SUSTAINABLE ENTREPRENEURSHIP PROJECT

Technology Management Studies

SUSTAINABLE ENTREPRENEURSHIP PROJECT
RESEARCH PAPER SERIES

Dr. Alan S. Gutterman
August 2017

Technology Management Studies

Published by the Sustainable Entrepreneurship Project (www.seproject.org) and copyrighted © August 2017 by Alan S. Gutterman.

All the rights of a copyright owner in this Work are reserved and retained by Alan S. Gutterman; however, the copyright owner grants the public the non-exclusive right to copy, distribute, or display the Work under a Creative Commons Attribution-NonCommercial-ShareAlike (CC BY-NC-SA) 4.0 License, as more fully described at http://creativecommons.org/licenses/by-nc-sa/4.0/legalcode.

About the Project

The Sustainable Entrepreneurship Project (www.seproject.org) engages in and promotes research, education and training activities relating to entrepreneurial ventures launched with the aspiration to create sustainable enterprises that achieve significant growth in scale and value creation through the development of innovative products or services which form the basis for a successful international business. In furtherance of its mission the Project is involved in the preparation and distribution of Libraries of Resources for Sustainable Entrepreneurs covering Entrepreneurship, Leadership, Management, Organizational Design, Organizational Culture, Strategic Planning, Governance, Corporate Social Responsibility, Compliance and Risk Management, Finance, Human Resources, Product Development and Commercialization, Technology Management, Globalization, and Managing Growth and Change. Each of the Libraries include various Project publications such as handbooks, guides, briefings, articles, checklists, forms, forms, videos and audio works and other resources; management tools such as checklists and questionnaires, forms and training materials; books; chapters or articles in books; articles in journals, newspapers and magazines; theses and dissertations; papers; government and other public domain publications; online articles and databases; blogs; websites; and webinars and podcasts. Changes to the Library are made on a continuous basis and notifications of changes, as well as new versions of this Research Paper, will be provided to readers that enter their names on the Project mailing list by following the procedures on the Project's website.

About the Author

Dr. Alan S. Gutterman is the Founding Director of the Sustainable Entrepreneurship Project and the Founding Director of the Business Counselor Institute (www.businesscounselorinstitute.org), which distributes Dr. Gutterman's widely-recognized portfolio of timely and practical legal and business information for attorneys, other professionals and executives in the form of books, online content, webinars, videos, podcasts, newsletters and training programs. Dr. Gutterman has over three decades of experience as a partner and senior counsel with internationally recognized law firms counseling small and large business enterprises in the areas of general corporate and securities matters, venture capital, mergers and acquisitions, international law and transactions, strategic business alliances, technology transfers and intellectual property, and has also held senior management positions with several technology-based businesses including service as the chief legal officer of a leading international distributor of IT products headquartered in Silicon Valley and as the chief operating officer of an emerging broadband media company. He received his A.B., M.B.A., and J.D. from the University of California at Berkeley, a D.B.A. from Golden Gate University, and a Ph. D. from the University of Cambridge. For more information about Dr. Gutterman, his publications, the Sustainable Entrepreneurship Project or the Business Counselor Institute, please contact him directly at alangutterman@gmail.com.

§1 Introduction

Every company, regardless of its size and activities, is touched in some way by technology. For example, the use of computer hardware and software has now become commonplace for recording the terms of business transactions and creating and maintaining business records and even the smallest firms need to be attentive to improvements in computing tools that can lead to lower costs and greater efficiencies. Technology becomes even more important for the firm as its activities expand to include product development and manufacturing. Also, as companies grow and establish relationships with employees, contracts, customers and other business partners in distant locations, communications technology becomes an essential element of success for the company and its ability to effectively complete necessary tasks and activities.

Companies involved in technology-based industries and markets must understand the importance of approaching technology management as an essential element of the firm's overall competitive strategy. This requires an appreciation of the potential competitive advantages offered by technology and the need to integrate technology into the analysis of the company's competitive position. In addition, an effort should be made to evaluate the strength of the company's core competencies in the technological areas that are most relevant to businesses that the company wishes to pursue and the products and services necessary for the company to be competitive in those business areas. Once the relationship of technology to the goals and strategies of the company is clearly understood senior management must develop the company's technology strategy and establish procedures for implementing and monitoring that strategy.

