International technology transfer: strategies for success

Robert T. Keller, Louisiana State University
Ravi R. Chinta, Sentron Medical, Inc.

Executive Overview

High-technology industries have led the way in the globalization of international business in recent years. Success often depends on how well a firm transfers technology to another firm or market in a foreign country. International technology transfer usually faces greater problems than in a domestic situation due to differing cultures, norms, laws, tax policies, etc. What should management focus on, and what are some strategies to achieve technology transfer abroad?

Many of the important factors are ambiguous by nature and difficult to measure. For instance, the technology to be transferred and the target markets may be changing, estimating costs and prices can be difficult, and the competition may consist of only a small number of firms or governments. Several critical factors may be external to the firms involved, such as political, cultural, and economic conditions. It is important, under these conditions, for management to have a good understanding of the international technology transfer process and the barriers and bonds that determine success.

Article

With the increasing globalization of international business, the high-technology sector has become a major segment of foreign trade. Such industries as semiconductor computer chips, commercial aircraft and engines, and industrial robots have become the battleground where firms fight to increase their market share to survive and prosper in international competition.

American managers are recently learning what many European and Asian managers have known for some time: To survive in the future a firm, especially a multinational corporation (MNC), must be able to transfer technology to other countries better than the competition. For example, the European Community (EC) has set a deadline of 1992 to form a single market without internal tariffs or quotas to impede trade. This gives U.S. firms only a few years to establish facilities in EC countries via expansion, joint ventures, subsidiaries, acquisitions, etc., before the door may be shut. Technology transfer to EC countries now becomes even more vital for MNCs based in the U.S. and other non-EC countries such as Japan and Switzerland.

A critical factor for success in this competition is the ability of a firm to effectively and quickly transfer technology across national boundaries. To do so, however, requires strategic planning and implementation geared to the special nature of international technology transfer.

Technology transfer is difficult enough in a purely domestic situation, but it is even more so in the international arena. Differences in national cultures, social norms, laws, and economies create impediments to technology transfer that are not present domestically.
International technology transfer usually involves a well-established relationship between organizations in different countries. This is in contrast to the short-term relationship generally involved in simple trade.

To successfully compete internationally, managers need to answer some important questions: What should management focus on? What are the major problems? What are some important strategies, and how can these strategies be successfully implemented?

This article answers these questions by first characterizing the nature of international technology transfer, and then providing an integrative framework to act as a guide in the discussion. Next, modes for achieving international technology transfer are investigated. These include examining barriers and bonds in the process, and strategies to create bonds.

**The Nature of International Technology Transfer**

Technology transfer is best understood as a process; that is, a process by which “know-how” information called technology is transferred across a boundary or boundaries to another organization. The technology can be transferred in a pure informational form, which has been called disembodied technology transfer. Or, the technology can be embodied in the form of a product, machine, process, or person and then transferred. The advantage of an embodied form of transfer is that the person, machine, software, etc., “packages” the know-how in a way that makes the technology able to be implemented. Often, a combination of embodied transactors are made where machinery and the personnel to operate it are transferred at the same time.²

The context in which international technology transfer occurs is better understood by examining the barriers, or impediments, to technology transfer, and the bonds, or bridges, that enhance it. Barriers and bonds exist between the home or supplier country and the host or recipient country. Two categories of factors may act as barriers or bonds: political/legal factors such as laws, trade policies, tariffs, licensing regulations, etc., and economic/technological/social factors.

Firms successful in international technology transfer, such as IBM, Philips, Merck, and General Electric, have developed strategies and implementation modes that can either overcome barriers or take advantage of a potential bond.

**An Integrative Framework as a Guide**

An integrative framework of the factors that affect international technology transfer is presented in Exhibit 1. This framework focuses on the importance of both barriers and bonds in achieving technology transfer. In addition, the content and mode of the transfer both play important roles. The integrative framework can also help to guide managers’ discussions and aid them in understanding the issues that follow. The degree of success of the transfer can act as feedback and lead to a future barrier or bond, or both, as the firm learns or recoils from its experiences.

Developing an integrative framework also increases systematic thought about the strategic issues involved in international technology transfer. The rapid increase in international trade in recent years sometimes rushes firms into competing in foreign markets before adequately considering all the factors unique to this area. Often, the success of companies such as IBM and Sony in foreign markets spurs management into doing something similar. As suggested by the integrative framework, however, many factors not faced on a domestic level must be considered. These factors, such as different cultures, laws, tax policies, etc., are new to firms that have limited experience in foreign markets.

