OPERATIONS MANAGEMENT

Building Effective R&D Capabilities Abroad

by Walter Kuemmerle

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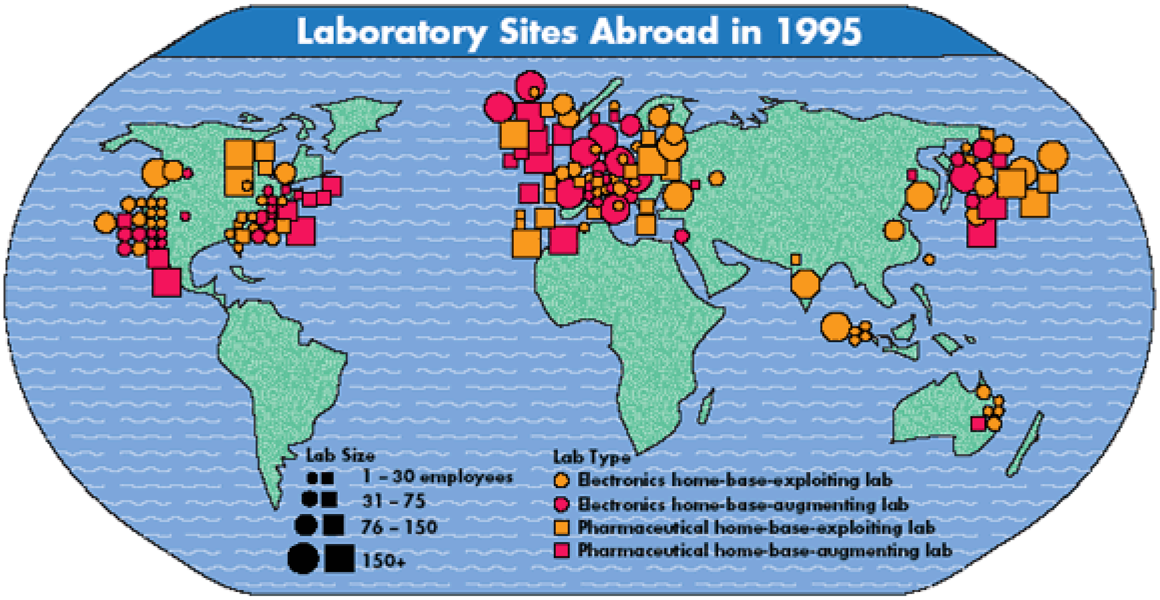
An increasing number of companies in technologically intensive industries such as pharmaceuticals and electronics have abandoned the traditional approach to managing research and development and are establishing global R&D networks in a noteworthy new way. For example, Canon is now carrying out R&D activities in 8 dedicated facilities in 5 countries, Motorola in 14 facilities in 7 countries, and Bristol-Myers Squibb in 12 facilities in 6 countries. In the past, most companies—even those with a considerable international presence in terms of sales and manufacturing—carried out the majority of their R&D activity in their home countries. Conventional wisdom held that strategy development and R&D had to be kept in close geographical proximity. Because strategic decisions were made primarily at corporate headquarters, the thinking went, R&D facilities should be close to home.

But such a centralized approach to R&D will no longer suffice—for two reasons. First, as more and more sources of potentially relevant knowledge emerge across the globe, companies must establish a presence at an increasing number of locations to access new knowledge and to absorb new research results from foreign universities and competitors into their own organizations. Second, companies competing around the world must move new products from development to market at an ever more rapid pace. Consequently, companies must build R&D networks that excel at tapping new centers of knowledge and at commercializing products in foreign markets with the speed required to remain competitive. And more and more, superior manufacturers are doing just that. (See the exhibit "Laboratory Sites Abroad in 1995.")



Laboratory Sites Abroad in 1995

In an ongoing study on corporate strategy and the geographical dispersion of R&D sites, I have been examining the creation of global research networks by 32 U.S., Japanese, and European multinational companies.[1] The most successful companies in my study brought each new site's research productivity up to full speed within a few years and quickly transformed knowledge created there into innovative products. I found that establishing networks of such sites poses a number of new, complex managerial challenges. According to my research, managers of the most successful R&D networks understand the new dynamics of global R&D, link corporate strategy to R&D strategy, pick the appropriate sites, staff them with the right people, supervise the sites during start-up, and integrate the activities of the different foreign sites so that the entire network is a coordinated whole.

