors and many other components and technologies. Companies with strong relational capabilities are able to shape the manufacturing ecosystem in their industry.

Successful innovators understand the intricate interdependencies between co-specific assets and are able to benefit from high-margin revenue streams. Classical examples of winning combinations are razors and blades or printers and supplies (ink or toner), where high profit margins are based on (temporary) monopolies for

highly specific complements. Firms like Apple, Microsoft and Cisco are extremely strong in exploiting the dynamics of complementary assets. Apple has been most effective in promoting new combinations of audio, video and mobile communication. It has entered the audio market and the mobile phone business, and has been a forerunner for new combinations of so far unrelated market segments. According to the BCG survey, the company ranks as the most admired innovator in the world.

Cisco was established around twelve years ago as a "bridge-builder", offering new and fast combinations as a problem-solver for customers around the world.[12] The company has recently announced that it will enter the market for servers and challenge companies like IBM, Dell and Hewlett-Packard. Following the strategy of combining and leveraging markets for complementary assets, the most successful corporation is probably Microsoft. This company is one of the most valuable corporations in the world and now heads the list of the world's largest R&D spenders. Microsoft is extremely strong in combining software, network solutions and the internet, up to the point where anti-trust authorities become concerned about complementary goods monopolies.

The dynamics of innovation in complementary goods markets in European companies often follow different routes from those pursued by North-American high-tech firms as just described. European firms often have a stronghold in low- or medium-tech sectors (food, machinery, transportation etc.). Still, these more traditional sectors are being transformed constantly through the application of high-tech based complements, as well as through new system configurations and business models. Siemens has effectively combined new solutions in factory automation, controls, software and digital signalling.[13] Orchestrating new developments in complementary goods markets can consist of integrating diverse components into an effective new business ecosystem. New combinations of goods and services can also exploit upstream as well as downstream complementarities. Leveraging upstream complementary assets is a typical strategy that can be observed in solar power and wind energy. While world markets for solar cells and modules become more and more competitive, special machinery and equipment companies in Germany have expanded successfully into a viable global solar supplier market. On the other hand, many companies in the Machinery industry, in Transportation and Medical equipment are effectively promoting new business models for exploiting complementary assets in downstream activities, building on service strategies, customer solutions and integrated lifecycle management.[14]

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[12] Cisco's logo depicts an artificial variant of the Golden Gate bridge as a symbol for its entrepreneurial role as a bridge builder.

[13] See, for example, the case of Siemens, described by Achatz and Heger in this volume. In the field of Industrial Automation, Siemens focuses its R&D activities on trendsetter projects, for which the corporation can actively influence and shape its ecosystem.

[14] An excellent example can be found in the chapter on innovation at Trumpf by Körber, Buchfink and Völker in this volume.

5 Managing the Dual Cycle of Innovation

The model of innovation outlined above (in Figs. 2 and 3) needs to be complemented by a dual cycle of innovation that we often observe in highly innovative companies. Inducements to innovation come from demanding customers and complementary goods manufacturers as well as from service firms, which often stimulate corporations to think about and develop appropriate new solutions. Certain firms have attained a strong reputation as innovative solution providers in a specific line of business, and they are persistently involved in co-production or in co-innovation activities. Typical examples include

- Cisco, that was founded on the idea of connecting and developing working solutions within the network business. Over the years, the company has developed a unique brand position as innovative problem-solver for large companies worldwide.[15]
- Tetrapak has followed a similar strategy as innovative solution provider to the food and drink business worldwide. This company has developed new packaging solutions and service concepts for the milk and soft-drink business and has consistently expanded into packaging machinery and other lines of business across the world. Tetrapak has also been ranked as a most admired innovator in the ADL (2005) survey.
- A similar strategy was followed by SGL, a specialty carbon and graphite manufacturer from Germany that has gained a good reputation as solution provider to steel and aluminum producers worldwide. In addition, the company builds on core technologies in carbon fiber composites and is constantly developing new technical solutions in automobile companies, for the semiconductor industry as well as for photovoltaic firms.

This dual-cycle strategy of co-producing innovation builds on joint work with demanding lead customers. Pilot projects are used to build a strong reputation as innovative solution providers for similar problems in related industries. Successive projects help to generate a sequence of products and service solutions and a broad base of knowledge about customers and specific applications worldwide. Over the years, the company develops a comprehensive repository of knowledge about customers, problem functionalities and workable solutions.

In Fig. 5, this "secondary" cycle of innovation is outlined in the upper part. Innovation is triggered through projects with demanding customers and the evolutionary path of firms involves (1) reputation building as problem-solver, (2) joint work with a series of lead customers, (3) the continuous generation of new solution and application capabilities used to (4) feed and extend a company-specific repository of knowledge. While this is the predominant innovation cycle for professional service firms, manufacturing-based corporations still rely on the classical

[15] See the case study on Cisco in Jennewein, Durand and Gerybadze (2007) and Jennewein (2005).