According to the National Task Force on Technology persons and organizations should be concerned about technology management for the following reasons[1]:

- The rapid pace of technological change demands a cross-discipline approach if economic development is to occur in an effective and efficient manner to take advantage of technological opportunities.
- The rapid pace of technological development and the increasing sophistication of consumers have shortened product life cycles. The result of these factors is a need for organizations to be more proactive in the management of technology.
- There is a need to cut product development times as well as to develop more flexibility in organizations. The lead-time from idea to market is being reduced by the emergence of new or altered technologies.
- Increasing international competition demands that organizations must maximize competitiveness by effectively using new technologies.
- As technology changes, the tools of management must change, but the process of determining what those new tools should be is in its infancy.

As with other areas of management research, technology management has commanded the most attention among academics and consultants in the US and other developed

[1] M. White and G. Bruton, The Management of Technology and Innovation: A Strategic Approach (2007), 18 (citing National Task Force on Technology (1987)).

countries. For example, the Centre for Technology Management at the University of Cambridge was launched to engage in research activities relating to processes and practices for identifying, selecting, acquiring, exploiting and protecting technology for business benefit.[2] The Centre's activities can be broken out into three broad, yet related, categories: strategic technology management, which includes technology planning, tracking and forecasting technology trends and breakthroughs, sourcing technologies and assessing the business value of technologies and creating strategies for marketing and monetizing that value; innovation management, which includes intellectual property management, management of projects focused on achieving innovation and management of collaborative innovation arrangements; and technology enterprise, which includes research and educational activities relating to the origins, start-up and growth of technology-based ventures and their impact on the economy.

The wide scope of activities included under the umbrella of technology management, and the need to place technology squarely within the company's overall strategic planning, means that it is important to designate one person who will be responsible for the advance of existing strategic technologies and identification of the future technology requirements of the company. In many cases, this person will be the company's chief technology officer, a position described in detail below, who will be responsible for a number of different activities including technology audits, benchmarking the company's technology portfolio in relation to competitors, technology forecasting, defining the strategic technology requirements of the company, and establishing procedures and practices for keeping informed of new developments and acquiring and protecting those technologies that are crucial to the business strategies of the company.

§2 Definition and scope of technology and technology management

Before there can be any discussion of the scope and practice of technology management there must be a basic understanding of the subject matter. Unfortunately, there is no commonly accepted definition of "technology" and there is no shortage of ideas on what the word means in the context of business strategy.[3] At its roots the term refers to the skills associated with application of proper techniques[4] or the practical application of knowledge. The following useful definition was supplied by Burgelman et al.: "technology refers to theoretical and practical knowledge, skills and artifacts that can be used to develop products and services as well as their production and delivery systems. Technology can be embodied in people, materials, cognitive and physical processes,

---

[2] The Centre for Technology Management is part of the Institute for Management at the University of Cambridge and the discussion in this paragraph is based on information available from the Institute's website as of September 2015. The science and practice of technology management is also the focus of the Journal of Technology Management & Innovation, a quarterly online, international, peer-reviewed journal.

[3] For further discussion, see "Organizational Design: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org).

[4] K. Hakkarainen, Strategic Management of Technology - from Creative Destruction to Superior Resilience (2006).

plant, equipment, and tools."[5] It is possible to derive the following principles from a synthesis of the definitions that are commonly suggested in the literature:

- Technology is the product of a systematic research and development process, or "R&D," rather than individual "know how" and skills which, while valuable, cannot be formalized and thus transferred for use by others.
- Technology is something more than mere basic techniques that can mastered easily by all. Instead, creation or improvement of technology requires scientific knowledge.
- Technology is used for industrial applications, such as manufacturing processes or functions that are performed by products. Techniques used in other functional areas, such as finance and marketing, are not technologies even though they may have value and be protected by law as "know how" or trade secrets.
- While basic scientific knowledge, and the research activities on which it is based, is an important condition for the creation of technology, the technology development process only begins when the activities turn to applying science to existing techniques in order to create new tangible products that solve commercially significant problems.