Adopting a Global Approach to R&D

Adopting a global approach to R&D requires linking R&D strategy to a company's overall business strategy. And that requires the involvement of managers at the highest levels of a company.

Creating a Technology Steering Committee.

The first step in creating a global R&D network is to build a team that will lead the initiative. To establish a global R&D network, the CEOs and top-level managers of a number of successful companies that I studied assembled a small team of senior managers who had both technical expertise and in-depth organizational knowledge. The technology steering committees reported directly to the CEOs of their respective companies. They were generally small—five to eight members—and included managers with outstanding managerial and scientific records and a range of educational backgrounds and managerial responsibilities. The committees I studied included as members a former bench scientist who had transferred into manufacturing and had eventually become the head of manufacturing for the company's most important category of therapeutic drugs; a head of marketing for memory chips who had worked before in product development in the same electronics company; and an engineer who had started out in product development, had moved to research, and eventually had become the vice president of R&D. Members of these committees were sufficiently senior to be able to mobilize resources at short notice; and they were actively involved in the management and supervision of R&D programs. In many cases, members included the heads of major existing R&D sites.

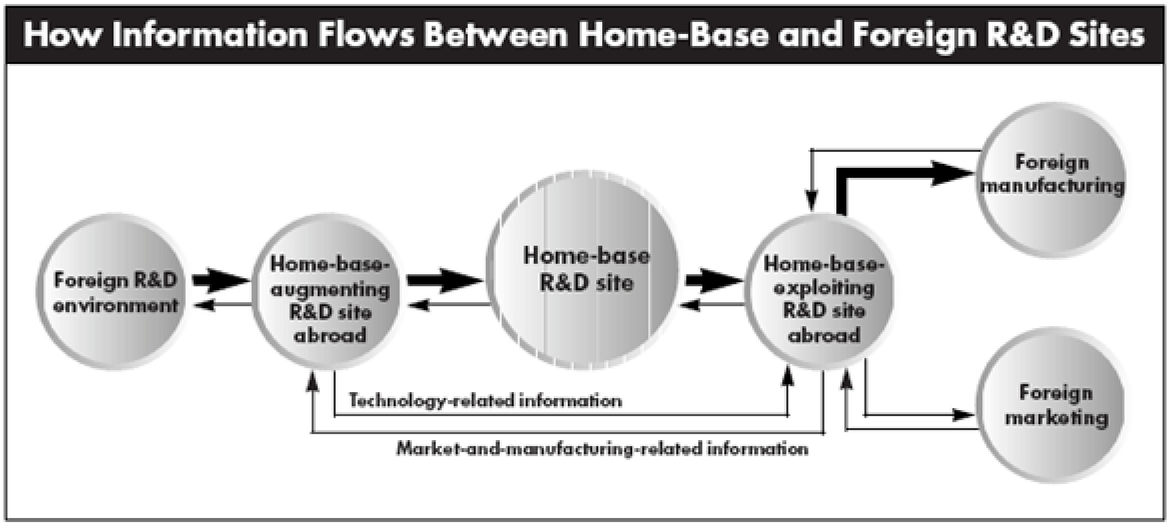
Categorizing New R&D Sites.

In selecting new sites, companies find it helpful first to articulate each site's primary objective. (See the exhibit "Establishing New R&D Sites.") R&D sites have one of two missions. The first type of site —what I call a *home-base-augmenting site*—is established in order to tap knowledge from competitors and universities around the globe; in that type of site, information flows *from* the foreign laboratory *to* the central lab at home. The second type of site—what I call a *home-base-exploiting site*—is established to support manufacturing facilities in foreign countries or to adapt standard products to the demand there; in that type of site, information flows *to* the foreign laboratory *from* the central lab at home. (See the exhibit "How Information Flows Between Home-Base and Foreign R&D Sites.")