**Barriers that Inhibit Technology Transfer**

The home or supplier country, or the host or recipient country, may pose
Often, a home country is concerned about the exportation of jobs, the creation of competition in the host country, or a threat to national security. The host country may be concerned about damage to the competitive strength of firms in its country, a possible loss of jobs, and even "economic imperialism" from a foreign country.³

Home Country Barriers
In the 1960s, several Japanese firms went to West Germany to learn about photo technology. The subsequent result of those visits was the creation of severe competition in a market in which West German firms were known for top product quality.

More recently, U.S. defense contractors worried about the competition resulting from the Japanese being allowed to rearm, or to use U.S. technology to develop weapon systems. Serious concerns pervade negotiations between the U.S. and Japan over the joint development of the FSX advanced jet fighter project for Japan’s air force by General Dynamics and Mitsubishi Heavy Industries. The U.S. Commerce Department fears that Japan will obtain the technology to launch its own commercial aviation industry and compete with the currently dominant U.S.⁴

In recent years, the U.S. and its NATO allies have attempted to prevent the transfer of sensitive technology to the Soviet Union that could be a threat to national security. Sophisticated computers and machine tools with possible military applications, and nuclear material have been banned for export to the Soviet Union or its allied countries.

Communist countries, such as the Soviet Union and East Germany, have used exit-visa restrictions or the Berlin Wall as barriers to the transfer of technology embodied in personnel—a "brain drain." Other countries have tried to limit attendance at foreign schools or conferences by scientists and engineers. The People’s Republic of China has a problem luring back people sent to Western
countries for training in science or engineering and who find much better career opportunities outside of China. The brain drain problem often means that less-developed countries are not able to maintain a core of technically sophisticated personnel who can help their country to absorb and diffuse technology transferred from a more advanced country.⁵

To control an important technological resource, firms in a home country may try to suppress the transfer of technology abroad. For example, a firm may patent a large number of related products, and then market only a limited range of new products with patent protection for the rest. U.S. government officials have charged that companies such as Toshiba, NEC, and Hitachi each file for over 10,000 patents every year in Japan. This situation causes delays of several years in the Japanese patent office to the detriment of such U.S. companies as Corning Glass Works and Fusion Systems who have had patent applications waiting.

Firms also pool patents as a means of limiting competition. When a license is negotiated for a product, a firm may limit the conditions and fields of use for the product as a way of controlling the diffusion of the technology. These technology control strategies act as barriers to the transfer of technology to another country.⁶

Host Country Barriers
Many barriers to technology transfer may be attempts by governments to pursue a policy of "technology-based mercantilism." Early nation-states often tried to protect manufacturers at home while promoting export abroad. Now, some governments seek to protect their home technological bases through barriers to entry.

Developed countries such as the U.S., Canada, Japan, West Germany, and France often have adopted the strategies of less-developed countries by the use of patent and copyright policies, restrictions on foreign investment, tax policies, and government purchase policies.

Again, the concern is a potential loss of jobs or damage to the competitive ability of host-country firms. The use of "Buy American," "Buy Japanese," or "Buy German" laws or customs in the telecommunications industry is a good example of a host country barrier. These laws are designed to increase domestic employment from government or government-related purchases and to reduce foreign inroads in domestic technological strengths. Often, a telecommunications technology can be designed to give domestic firms an advantage in compatibility vis-à-vis the technologies used by foreign firms. The acquisition of IBM's Poin telephone-equipment business by Siemens can be viewed as a means to overcome barriers in the North American market. Similarly, AT&T signed an agreement with the state-owned telephone company of Italy to enter that market. Japan's choice of an operating system for educational computers developed by Matsushita Electric Industrial is yet another example of a technological barrier. U.S. trade officials have charged that American computers designed to run on MS-DOS or UNIX operating systems face an unfair barrier.⁷

Lack of compatible or existing industrial standards in the host country can be another barrier to technology transfer. Thousands of standards are normally required for a modern economy to function efficiently, and if these standards are different or nonexistent in the host country, the costs of modification can be considerable. Industrialized countries almost always have standards for electrical voltage, metricalion of weights and measures, threading of fasteners, dimensions of roadways or railroads, radio and television frequencies, building codes, etc. Countries may resist adopting common standards from abroad due to a sensitivity that to do so would be subversive to national sovereignty or pride. As Holland's Philips group has found, however, many electronic products must interface with components made by other companies, thereby, increasing the importance of
standardization. Thus, divergence in these industrial standards between home and host countries can act as a barrier to technology transfer.