Like the definition of "technology", the meaning of the term "technology management" has also been debated. In a report issued in 1987 the National Research Council defined the management of technology as linking "engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization." White and Bruton were critical of this definition, arguing that it failed to include attention to the evaluation and control that they believed was necessary for a strategic approach to technology management, and suggested that a better definition would be the following: "The management of technology is the linking of different disciplines to plan, develop, implement, monitor, and control technological capabilities to shape and accomplish the strategic objectives of an organization."[6]

Chanaron and Grange offered the following comprehensive definition and accompanying explanation of technology management: "Technology management is the management of innovation, whether it be a product, a process or an organization, from its conception to its diffusion, and therefore to its implementation within the company, including the consequences, advantages and disadvantages for all of the variable and actors involved in running the company. Innovation is seen as any change produced by technology in an organization towards the satisfaction of its economic goals, i.e., providing an economic advantage. Technological management is then the management of change, i.e., the management of technology. But it also involves management by and through technology or, in other words, how technology is used to run the company, then the management of the appropriation of technology by the organization. It is a set of tools that creates value

[5] R. Burgelman, A. Maidique and S. Wheelright, Strategic Management of Technology and Innovation (2001), 4.
[6] M. White and G. Bruton, The Management of Technology and Innovation: A Strategic Approach (2007), 18.

by generating new markets and opportunities and/or by reducing production and transaction costs."[7]

In general, technology management concerns itself with the creation or acquisition of technology, particularly the process of transforming basic knowledge, or science, into products that have practical and commercial utility in the marketplace or in internal business activities. In other words, technology management implies managing what adds value to products and services on the market to create wealth; it is therefore managing the application of knowledge and know-how in order to create value.[8] This process is also often referred to as "innovation" and has been the subject of analysis and commentary by a wide range of academics and business consultants, particularly as to those industries that are grounded in continuous advances in scientific knowledge. Technology management also includes the steps that need to be taken to protect the technology of the firm, including the development and maintenance of an intellectual property rights portfolio, and the formulation and implementation of strategies for commercial exploitation of the company's technological assets.

Given the uncertainties associated with the development and commercialization of emerging technologies, which are defined and discussed below, as well as the pervasive impact that all forms of technology have on the way in which organization conduct their activities, it is not surprising that technology management has become a recognized strategic and professional discipline. In addition to the general areas of interested mentioned above, technology management requires attention to a wide range of difficult specific issues, including the following:

- What procedures can be identified and implemented for identifying and evaluating technologies worthy of investment in situations where the risk associated with the development of the technologies are extremely high and the outcome of the development activities is uncertain?
- What strategies should be adopted to access the technologies needed by the company to pursue its goals and objectives, including internal development, licensing or more extensive strategic alliances with outside partners?
- How can the company identify markets that are suitable for products and services based on its emerging technologies given that the uncertainty and newness of the technology will necessarily make it difficult to gauge customer requirements, competition and the potential size of the market?
- What organizational structure should be created in order to manage the development of new technologies and their associated products and services?
- What steps need to be taken in order to perfect and maintain the optimal level of intellectual property protection for the company's technology assets, particularly in situations where patent offices have little or no experience with the technology?
- Is it possible to make an educated guess regarding the direction that new industries based on emerging technologies will take over the company's planning period?

---

[7] J. Chanaron and T. Grange, Towards a Re-Definition of Technology Management (2006).
[8] Id.

The results of a survey conducted in the mid-1980s among academics and industrial managers from 17 countries revealed that strategic planning of technology products was clearly the highest priority with respect to technology management. Other issues, in descending order of importance, included project selection methods and criteria, methods and tools for organizational learning, identification and development of key competencies, reducing the length of the product development life cycle, creating an "ad hoc" organizational culture, coordinating and managing new product development teams, analyzing and understanding technological trends and shifts and, finally, orchestrating more involvement from marketing teams.[9] For their part, Khalil and Bayraktar suggested that technology management requires consideration of the following fundamental questions[10]:

- How should technology be integrated into the objectives of corporate strategy?
- How can technologies be released and accessed more quickly and efficiently?
- How can technology be assessed more efficiently?
- How can the transfer of technology be optimized?
- How does one reduce the development time of a new product, process or organization?
- How should major, interdisciplinary and inter-organizational projects or complex systems be managed?
- How should the internal usage of technology within the organization be managed?
- How can the efficiency of technical personnel be improved?