Establishing New R&D Sites

Types of R&D Sites	Phase 1 Location Decision	Phase 2 Ramp-Up Period	Phase 3 Maximizing Lab Impact
Home-Base-Augmenting Laboratory Site Objective of establishment: absorbing knowledge from the local scientific community, creating new knowledge, and transferring it *to* the company's central R&D site	–Select a location for its scientific excellence –Promote cooperation between the company's senior scientists and managers	–Choose as first laboratory leader a renowned local scientist with international experience – one who understands the dynamics of R&D at the new location –Ensure enough critical mass	–Ensure the laboratory's active participation in the local scientific community –Exchange researchers with local university laboratories and with the home-base lab
Home-Base-Exploiting Laboratory Site Objective of establishment: commercializing knowledge by transferring it *from* the company's home base to the laboratory site abroad and from there to local manufacturing and marketing	–Select a location for its proximity to the company's existing manufacturing and marketing locations –Involve middle managers from other functional areas in start-up decisions	–Choose as first laboratory leader an experienced product-development engineer with a strong companywide reputation, international experience, and knowledge of marketing and manufacturing	–Emphasize smooth relations with the home-base lab –Encourage employees to seek interaction with other corporate units beyond the manufacturing and marketing units that originally sponsored the lab

Establishing New R&D Sites



How Information Flows Between Home-Base and Foreign R&D Sites

The overwhelming majority of the 238 foreign R&D sites I studied fell clearly into one of the two categories. Approximately 45% of all laboratory sites were home-base-augmenting sites, and 55% were home-base-exploiting sites. The two types of sites were of the same average size: about 100 employees. But they differed distinctly in their strategic purpose and leadership style.[2] (See the sidebar "Home-Base-Augmenting and Home-Base-Exploiting Sites: Xerox and Eli Lilly.")

Home-Base-Augmenting and Home-Base-Exploiting Sites: Xerox and Eli Lilly

The particular type of foreign R&D site determines the specific challenges managers will face. Setting up a *home-base-augmenting site*—one designed to gather new knowledge for a company—involves certain skills. And launching a *home-base-exploiting site*—one established to help a company efficiently commercialize its R&D in foreign markets—involves others. The cases of Xerox and Eli Lilly present an instructive contrast.

Choosing a Location for the Site.

Home-base-augmenting sites should be located in regional clusters of scientific excellence in order to tap new sources of knowledge. Central to the success of corporate R&D strategy is the ability of senior researchers to recognize and combine scientific advancements from different areas of science and technology. Absorbing the new knowledge can happen in a number of ways: through participation in formal or informal meeting circles that exist within a geographic area containing useful knowledge (a knowledge cluster), through hiring employees from

Xerox established a home-base-augmenting laboratory in Grenoble, France. Its objective: to tap new knowledge from the local scientific community and to transfer it back to its home base. Having already established, in 1986, a home-base-augmenting site in Cambridge, England, Xerox realized in 1992 that the research culture in continental Western Europe was sufficiently different and complementary to Great Britain's to justify another site. Moreover, understanding the most advanced research in France or Germany was very difficult from a base in Great Britain because of language and cultural barriers. One senior R&D manager in the United States notes, "We wanted to learn firsthand what was going on in centers of scientific excellence in Europe. Being present at a center of scientific excellence is like reading poetry in the original language."

It was essential that managers from the highest levels of the company be involved in the decision-making process from the start. Senior scientists met with high-level managers and entered into a long series of discussions. Their first decision: to locate the new laboratory at a center of scientific excellence. Xerox also realized that it had to hire a renowned local scientist as the initial laboratory leader. The leader needed to be able to understand the local scientific community, attract junior scientists with high potential, and target the right university institutes and scholars for joint research projects. Finally, Xerox knew that the laboratory would have an impact on the company's economic performance only if it had the critical mass to become an accepted member of the competitors, or through sourcing laboratory equipment and research services from the same suppliers that competitors use.

For example, the Silicon Valley knowledge cluster boasts a large number of informal gatherings of experts as well as more formal ways for high-tech companies to exchange information with adjacent universities, such as industrial liaison programs with Stanford University and the University of California at Berkeley. In the field of communication technology, Siemens, NEC, Matsushita, and Toshiba all operate laboratory sites near Princeton University and Bell Labs (now a part of Lucent Technologies) to take advantage of the expertise located there. For similar reasons, a number of companies in the same industry have established sites in the Kanto area surrounding Tokyo. Texas Instruments operates a facility in Tsukuba Science City, and Hewlett-Packard operates one in Tokyo.