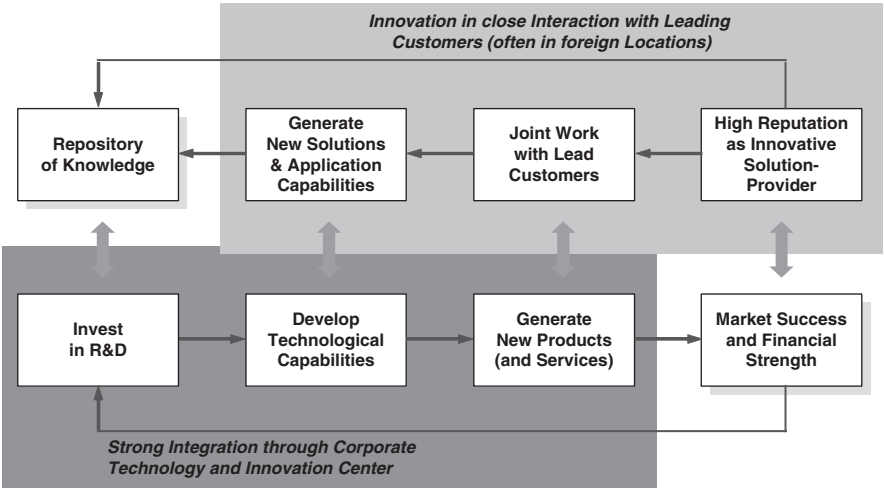

Fig. 5 Effective management of the dual cycle of innovation

cycle of innovation management as outlined in the lower part of Fig. 5, but even these manufacturing firms increasingly emphasize the dual cycle of innovation as a complement.

6 New Forms of Integrated Innovation Management

One of the key themes in most studies on innovation-excellent companies is corporate coherence and strong integration and dedication towards renewal and creative business development. Leading innovators maintain an effective integration between corporate strategy and technology strategy. They strongly emphasize the corporate innovation mission, not just as a statement or lip-service, but as a sustained effort to "push the innovation frontier". And this strong mission must be implemented with similar efforts at all levels of the corporation (corporate units, business units and major product groups). Most companies considered as the admired innovators in their industry follow *one* stringent innovation mission, which is coherently implemented at all levels of the firm.

This innovation mission may often be in conflict with efficiency and with capital market priorities. Financial investors and stock markets put pressure on quarterly earnings and short-term profits, and the CEOs of large corporations are under extreme pressure to optimize financial performance and to focus on balance-sheet optimization. As a result, finance-minded managers and hardcore cost-cutters often rise to the top and leave more long-term oriented projects for innovation and business renewal by the wayside. Sustainable innovation leaders, however, need strong CEOs who actively support the mission for renewal and long-term growth without neglecting their capabilities to deal with short-term capital market pressures. Not

surprisingly, some of the most admired innovators are still led by owner managers who can emphasize corporate mission and who serve as an integrator within the company. Take as an example Microsoft, Apple, Samsung, Cisco and Dell, where family owners still play a dominant role. In a similar way, mid-size companies with strong innovation performance in Europe are often influenced by the sustained efforts of a dominant entrepreneurial figurehead.[16]

While CEOs and CFOs have to follow mainly financial missions and need to be supportive of innovation, the prime responsibility rests with the Chief Technology Officer (CTO) or the Senior Vice President of R&D. Most large R&D-intensive corporations have introduced the role of a CTO as a new position. However, CTOs are often not in the center of the power game. There are significant differences with respect to the role, responsibilities and the strength of the CTO across large corporations.[17] After a phase of implementing this CTO role, many companies have even undermined their position, and in a number of large firms, the CTO is no longer a member of the Executive Board. This tendency is in stark contrast to the increasing role played by R&D and the innovation mission. Corporations that remain at the forefront of technological change and innovation need to have a strong CTO, who serves as the network node between the CEO and the major R&D units and innovation projects. Most innovation-excellent companies, such is our hypothesis, need to place strong priority on the CTO function and should select a strong leader to serve as a corporate-wide integrator.

Large investments in R&D are critical requirements for success, but they are not a sufficient condition. R&D budgets are often diluted over too many activities and it is critical to manage an effective mechanism for selecting and implementing large strategic projects.[18] Strong innovators select a limited number of "corporate projects" or "top-priority projects", and these need to be managed and governed appropriately, with top management support, strong project managers and an effective stage-gate process leading to the effective launch of large and growing new business units. A typical form of how effective innovation project management can be implemented within the corporate hierarchy is described in Fig. 6.