Chanaron and Grange argued that strategic management of innovations and technology covers a broad range of research issue and managerial practices such as the following[11]:

- Strategic reflection on the role of technology in attaining the objectives of corporate strategy: What role and what priority should be given to innovation and technology? What are the technologies of the future? What are the mainstream trends liable to impact on the emergence and rate of diffusion? Which key technological competencies should be maintained, developed, abandoned and at what rate? What are the markets of the future?
- Strategic reflection on internal organization and industrial relations with corporate partners: Undertake, acquire or delegate technological development? Acquire, merge or develop technological alliances? Which human and financial resources? Which systems should be used to assess the performances of the organization and piloting?
- Operational management of the innovation process: Management of R&D and design; management of knowledge and know-how; management of the specific competencies of technical personnel; management of R&D and design personnel; management of technological acquisitions, partnerships, alliances and contracts; management of

[9] Id. (citing G. Scott, "Top Priority Management Concerns About New Product Development", The Academy of Management Executive, 13(3) (1999), 77).
[10] T. Khalil and B. Bayraktar, Management of Technology: The Key to Global Competitiveness (1990).
[11] J. Chanaron and T. Grange, Towards a Re-Definition of Technology Management (2006).

budgets allocated to research, technological scanning and innovation marketing; management of market release

- Management of the technological value chain and innovation process: Industrial management of scientific and technical projects; management of interfaces between research and industry; management of budget allocations to research, technological scanning and innovation marketing; management of the localization of knowledge production activities, especially poles of excellence; and management of market release
- Management of innovative product marketing: Understanding the determinants of new product performance; strategies for managing competitive reactions; management and composition of new product development teams; methods for forecasting sales of new products; methods for setting prices of innovative products; management of the life of new products, including the launch agenda; and management of communication, especially the pre-announcement

It was noted that while small- and medium-sized enterprises ("SMEs") face all or most of the problems listed above areas of particular interest for those types of firms appear to be tools and methods; scientific and technical partnership, alliances of a technological nature; funding; and marketing of innovative products and services.

§3 Schools of technology management

Sahlman explained that technology management has developed and evolved for a significant period of time beginning with the rise in importance of corporate research and development laboratories at the end of the 19th century and noted that four "schools of technology management" had been identified and described by Drejer[12]:

- The "R&D management school", which regards research, development and technology as strategic instruments for long-term competitiveness and innovations[13] and thus emphasizes formulation of explicit technology strategies and integration of technology into a firm's overall corporate and business strategies. Some of the areas of interest to researchers in R&D management include knowledge acquisition and diffusion, networked R&D and open innovation.[14]
- The "innovation management school", which analyzes how firms manage the process of "innovation" from the initial generation of ideas through the commercialization phase. Researchers interested in innovation management have identified various types of process, product and service innovations (i.e., discontinuous, radical, really

[12] K. Sahlman, Elements of Strategic Technology Management (2010), 40-41 (citing A. Drejer, The Discipline of Management of Technology, Based on Considerations Related to Technology, Technovation, 17(5) (1997), 253).

[13] See, e.g., J. Edler, F. Meyer-Krahmer and G. Reger, "Changes in the Strategic Management of Technology: Results of a Global Benchmarking Study", R&D Management, 32(2) (2002), 149.

[14] H. Chesbrough, Open Business Models (2006); F. Chiaromonte, "From R&D Management to Strategic Technology Management: Evolution and Perspectives", International Journal of Technology Management, 25(6-7) (2003), 538; and U. Lichtenthaler, "Opening Up Strategic Technology Planning: Extended Roadmaps and Functional Markets", Management Decision, 46(1) (2008), 77.

new, incremental and imitative)[15] as well as multiple sources of innovation.[16] Proponents of innovation management believe that while the external environment changes it is possible and desirable to adopt tools and methods for predicting those changes (e.g., technology forecasting) in order to make decisions about technology strategies.

- The "technology planning school", which, as the name implies, is primarily concerned with using various planning tools (e.g., forecasting, portfolio analysis and management methods) to plan and react to technological developments in a continuously changing business environment.[17]
- The "strategic technology management school", which views technology as the starting point for strategy and focuses on combining technological and business issues and integrating decisions on those issues into corporate strategy using a comprehensive strategic management process.[18]

§4 Technology management frameworks

Numerous efforts have been made to develop "technology management frameworks" that could be used by researchers and managers as a means for presenting and communicating ideas and prescriptions regarding technology management. These frameworks range from quite theoretical to some simplistic, albeit practical, models, each of which share a common purpose of attempting to identify the elements of strategic technology management. Sahlman offered the following list, and brief descriptions, of some of the most well-known technology management frameworks[19]:

- Generic process model: Views technology management as a generic process of distinct steps including identification, selection, acquisition, exploitation and protection of technology[20]
- Technology management functions: Emphasis on key functions of technology management including technology strategy, road mapping, development, information

[15] R. Garcia and R. Galantone, "A Critical Look at Technological Innovation Typology and Innovativeness Technology: A Literature Review", Journal of Product Innovation Management, 19(2) (2002), 110.
[16] K. Pavitt, "What We Know About Strategic Management of Technology", California Management Review, 32(3) (1990), 17; and E. Von Hippel, The Sources of Innovation (1988).
[17] M. Andreasen and L. Hein, Integrated Product Development (1987); and R. Cooper, S. Edgett and E. Kleinschmidt, Portfolio Management for New Products (1998).
[18] K. Brockhoff, "Technology Management as Part of Strategic Planning – Some Empirical Results", R&D Management, 28(3) (1998), 129; R. Burgelman, A. Maidique and S. Wheelright, Strategic Management of Technology and Innovation (2001); A. Drejer, "Back to Basics and Beyond: Strategic Management - An Area Where Practice and Theory are Poorly Related", Management Decision, 22(3-4) (2004), 508; R. Phaal, C. Farrukh and D. Probert, "A Framework for Supporting the Management of Technological Knowledge", International Journal of Technology Management, 27(1) (2004), 1; and U. Lichtenthaler, "Opening Up Strategic Technology Planning: Extended Roadmaps and Functional Markets", Management Decision, 46(1) (2008), 77.
[19] K. Sahlman, Elements of Strategic Technology Management (2010), 42.
[20] M. Gregory, Technology Management: A Process Approach, 209 (B5) Proceedings of the Institution of Mechanical Engineers (1995), 347.

and knowledge management, acquisition, transfer, forecasting, product development, life-cycle management and commercialization[21]

- Technology management routines: Emphasis on key routines relating to identification, development and use technology including producing scientific and technological knowledge, transforming knowledge into working artifacts, matching artifacts with user requirements and providing organizational support[22]
- Integration of technology management activity to business processes: A practical model focusing on “best practices” for integrating technology planning into business planning including planning, involvement, commitment, buy-in and accountability[23]
- Technology strategy approach: Focuses on key activities and decisions for creation and implementation of technology strategies including definition of core and complementary technologies, competencies, make/buy decisions, environment analysis and planning[24]
- Integrated management concept: See technology management as a bundle of general management tasks and activities including normative (vision, know-how acquisition, decision-making, policies, innovation culture creation); strategic (planning, organizational design, make/buy, alliances creation) and operative (R&D goals, motivation, tasks fulfillment)[25]
- Innovation funnel: Sometimes referred to as “open innovation” in the context of developing technological innovations, this framework focuses on the process of new product development from the concept stage through commercialization with particular emphasis on knowledge flows and networked technology/resource/R&D[26]
- Knowledge management: Focuses on the integration and management of dimensions of “knowledge”) (i.e., what, why, how, when, who, where) using processes, methods, tools and people[27]

---

[21] H. Kropsu-Vehkaperä, H. Haapasalo and J. Rusanen, “Analysis of Technology Management Functions in Finnish High Tech Companies”, The Open Management Journal, 2 (2009), 1.

[22] D. Levin and H. Barnard, “Technology Management Routines that Matter to Technology Managers”, International Journal of Technology Management, 41(1-2) (2008), 22.

[23] P. Metz, “Integrating Technology Planning with Business Planning”, Research Technology Management, 39(3) (1996), 19. See also R. Phaal, C. Farrukh and D. Probert, Practical Frameworks for Technology Management and Planning (2000); and R. Phaal, C. Farrukh and D. Probert, “A Framework for Supporting the Management of Technological Knowledge”, International Journal of Technology Management, 27(1) (2004), 1 (generic framework integrating technology management core processes to processes of strategy, innovation and operations).

[24] R. Burgelman, A. Maidique and S. Wheelwright, Strategic Management of Technology and Innovation (2001); M. Porter, Competitive Advantage: Creating and Sustaining Superior Performance (1985); and M. Dodgson, D. Gann and A. Salter, The Management of Technological Innovation: Strategy and Practice (2008).

[25] H. Tschirky, Technology Management: An Integrated Function of General Management (1991); and M. Luggen and H. Tschirky, A Conceptual Framework for Technology and Innovation Management in New Technology-Based Firms (2003).