After a company has picked and established its major R&D sites, it might want to branch out. It might selectively set up secondary sites when a leading competitor or a university succeeds in building a critical mass of research expertise in a more narrowly defined area of science and technology outside the primary cluster. In order to benefit from the resulting miniclusters of expertise, companies sometimes establish additional facilities. For that reason, NEC operates a small telecommunications-oriented R&D facility local scientific community. At the same time, it could not become isolated from the larger Xerox culture.

Xerox considered a number of locations and carefully evaluated such aspects as their scientific excellence and relevance, university liaison programs, licensing programs, and university recruiting programs. The company came up with four potential locations: Paris, Grenoble, Barcelona, and Munich. At that point, Xerox also identified potential laboratory leaders. The company chose Grenoble on the basis of its demonstrated scientific excellence and hired as the initial laboratory leader a highly regarded French scientist with good connections to local universities. Xerox designed a facility for 40 researchers and made plans for further expansion. In order to integrate the new laboratory's scientists into the Xerox community, senior R&D management in Palo Alto, California, allocated a considerable part of the initial laboratory budget to travel to other Xerox sites and started a program for the temporary transfer of newly hired researchers from Grenoble to other R&D sites. At the same time, the Grenoble site set out to integrate itself within the local research community.

In 1989, Eli Lilly considered establishing a home-base-exploiting laboratory in East Asia. The company's objective was to commercialize its R&D more effectively in foreign markets. Until then, Eli Lilly had operated one home-base-augmenting laboratory site abroad and some small sites in industrialized countries for clinical testing and drug approval procedures. But in order to exploit Lilly's R&D capabilities and product portfolio, the company needed a dedicated laboratory site in East Asia. The new site would support efforts to

close to a university laboratory in London, and Canon operates an R&D facility in Rennes, France, close to one of France Telecom's major sites.

Home-base-exploiting sites, in contrast, should be located close to large markets and manufacturing facilities in order to commercialize new products rapidly in foreign markets. In the past, companies from industrialized countries located manufacturing facilities abroad primarily to benefit from lower wages or to overcome trade barriers. Over time, however, many of those plants have taken on increasingly complex manufacturing tasks that require having an R&D facility nearby in order to ensure the speedy transfer of technology from research to manufacturing. A silicon-wafer plant, for example, has to interact closely with product development engineers during trial runs of a new generation of microchips. The same is true for the manufacture of disk drives and other complex hardware. For that reason, Hewlett-Packard and Texas Instruments both operate laboratories in Singapore, close to manufacturing facilities.

The more complex and varied a manufacturing process is, the more often manufacturing engineers will have to interact with product development engineers. For example, in the case of one of Toshiba's laptop-computer-manufacturing plants, a new model is introduced to the manufacturing line every two weeks. The introduction has to happen seamlessly, without manufacture and market pharmaceuticals by adapting products to local needs. To that end, the management team decided that the new laboratory would have to be located close to relevant markets and existing corporate facilities. It also determined that the initial laboratory leader would have to be an experienced manager from Lilly's home base—a manager with a deep understanding of both the company's local operations and its overall R&D network.

The team considered Singapore as a potential location because of its proximity to a planned Lilly manufacturing site in Malaysia. But ultimately it decided that the new home-base-exploiting laboratory would have the strongest impact on Lilly's sales if it was located in Kobe, Japan. By establishing a site in the Kobe-Osaka region—the second-largest regional market in Japan and one that offered educational institutions with high-quality scientists—Lilly would send a signal to the medical community there that the company was committed to the needs of the Japanese market. Kobe had another advantage: Lilly's corporate headquarters for Japan were located there, and the company was already running some of its drug approval operations for the Japanese market out of Kobe. The city therefore was the logical choice.

The team assigned an experienced Lilly researcher and manager to be the initial leader of the new site. Because he knew the company inside and out—from central research and development to international marketing—the team reasoned that he would be able to bring the new laboratory up to speed quickly by drawing on resources from various divisions within Lilly. In order to integrate the new site into disturbing the production of existing models on the same line. In order to predict and remedy bugs during initial production runs, development engineers and manufacturing engineers meet several times a week. The proximity of Toshiba's laptop-development laboratory to its manufacturing plant greatly facilitates the interaction.