Incompatible cultural values between an MNC in a developed home country and a host organization in a less-developed country may serve as a barrier. For example, technology transfer from a country such as West Germany, where assertiveness and achievement are valued, to a country such as India, where value is placed on social relationships above money and achievement, may be difficult for the host country. India has a traditional and structured social power system, so technologies that disturb that power system may also be resisted. Cultural factors are more serious barriers when the technology is embodied in a process or person, than technologies embodied in a product or disembodied in only informational form.  

**Bonds that Promote Technology Transfer**

Firms can use several bonds or factors that facilitate the transfer of knowledge, products, processes, or personnel across organizational and international boundaries. These factors are broadly classified into intra-firm and inter-firm bonds.  

**Intra-Firm Bonds**

Intra-firm bonds can be provided through growth strategies such as the international expansion of existing products or services. Here, an MNC may initially transfer a product to another country, and then transfer the manufacturing process and some personnel later. Honda, for example, initially exported its autos to the U.S., then transferred manufacturing plants, and finally exported U.S.-made Hondas back to Japan for sale.

Redeployment strategies of existing products or processes can be implemented in different ways depending on the stage of the product or process technological life cycle. Three basic formats exist: parallel, delayed, and sequential introductions into another country.

In a parallel introduction, an MNC simultaneously introduces the new technology in both the home and a foreign host country. DuPont is often noted for the parallel introduction of new chemical products and manufacturing processes on a global scale. Computer chips made by Intel are usually simultaneously introduced in U.S. computers made by IBM and Japanese computers manufactured by Fujitsu.

In delayed introduction, a new technology is first introduced in the home country. Later, after experience is gained and improvements made, the technology is transferred to a foreign country. For instance, Otis Elevator entered into a joint venture with the People’s Republic of China to manufacture, sell, and service elevators in that country which represented technology that had been proven successful elsewhere. Corning Glass Works will also transfer color-television picture tube technology to the People’s Republic of China through a joint venture to build a plant based on existing Corning technology. 

European pharmaceutical firms such as Hoffman-LaRoche and Ciba-Geigy, and even some U.S. pharmaceutical firms such as Vestar and Genentech, often introduce a new drug in a European country before introducing it in the U.S. This is because the U.S. has stricter requirements for government approval of drugs. This delay has occurred with interferon drugs used for cancer treatment, liposomes for drug delivery, and non-ionic contrasts for imaging techniques.
Smaller or used equipment may be more appropriate to the level of technical sophistication and maintenance facilities of the host country, but sometimes this policy is resisted because this equipment may be seen as lacking prestige.

In a sequential transfer, a technology is transferred to a foreign country only after the technology is completely through its life cycle in the home country. Crown, Cork, and Seal, for example, transferred its three-piece can manufacturing technology to less-developed countries only after a more modern two-piece technology was introduced in the home country of the U.S. Similar examples of sequential transfer include pesticides and electrical equipment transferred to less-developed countries from industrialized home countries, and even the transfer of smaller or used tractors and the recycling of used heart-pacemakers.

Smaller or used equipment may be more appropriate to the level of technical sophistication and maintenance facilities of the host country, but sometimes this policy is resisted because this equipment may be seen as lacking prestige.

Exhibit 2 presents a list of advantages and disadvantages associated with parallel, delayed, and sequential strategies.

Since intra-firm transfers are usually less costly than inter-firm transfers, a cost advantage can act as a bond. Several reasons for these lower costs exist.