[26] S. Wheelwright and K. Clark, Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality (1992); and H. Chesbrough, Open Business Models (2006).

[27] H. Chai, M. Gregory and Y. Shi, “Bridging Islands of Knowledge: A Framework of Knowledge Sharing Mechanisms”, International Journal of Technology Management, 25(8) (2003), 703; and I. Nonaka and H. Takeuchi, The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation (1995).

- Methods and tools approach: Focuses on the use of specific sophisticated tools and methods for technology management such as road mapping, blue-box analysis, portfolio analysis/management, benchmarking, forecasting, decision grids and trees and performance indicators[28]

Sahlman noted that many of the elements mentioned above in the context of one or more of the technology management frameworks were themselves the subjects of specific practice models such as technology forecasting, road mapping, portfolio management, evaluation, benchmarking, selection, patenting, licensing, decision grids and strategy making.[29]

Phaal et al. conducted their own extensive review of the relevant literature and research to suggest a framework for practical and theoretical understanding of the management of technological innovation that incorporated various business processes they thought to be especially important for effective technology management: core processes such as strategy, innovation and operations and the well-known supporting technology management processes that included identification, selection, acquisition, exploitation and protection. Specifically, they argued that a technology management framework must incorporate the following key elements to be effective[30]:

- The technology base of the firm;
- The technology management processes (identification, selection, acquisition, exploitation and protection) that operate on the technology base to support innovation in the firm;
- The core business processes of strategy, innovation (including new product development) and operations, which provide the means by which the potential value of technology can be realized;
- The mechanisms by which the technological and commercial perspectives of the firm are brought together, to ensure an appropriate balance between market "pull" (requirements) and technology "push" (capabilities); and
- The internal and external factors that provide context to technology management in the firm, such as business purpose, organizational structure, culture and infrastructure, market environments, drivers, etc.

They noted also that time is a key dimension in technology management, although it was not explicitly depicted in their framework. Overall, they emphasized that the integration of knowledge, processes, activities and methods—using techniques such as technology road mapping—is essential for effective technology management.

§5 Emerging technologies

[28] R. Phaal, C. Farrukh and D. Probert, "Technology Management Tools: Generalization, Integration and Configuration", International Journal of Innovation and Technology Management, 3(3) (2006), 1.
[29] Id.
[30] Id. at 12.

Technology management is not an easy task in any situation; however, the challenges are even greater when the company is involved with "emerging technologies." A technology is "emerging" when the relevant knowledge base is expanding rapidly and is being used in innovative activities that will result either in the radical transformation of an existing industry or key market sector therein or the creation of new industries or markets. Emerging technologies may be "evolutionary" to the extent that they are based on the convergence of research that had previously been conducted independently. Examples in this area include MRI imaging, HDTV and the Internet. Alternatively, an emerging technology may be represented by a discovery that is radically different from, and generally totally unconnected with, any existing body of research work. Examples in this area include biotherapeutics and microrobots.

§6 --Distinguishing challenges of emerging technologies

Companies must understand that involvement with emerging technologies will have a significant impact on the way in which the firm conducts its business activities. Among the key differences between industries and markets based on established, or mature, technologies and those that may arise from emerging technologies are the following:

- While established industries are presumably stable and predictable, emerging industries are riddled with volatility and uncertainties. For example, while many established industries have recognized technical standards in place, emerging industries are based on rapidly evolving scientific knowledge and it is often not clear what standards will apply or what actual benefits to customers will emerge.
- The competitive landscape, and the identity of the key players, is well known in established industries while it is often unclear where competition will come from with emerging technologies. In many cases, development and appropriate of the advantages of emerging technologies allows new businesses to enter the arena and sweep aside entrenched firms.
- The organizational context for firms involved in established industries is well defined and populated by accepted and understood rules and procedures; however, work with emerging technologies provides little time for setting such standards. Moreover, the pace of development with emerging technologies often dictates that decisions must be made quickly without the deliberative process found in established industries.
- Established industries rely on traditional strategic planning tools focusing on securing identifiable competitive advantages while the uncertainties involved with emerging technologies requires the use of alternative forecasting tools and the development of multiple strategies based on the unknown evolution of core technologies and related new product concepts.
- The allocation of capital and other business assets, and measure of the uses thereof, in established industries is based on known milestones and procedures while budgeting for development of emerging technologies is problematic and based primarily on the intuition and experience of the managers involved in the process.
- Market assessment for traditional technologies can be based on mainstream market research techniques while interest in products based on emerging technologies requires experimentation and a series of "trail-and-error" tests and queries. In most