Establishing a New R&D Facility

Whether establishing a home-base-augmenting or a home-base-exploiting facility, companies must use the same three-stage process: selecting the best laboratory leader, determining the optimal size for the new laboratory site, and keeping close watch over the lab during its start-up period in order to ensure that it is merged into the company's existing global R&D network and contributes sufficiently to the company's product portfolio and its economic performance.

Selecting the Best Site Leader.

Identifying the best leader for a new R&D site is one of the most important decisions a company faces in its quest to establish a successful global R&D network. My research shows that the initial leader of an R&D site has a powerful impact not only on the culture of the site but also on its long-term research agenda and performance. The two types of sites require different types of leaders, and each type of leader confronts a particular set of challenges.

the overall company, some researchers from other Lilly R&D sites received temporary transfers of up to two years to Kobe, and some locally hired researchers were temporarily transferred to other Lilly sites. It took about 30 months to activate fully the Kobe operation—a relatively short period. Today the site is very productive in transferring knowledge from Lilly's home base to Kobe and in commercializing that knowledge throughout Japan and Asia.

The initial leaders of home-base-augmenting sites should be prominent local scientists so that they will be able to fulfill their primary responsibility: to nurture ties between the new site and the local scientific community. If the site does not succeed in becoming part of the local scientific community quickly, it will not be able to generate new knowledge for the company. In addition to hiring a local scientist, there are a variety of other ways to establish local ties. For example, Toshiba used its memory-chip joint venture with Siemens to develop local ties at its new R&D site in Regensburg, Germany. The venture allowed Toshiba to tap into Siemens's dense network of associations with local universities. In addition, it helped Toshiba develop a better understanding of the compensation packages required to hire first-class German engineering graduates. Finally, it let the company gain useful insights into how to establish effective contract-research relationships with government-funded research institutions in Germany.

In contrast, the initial leaders of home-base-exploiting sites should be highly regarded managers from within the company–managers who are intimately familiar with the company's culture and systems. Such leaders will be able to fulfill their primary responsibility: to forge close ties between the new lab's engineers and the foreign community's manufacturing and marketing facilities. Then the transfer of knowledge from the company's home base to the R&D site will have the maximum impact on manufacturing and marketing located near that site. When one U.S. pharmaceutical company established a home-base-exploiting site in Great Britain, executives appointed as the initial site leader a manager who had been with the company for several years. He had started his career as a bench scientist first in exploratory research, then in the development of one of the company's blockbuster drugs. He had worked closely with marketing, and he had spent two years as supervisor of manufacturing quality at one of the company's U.S. manufacturing sites. With such a background, he was able to lead the new site effectively.

However, the best candidates for both home-base-augmenting and home-base-exploiting sites share four qualities: they are at once respected scientists or engineers and skilled managers; they are able to integrate the new site into the company's existing R&D network; they have a comprehensive understanding of technology trends; and they are able to overcome formal barriers when they seek access to new ideas in local universities and scientific communities.

> The best managers of foreign R& D sites are respected scientists or engineers and, atthe same time, skilled managers.

Appointing an outstanding scientist or engineer who has no management experience can be disastrous. In one case, a leading U.S. electronics company decided to establish a home-base-augmenting site in the United Kingdom. The engineer who was appointed as the first site leader was an outstanding researcher but had little management experience outside the company's central laboratory environment. The leader had difficulties marshaling the necessary resources to expand the laboratory beyond its starting size of 14 researchers. Furthermore, he had a tough time mediating between the research laboratory and the company's product development area. Eleven of the 14 researchers had been hired locally and therefore lacked deep ties to the company. They needed a savvy corporate advocate who could understand company politics and could promote their research results within the company. One reason they didn't have such an advocate was that two of the three managers at the company's home base—people who had promoted the establishment of the new R&D lab—had quit about six months after the lab had opened because they disagreed about the company's overall R&D strategy. The third manager had moved to a different department.

In an effort to improve the situation, the company appointed a U.S. engineer as liaison to the U.K. site. He realized that few ideas were flowing from the site to the home base; but he attributed the problem to an inherently slow scientific-discovery process rather than to organizational barriers within the company. After about two years, senior management finally replaced the initial laboratory leader and the U.S. liaison engineer with two managers—one from the United Kingdom and one from the United States. The managers had experience overseeing one of the company's U.S. joint ventures in technology, and they also had good track records as researchers. Finally, under their leadership, the site dramatically increased its impact on the company's product portfolio. In conjunction with the increase in scientific output, the site grew to its projected size of 225 employees and is now highly productive.