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARALLEL: SIMULTANEOUS INTRODUCTION IN HOME &amp; HOST COUNTRIES</td>
<td>—GOOD FOR PRODUCTS/ PROCESSES WITH SHORT LIFE CYCLES —GLOBAL PRESENCE CAN BE A BARRIER TO ENTRY FOR COMPETITION —GOOD WITH CENTRALIZED MANAGEMENT AND MULTI-PLANT STRATEGY</td>
<td>—DIFFERENT REGULATORY POLICIES ACROSS COUNTRIES MAY CAUSE PROBLEMS —LARGE PRE-MARKET DEVELOPMENT COSTS TO RECOUP —NEEDS SIMILAR MARKETS ACROSS COUNTRIES —NO LEARNING CURVE EFFECTS</td>
</tr>
<tr>
<td>DELAYED: INTRODUCTION IN HOME COUNTRY, AND LATER INTRODUCTION IN HOST COUNTRY</td>
<td>—GOOD WHEN PRODUCTS/ PROCESSES HAVE A LONGER LIFE CYCLE —SIGNIFICANT LEARNING CURVE EFFECTS FOR SIMILAR MARKETS —ALLOWS FOR SOME PRODUCT MODIFICATION —ALLOWS FOR MEETING Regulatory differences across countries</td>
<td>—MAY LAG THE TECHNOLOGY OF FIRMS IN THE HOST COUNTRY —DELAY MAY ATTRACT COMPETITORS —HOST COUNTRY GOVERNMENT MAY WANT STATE-OF-THE-ART TECHNOLOGY FOR PRESTIGE</td>
</tr>
<tr>
<td>SEQUENTIAL: INTRODUCTION IN HOST COUNTRY AFTER THE LIFE CYCLE IS COMPLETED IN HOME COUNTRY</td>
<td>—DEVELOPMENT COSTS HAVE OFTEN BEEN RECOUPED EARLIER, AND THIS IS A FINAL SQUEEZE FROM OLDER TECHNOLOGY —MAY MATCH NEEDS OF LESS DEVELOPED COUNTRIES —BEST FOR LOCALIZED MATCH, RATHER THAN GLOBAL MATCH</td>
<td>—MAY BE UNCOMPETITIVE WITH NEWER TECHNOLOGIES —RESISTANCE FROM HOST COUNTRY MAY OCCUR FROM USING OLD TECHNOLOGY —NEEDS DECENTRALIZED CONTROL DUE TO DISSIMILAR MARKETS IN HOME AND HOST COUNTRIES</td>
</tr>
</tbody>
</table>

EXHIBIT 2. Redeployment Strategies of Existing Products or Processes

38

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Personnel in both countries have organizational and technological commonalities, extended legal negotiations are unnecessary, there is little risk of non-payment or a need for a performance bond, and concerns about a failure of the technology to work are minimal. Thus, an MNC often has a cost advantage in international technology transfer over two separate firms operating at arms length. Philips of Holland has used intra-firm transfers among electronic components manufacturers in Europe, Asia, and the U.S. to keep costs low. IBM has done the same in its mainframe computer line with components manufactured in several countries.  

A small but growing trend is for an MNC to set up complementary R&D facilities in more than one country. This strategy allows technological developments to be monitored, establishes communication links for technical flows across national boundaries, and establishes networks with universities and technical associations in other countries.

It also creates valuable communication and personnel networks that can significantly aid in technology transfer. Firms such as Eastman Kodak in photography and chemicals, Corning Glass Works in fiber optics, and IBM in visual display panels have successfully followed this strategy to form bonds for international technology transfer. The EC may also require that R&D work be done in a member country to avoid import duties after the 1992 single market plan is implemented.  

Inter-firm Bonds

Inter-firm bonds also take different forms. One of the most evident forms is a joint venture where two or more firms join in a business venture to transfer a product or manufacturing process across national boundaries. Toyota and General Motors formed a joint venture to manufacture the Chevrolet Nova, which is similar to the Toyota Corolla, in California. The commercial aviation business has had several multinational joint ventures. Airbus Industrie manufactures and sells the A300, A310, and A320 jet aircraft as a joint venture made up of Aerospatiale (France), Deutsche Airbus (West Germany), British Aerospace (United Kingdom), and CASA (Spain). General Electric of the U.S. has separate joint ventures for jet engines with SNECMA of France, and with Rolls Royce of the United Kingdom.

Some countries, such as Mexico, in the past have required a majority ownership by a Mexican firm to do business in that country. A joint venture between a foreign firm with needed technology and a Mexican firm has often been used to accomplish technology transfer.  

Licensing of a firm in the host country by a firm in the home country is another popular mode of transfer. U.S. defense contractors have often licensed a firm in Japan, Europe, or Egypt, for example, to produce, under license, an F-15 aircraft or, M-1 tank. Usually, some subassemblies are made in the home country with final assembly in the host country. Personnel are provided to help with the technology transfer process. Bristol Laboratories has licensed pharmaceutical firms in Mexico to produce antibiotics, and Merck has done the same in India. In a different twist, IBM and Samsung Electronics of Korea agreed to swap patents on semiconductor products through a cross-licensing agreement.