The multitude of projects pursued in many R&D-intensive companies and the need to permanently adapt projects to changing technological and market priorities requires the implementation of a strong steering committee as a governance body. Most innovation-excellent companies have one corporate-wide steering group overseeing the major projects and initiatives. In very research-intensive companies, we often find a differentiation between a research committee and an additional group responsible for major business development activities. Corporate research

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[16] Take, as an example, the innovation success story of Trumpf and the strong role of the majority owner, Mr. Leibinger.

[17] See the Global Benchmark Survey of Strategic Management of Technology that provides a survey of the role CTOs play in American, European and Japanese firms in Roberts (2001).

[18] See Cooper (2009) and ADL (2005a), who emphasize the role of "Strategic buckets" and "top-priority projects".

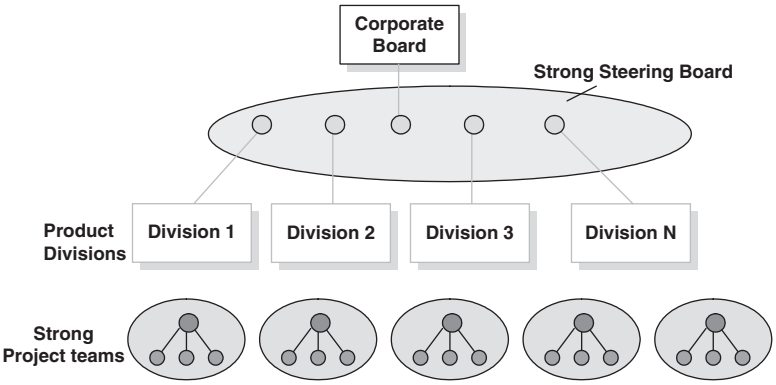

Fig. 6 Organizing for innovation

committees are typically headed by the CTO and involve the major members of the large R&D laboratories. For projects with a more direct commercial orientation, the corporate steering committee is often headed by the CEO himself, or alternatively by the CTO. The general managers of the major business units are regular members of this committee and they will ensure that strategic projects are transferred appropriately to the manufacturing as well as marketing and sales organizations.

7 Integrated Design and Corporate Intellectual Property Management

Another characteristic of integrated innovation management involves design and the integrity of form and content. Many of the leading corporations in product innovation are also leaders in design. An annual contest for industrial design takes place in different countries, and the International Forum on Design (IFF) has published a ranking of the Top 100 corporations, in terms of product design. Many of the corporations considered as leaders in industrial design such as Apple, Samsung and Sony also rank high in terms of R&D spending and innovation excellence. There seems to be a reason behind this phenomenon: top-level innovators have a clear mission and this mission is communicated from top to bottom and across the world: we develop and manufacture new products that customers like and that are impressive at first sight. Such corporations with integrated design gain a strong reputation, earn above-average returns, and these are used to fund the next generation of breakthrough products.

Corporate design is linked to the industrial design of products which again is linked to well-formulated technical and esthetic design attributes. Advanced corporations follow a “gestalt principle”, a coherent logic, which applies similarly to the design of office buildings, the layout of equipment in factories and the form of

products. Finally, this corporate design idea extends to chosen colors and symbols, which are used in brochures, presentations, business cards etc. This "gestalt principle" is extended to the R&D function and many of the leading innovators develop new products that can instantly be recognized as products of this particular company. Think of Apple or Sony, where similar design ideas are applied for quite a diverse set of products. Similar principles apply for the use of colors, e.g. blue for IBM or magenta for Telekom. This integrated view of innovation and design has become a typical characteristic of large innovation pioneers from the U.S. and Asia, and it is also a typical strategy for medium-sized innovators from Europe, who follow very intelligent design principles.[19] Design and branding help to create uniqueness and company specificity.

Just as technical functions are connected to esthetic functions, different forms of intellectual property, such as trademarks, copyrights, labels, logos, etc. are mobilized together with more technical IP rights (product and process patents). A new field of integrated intellectual property management emerges, which is effectively developed by leading innovative corporations. In contrast to more traditional approaches, where firms employed patent attorneys in their patent department, trademark specialists in marketing, and a number of other specialists in the legal department dealing with diverse aspects of intellectual property, this has now become a much more integrated managerial function that needs to be located very close to headquarters. Corporations like IBM, Siemens or Samsung that manage large patent portfolios are developing a more integrated approach to intellectual property management, and this is becoming a rather large headquarter function, often under the leadership of the CTO. As effective intellectual property management is becoming as important as R&D management, this organizational capability is developing into a major factor for explaining advanced innovation performance.

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[19] On the list of top international design firms, we find companies such as Miele, Hilti, Hansgrohe, Festo and Kärcher, all of which follow integrated innovation and design strategies.

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