In the case of both types of sites, the ideal leader has in-depth knowledge of both the home-base culture and the foreign culture. Consider Sharp's experience. In Japan, fewer corporate scientists have Ph.D.s than their counterparts in the United Kingdom; instead they have picked up their knowledge and skills on the job. That difference presented a management challenge for Sharp when it established a home-base-augmenting facility in the United Kingdom. In order to cope with that challenge, the company hired a British laboratory leader who had previously worked as a science attaché at the British embassy in Japan. In that position, he had developed a good understanding of the Japanese higher-education system. He was well aware that British and Japanese engineers with different academic degrees might have similar levels of expertise, and, as a result, he could manage them better.

The pioneer who heads a newly established home-base-augmenting or home-base-exploiting site also must have a broad perspective and a deep understanding of technology trends. R&D sites abroad are often particularly good at combining knowledge from different scientific fields into new ideas and products. Because those sites start with a clean slate far from the company's powerful central laboratory, they are less plagued by the "not-invented-here" syndrome. For example, Canon's home-base-augmenting laboratory in the United Kingdom developed an innovative loudspeaker that is now being manufactured in Europe for a worldwide market. Senior researchers at Canon in Japan acknowledge that it would have been much more difficult for a new research team located in Japan to come up with the product. As one Canon manager puts it, "Although the new loudspeaker was partially based on knowledge that existed within Canon already, Canon's research management in Japan was too focused on existing product lines and would probably not have tolerated the pioneering loudspeaker project."

Finally, leaders of new R&D sites need to be aware of the considerable formal barriers they might confront when they seek access to local universities and scientific communities. These barriers are often created by lawmakers who want to protect a nation's intellectual capital. Although foreign companies do indeed absorb local knowledge and transfer it to their home bases—particularly in the case of home-base-augmenting sites—they also create important positive economic effects for the host nation. The laboratory leader of a new R&D site needs to communicate that fact locally in order to reduce existing barriers and prevent the formation of new ones.

Determining the Optimal Size of the New R&D Site.

My research indicates that the optimal size for a new foreign R&D facility during the start-up phase is usually 30 to 40 employees, and the best size for a site after the ramp-up period is about 235 employees, including support staff. The optimal size of a site depends mainly on a company's track record in international management. Companies that already operate several sites abroad tend to be more successful at establishing larger new sites.

Companies can run into problems if their foreign sites are either too small or too large. If the site is too small, the resulting lack of critical mass produces an environment in which there is little cross-fertilization of ideas among researchers. And a small R&D site generally does not command a sufficient level of respect in the scientific community surrounding the laboratory. As a result, its researchers have a harder time gaining access to informal networks and to scientific meetings that provide opportunities for an exchange of knowledge. In contrast, if the laboratory site is too large, its culture quickly becomes anonymous, researchers become isolated, and the benefits of spreading fixed costs over a larger number of researchers are outweighed by the lack of cross-fertilization of ideas. According to one manager at such a lab, "Once people stopped getting to know one another on an informal basis in the lunchroom of our site, they became afraid of deliberately walking into one another's laboratory rooms to talk about research and to ask questions. Researchers who do not know each other on an informal basis are often hesitant to ask their colleagues for advice: they are afraid to reveal any of their own knowledge gaps. We realized that we had crossed a critical threshold in size. We subsequently scaled back somewhat and made an increased effort to reduce the isolation of individual researchers within the site through communication tools and through rotating researchers among different lab units at the site."

Supervising the Start-Up Period.

During the initial growth period of an R&D site, which typically lasts anywhere from one to three years, the culture is formed and the groundwork for the site's future productivity is laid. During that period, senior management in the home country has to be in particularly close contact with the new site. Although it is important that the new laboratory develop its own identity and stake out its fields of expertise, it also has to be closely connected to the company's existing R&D structure. Newly hired scientists must be aware of the resources that exist within the company as a whole, and scientists at home and at other locations must be aware of the opportunities the new site creates for the company as a whole. Particularly during the start-up period, senior R&D managers at the corporate level have to walk a fine line and decide whether to devote the most resources to connecting the new site to the company or to supporting ties between the new site and its local environment.