Corporate philosophy has been changing recently among many MNCs in
industrialized countries. "Technology sharing" of a firm's technology assets among markets in several countries has become the mode. The emphasis is on being globally rather than just domestically competitive. Some MNCs believe that they should have manufacturing facilities in a host country, as well as a marketing effort to be truly competitive. The manufacturing presence helps the MNC better understand the host market, shows commitment to the host government, and reduces the effects of currency fluctuations. The internationalization of the auto and computer industries, and the desire of Middle East oil-producing countries to own refining, petrochemical, and marketing facilities in industrialized, western countries are excellent examples of this multinational philosophy. As cases in point, Honda manufactures automobiles in Japan, the U.S., and the United Kingdom, and exports different models among the three countries. AT&T manufactures computer chips in the U.S., and now has a large plant in Spain to establish a manufacturing base in the EC.13

Cultural compatibilities between firms in countries that have similar and shared values can act as a bond to technology transfer. Japan, South Korea, Taiwan, and Hong Kong all tend to value assertiveness and achievement in economic matters. This compatibility has enhanced their reception to technology transfers in the electronics, auto, and steel industries. Indeed, it has been suggested that an action orientation and desire to compete makes these countries both competitors and cooperators in technology-driven economic development. It has also made the Pacific Rim the fastest growing economic area of the world.

Sophisticated technical personnel with a cosmopolitan, outward-looking orientation can act as a bond in inter-firm technology transfer. Technically sophisticated personnel can help in the understanding and diffusion of the transferred technology, and a cosmopolitan orientation can help to reduce resistance to outside ideas and the "Not-Invented-Here" syndrome.

Thus, bonds can be formed by similarities in technical knowledge and a cosmopolitan orientation among personnel in firms from different countries. Toward this end, the Indian government has helped in the establishment of a satellite uplink with U.S. companies such as Texas Instruments and Laser-Data so that Indian programmers can do work for the American companies. This arrangement helps to alleviate the brain drain problem and to increase the number of technical specialists in India.14

How Can Organization Strategies Create Bonds?
An effective international technology transfer strategy identifies the knowledge creation and knowledge utilization subunits of the organization within an MNC and then creates bonds to transfer technology from the creators to the utilizers. These bonds can take the form of organizational structure and design arrangements, human resource management policies, or organizational control policies.

Organizational Design Strategies
An appropriate organizational design can facilitate technology transfer across subunits. One study found that MNCs with a global matrix design had greater success with product and process technology transfers across national boundaries than did MNCs with more decentralized structures. Matrix structures enable a cross-fertilization of ideas and technologies by pooling resources across several organizational subunits such as R&D, marketing, and manufacturing which may exist in different countries. The design of new products is significantly accelerated.

Another organizational design strategy is to identify the firm's "value chain"
components and then locate the various components in different countries. For example, IBM develops and designs computer components in the U.S. or Japan, manufactures semi-finished computer parts in Taiwan or Mexico, and then ships them to another country, such as Italy, for further processing. Marketing the final product is often made easier since technology transfer accompanies the flow of material and information through the global network, and market needs from each country are often included in the product design. Knowledge creators and utilizers in an MNC can transfer technology across national boundaries through the bonds established by organizational design strategies and arrangements.\textsuperscript{15}

Cost of manufacture and currency differences can also lead to organizational design strategies that create bonds for technology transfer. In the early 1980s, the strong U.S. dollar and lower foreign labor costs led MNCs to establish manufacturing plants for autos, electronics, and semiconductors in such countries as Japan, Taiwan, and Mexico. The U.S. operations were left to specialize in marketing. In the past few years, however, the triad of the U.S. dollar has dropped substantially and U.S. manufacturing plants have improved on cost and quality. The upshot is a resurgence of the U.S. manufacturing base in the aircraft, chemical, steel, and aluminum industries.

These changes have put a premium on the ability of an MNC to transfer technology for manufacturing across national boundaries. Indeed, many MNCs such as IBM in computers, Honda in autos, and Philips in electronics have chosen to place both manufacturing and marketing units in the triad of the U.S., Japan, and the EC, as well as other countries. This true multinational presence can act as a bond to technology transfer.

**Human Resource Management Policies**

Job rotation of personnel among international subsidiaries can create a sense of corporate community which acts as a bond to international technology transfer. Otherwise, parochial geographic orientations develop that impede technology transfer. Job rotation can also include personnel from knowledge creator and user subunits of the organization located in different countries so that bonds for technology transfer can be developed among subunits with different roles.\textsuperscript{16}

Hiring respected personnel in a host country with a markedly different culture than the home country is an effective human resource strategy. For example, some U.S. firms hired retired executives or professors in Japan to help guide strategy in the Japanese market. These respected personnel add credibility to the effort. They can be trained in the firm's strategy, and most importantly, they truly understand the culture, markets, laws, etc. of the host country. These personnel serve as a useful bond to the firm in transferring technology to the host country.