To integrate a new site into the company as a whole, managers must pay close attention to the site's research agenda and create mechanisms to integrate it into the company's overall strategic goals. Because of the high degree of uncertainty of R&D outcomes, continuous adjustments to research agendas are the rule. What matters most is speed, both in terms of terminating research projects that go nowhere and in terms of pushing projects that bring unexpectedly good results.

Managers must integrate a site's research agenda into the company's overall goals.

The rapid exchange of information is essential to integrating a site into the overall company during the start-up phase. Companies use a number of mechanisms to create a cohesive research community in spite of geographic distance. Hewlett-Packard regularly organizes an in-house science fair at which teams of researchers can present projects and prototypes to one another. Canon has a program that lets researchers from home-base-augmenting sites request a temporary transfer to home-base-exploiting sites. At Xerox, most sites are linked by a sophisticated information system that allows senior R&D managers to determine within minutes the current state of research projects and the number of researchers working on those projects. But nothing can replace face-to-face contact between active researchers. Maintaining a global R&D network requires personal meetings, and therefore many researchers and R&D managers have to spend time visiting not only other R&D sites but also specialized suppliers and local universities affiliated with those sites.

Failing to establish sufficient ties with the company's existing R&D structure during the start-up phase can hamper the success of a new foreign R&D site. For example, in 1986, a large foreign pharmaceutical company established a biotechnology research site in Boston, Massachusetts. In order to recruit outstanding scientists and maintain a high level of creative output, the company's R&D management decided to give the new laboratory considerable leeway in its research agenda and in determining what to do with the results—although the company did reserve the right of first refusal for the commercialization of the lab's inventions. The new site was staffed exclusively with scientists handpicked by a newly hired laboratory leader. A renowned local biochemist, he had been employed for many years by a major U.S. university, where he had carried out contract research for the company. During the start-up phase, few of the company's veteran scientists were involved in joint research projects with the site's scientists—an arrangement that hindered the transfer of ideas between the new lab and the company's other R&D sites. Although the academic community now recognizes the lab as an important contributor to the field, few of its inventions have been patented by the company, fewer have been targeted for commercialization, and none have reached the commercial stage yet. One senior scientist working in the lab commented that ten years after its creation, the lab had become so much of an "independent animal" that it would take a lot of carefully balanced guidance from the company to instill a stronger sense of commercial orientation without a risk of losing the most creative scientists.

There is no magic formula that senior managers can follow to ensure the success of a foreign R&D site during its start-up phase. Managing an R&D network, particularly in its early stages, is delicate and complex. It requires constant tinkering—evaluation and reevaluation. Senior R&D managers have to decide how much of the research should be initiated by the company and how much by the scientist, determine the appropriate incentive structures and employment contracts, establish policies for the temporary transfer of researchers to the company's other R&D or manufacturing sites, and choose universities from which to hire scientists and engineers.

> Managing an R&D network is both delicate and complex. It requires constant tinkering—evaluation and reevaluation.

Flexibility and experimentation during a site's start-up phase can ensure its future productivity. For example, Fujitsu established a software-research laboratory site in San Jose, California, in 1992. The company was seriously thinking of establishing a second site in Boston but eventually reconsidered. Fujitsu realized that the effort that had gone into establishing the San Jose site had been greater than expected. Once the site was up and running, however, its productive output also had been higher than expected. Furthermore, Fujitsu found that its R&D managers had gained an excellent understanding of the R&D community that created advanced software-development tools. Although initially leaning toward establishing a second site, the managers were flexible. They decided to enlarge the existing site because of its better-than-expected performance as well as the limited potential benefits of a second site. The San Jose site has had a major impact on Fujitsu's software development and sales—particularly in Japan but in the United States, too. Similarly, at Alcatel's first foreign R&D site in Germany, senior managers were flexible. After several months, they realized that the travel-and-communications budget would have to be increased substantially beyond initial projections in order to improve the flow of knowledge from the French home base. For instance, in the case of a telephone switchboard project, the actual number of business trips between the two sites was nearly twice as high as originally projected.

Integrating the Global R&D Network

As the number of companies' R&D sites at home and abroad grows, R&D managers will increasingly face the challenging task of coordinating the network. That will require a fundamental shift in the role of senior managers at the central lab. Managers of R&D networks must be global coordinators, not local administrators. More than being managers of people and processes, they must be managers of knowledge. And not all managers that a company has in place will be up to the task.

Consider Matsushita's R&D management. A number of technically competent managers became obsolete at the company once it launched a global approach to R&D. Today managers at Matsushita's central R&D site in Hirakata, Japan, continue to play an important role in the research and development of core processes for manufacturing. But the responsibility of an increasing number of senior managers at the central site is overseeing Matsushita's network of 15 dedicated R&D sites. That responsibility includes setting research agendas, monitoring results, and creating direct ties between sites.

How does the new breed of R&D manager coordinate global knowledge? Look again to Matsushita's central R&D site. First, high-level corporate managers in close cooperation with senior R&D managers develop an overall research agenda and assign different parts of it to individual sites. The process is quite tricky. It requires that the managers in charge have a good understanding of not only the technological capabilities that Matsushita will need to develop in the future but also the stock of technological capabilities already available to it.

Matsushita's central lab organizes two or three yearly off-site meetings devoted to informing R&D scientists and engineers about the entire company's current state of technical knowledge and capabilities. At the same meetings, engineers who have moved from R&D to take over manufacturing and marketing responsibilities inform R&D members about trends in Matsushita's current and potential future markets. Under the guidance of senior project managers, members from R&D, manufacturing, and marketing determine timelines and resource requirements for specific home-base-augmenting and home-base-exploiting projects. One R&D manager notes, "We discuss not only why a specific scientific insight might be interesting for Matsushita but also how we can turn this insight into a product quickly. We usually seek to develop a prototype early. Prototypes are a good basis for a discussion with marketing and manufacturing. Most of our efforts are targeted at delivering the prototype of a slightly better mousetrap early rather than delivering the blueprint of a much better mousetrap late."

To stimulate the exchange of information, R&D managers at Matsushita's central lab create direct links among researchers across different sites. They promote the use of videoconferencing and frequent face-to-face contact to forge those ties. Reducing the instances in which the central lab must act as mediator means that existing knowledge travels more quickly through the company and new ideas percolate more easily. For example, a researcher at a home-base-exploiting site in Singapore can communicate with another researcher at a home-base-exploiting site in Franklin Park, Illinois, about potential new research projects much more readily now that central R&D fosters informal and formal direct links.

Finally, managers at Matsushita's central lab constantly monitor new regional pockets of knowledge as well as the company's expanding network of manufacturing sites to determine whether the company will need additional R&D locations. With 15 major sites around the world, Matsushita has decided that the number of sites is sufficient at this point. But the company is ever vigilant about surveying the landscape and knows that as the landscape changes, its decision could, too.

As more pockets of knowledge emerge worldwide and competition in foreign markets mounts, the imperative to create global R&D networks will grow all the more pressing. Only those companies that embrace a global approach to R&D will meet the competitive challenges of the new dynamic. And only those managers who embrace their fundamentally new role as global coordinators and managers of knowledge will be able to tap the full potential of their R&D networks.

1. In a systematic effort to analyze the relationship of global strategy and R&D investments in technologically intensive industries, I have been collecting detailed data on all dedicated laboratory sites operated by 32 leading multinational companies. The sample consists of 10 U.S., 12 Japanese, and 10 European companies. Thirteen of the companies are in the pharmaceutical industry, and 19 are in the electronics industry. Data collection includes archival research, a detailed questionnaire, and in-depth interviews with several senior R&D managers in each company. Overall, these companies operate 238 dedicated R&D sites, 156 of them abroad. About 60% of the laboratory sites abroad were established after 1984. I have used this sample, which is the most complete of its kind, as a basis for a number of quantitative and qualitative investigations into global strategy, competitive interaction, and R&D management.

2. My research on global R&D strategies builds on earlier research on the competitiveness of nations and on research on foreign direct investment, including Michael E. Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), and Thomas J. Wesson, "An Alternative Motivation for Foreign Direct Investment" (Ph.D. dissertation, Harvard University, 1993). My research also builds on an existing body of knowledge about the management of multinational companies. See, for example, Christopher A. Bartlett and Sumantra Ghoshal, *Managing Across Borders* (New York: The Free Press, 1989).

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Walter Kuemmerle is an associate professor at Harvard Business School in Boston.

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