**Organizational Control Policies**

Control policies can also be used to create bonds for international technology transfer. Establishing a single profit center for knowledge creator and user subunits located in different countries establishes a common goal. Compensation policies can be integrated into the profit center plan as a way of reinforcing the global approach.

A firm's strategic plan used as a control mechanism can act as a bond if the strategy is to transfer the firm's most recent technology to company units in other countries. This is in contrast to transferring more mature, standardized technologies. The first plan emphasizes efficient transfer to achieve sales and market share goals; hence, employees in different countries in the firm are bonded by the strategic plan and its goals.
Concluding Comments: The Ambiguities of International Technology Transfer

Many of the important factors in international technology transfer are ambiguous and difficult to measure. The technology may be changing, the markets may be unclear, and determining a market price for goods or services may lead to widely varying estimates. Often, a new market is created, and true competition is limited when governments or only a small number of firms are germane to the transfer.

Important factors may also be external to the firms involved in the transfer of technology. Political and national security issues, employment implications, and political and social power concerns may end up as the deciding factors on technology transfer. How can these factors be defined or measured? Do markets determine the results or do political and cultural forces?

Some view the transfer of technology to another country as analogous to the transplantation of a living organ from one person to another. If the host country finds the technology to be incompatible, it may be rejected, and problems may continue even after the rejection. The benefits, however, may be renewed or invigorated life for both the host and the donor countries.

To be successful, firms need careful strategic thought and planning, skilled and knowledgeable implementation, and the understanding that successful technology transfer can be greatly beneficial to both the firms and countries.

Endnotes

The authors wish to thank Ben L. Kedir, Gary J. Costagiappianni, Karen A. Fontenot, and Donald W. Pennington for their helpful comments and suggestions.


6 Richard Dunford, "The Suppression of Technology as a Strategy for Controlling Resource Dependence," Administrative Science Quarterly, 1967, 32, 512-525, tells how the suppression of technology transfer has been used as a business strategy along with several examples. Also see, "U.S. Tries Once Again to Persuade Japan to Overhaul 'Unfair' Patent Procedures," Wall Street Journal, August 26, 1988, 8.


18 Both Peter Killing, Strategies for Joint Venture Success (London: Creem Helm, 1983), and Richard D. Robinson, The Internationalization of Business (Hinsdale, IL: Dryden, 1984), provide discussions of organization design and management styles to achieve international technology transfer. Several examples of design teams involving R&D, marketing, and manufacturing are described in "Special Bonus Issue: Innovation in America," Business Week, June, 1989, 104-134, on "Managing Innovation."


20 See Denis Goulet, The Uncertain Promise, Value Conflict in Technology Transfer (New York, IDOC/North America, 1977), for a discussion of these ambiguous factors.

21 See Endnotes 11 and 17.

About the Authors

Robert T. Keller is professor of management at Louisiana State University. His research interests include the management of technology, organization design and innovation, and the management of R&D professionals. Professor Keller has consulted for a variety of organizations in the U.S., Europe, and Mexico, and has held administrative positions at Westinghouse Electric Corporation and Westvaco Corporation. His research has been supported by the National Science Foundation, and the Center for Innovation Management Studies, Lehigh University. Professor Keller has authored numerous articles and papers, and he serves, or has served, on the editorial boards of Academy of Management Journal, IEEE Transactions on Engineering Management, Group and Organization Studies, Journal of High Technology Management Research, and Journal of Engineering and Technology Management. He holds an M.B.A. from the State University of New York at Buffalo, and a Ph.D. in management from The Pennsylvania State University.

As manager of business planning, Ravi Chinta conducts strategic planning for Sentron Medical, Inc., Cincinnati and its portfolio companies, and executes strategic business analysis and due diligence for its portfolio companies. Before joining Sentron, Ravi was assistant professor in business policy and planning at Louisiana State University. Prior to that, Ravi worked as planning and development manager for the Indian subsidiary of NitroNobel as well as in planning functions at two other Indian companies. Ravi holds a B.S. in Chemical Engineering from the Indian Institute of Technology, an M.B.A. from the Indian Institute of Management, and a Ph.D. in strategic planning from the University of Pittsburgh.