cases, the requirements of customers and participants in distribution channels will not be known with certainty for some period of time, thereby delaying the ability of the firm to create and enforce production standards internally and with its vendors.
- The development process for new products based on traditional technologies can be based on carefully defined steps from concept generation to launch that continuously narrow the focus while the process for products based on emerging technologies must be more open ended and amenable to pursuit of multiple alternatives at one time.
- While established technologies generally have known rules and guidelines for protection of proprietary rights, appropriation of gains from development of emerging technologies may be more uncertain and may require reliance on lead time and control of complimentary assets as well as intellectual property rights.
- While established technologies generally have well-defined regulatory guidelines, the process of creating and formalizing testing and reporting standards for products based on emerging technologies can be quite time-consuming. Also, regulators are often forced to modify their initial decisions with respect to emerging technologies as they become aware of new information.

In many cases, a company's involvement with an emerging technology is the very reason that the firm was established. In many ways, these new businesses, often referred to as "emerging companies," have substantial advantages in that they are unencumbered by the rules and restrictions that apply to firms grounded in established technologies. On the other hand, emerging companies are perceived by investors as carrying high levels of risk because of the aforementioned uncertainties relating to emerging technologies and the lack of a broad-based portfolio of established products and technologies that can sustain the firm while the emerging technology evolves and matures. While recent history is full of success stories for emerging companies, the more common result is failure.[31]

§7 --Emerging technologies and established companies

Emerging technologies present special challenges to established companies. While emerging technologies are, by definition, generally considered to be significant variations from the norm, they are seldom total surprises for companies that maintain some minimal level of attentiveness to the scientific and competitive environment in which they operate. Nonetheless, each industry has it own set of stories about firms that failed to anticipate or otherwise adequate prepare for the introduction of new technology that ultimately led to their displacement as industry leaders. It is therefore important for established firms to be mindful of some of the common mistakes that might be made with respect to emerging technologies. In that way, steps can be taken to create processes that can enhance the adaptability of the firm and its technology management strategies.

The first issue that an established company needs to consider is whether to become involved in the pursuit of an emerging technology. Established firms often suffer initial setbacks in their efforts to participate in the development and commercialization of

[31] For further discussion the characteristics of emerging companies and the specific challenges associated with managing such companies, see "Entrepreneurship: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org).

emerging technologies because they fail to enter the fray soon enough. It is important that the company make an effort to evaluate any emerging technology to make some initial assessment of where it might lead and what applications and products might appear at some point in the future. This process is not easy and requires a substantial level of imagination and scenario planning. Of course, any anticipated benefits and advantages to the technology must be weighed against the costs of development and the risks associated with the development process.

Established firms have developed various strategies and practices for handling the uncertainties relating to emerging technologies. For example, realizing that the risky nature of the development process for emerging technologies presents a formidable challenge to the use of traditional tools of financial analysis, such as discounted cash flows, companies have been to use new techniques for investment decisions in this area. One popular method is referred to as "real options" and takes into account certain intangible factors relating to emerging technologies that cannot be quantified at the time the initial investment decision is made. Accordingly, companies may decide to proceed with a development project that does not otherwise satisfy the benchmark return on investment requirements because of the good faith belief of management that the project will ultimately position the company to exploit attractive opportunities in new markets that may become better defined as the project unfolds.

Established firms, when confronted with a potential market opportunity or a customer need, often tend to rely on existing technological solutions that are most familiar to the firm. Consider, for example, the way that many "bricks-and-mortar" companies were reluctant to establish online businesses for promoting and selling their product and services. This is not surprising, given that companies often have substantial investments in the technologies that are currently the industry standard and typically lack the in-house resources to evaluate emerging technologies. Companies must, however, have the courage and insight to be open to new trends and ideas. This can be accomplished by recruiting experts who can independently review the company's technology position. In addition, the company should establish relationships with individuals and entities who are engaged in cutting-edge research, even if their work does not appear to have an obvious relationship to the company's current business activities.

The next issue is the level of commitment to participating in the development of an emerging technology. When established firms do decide to enter into the development of emerging technologies, they often hamper themselves by their unwillingness to aggressively attack the development effort. This is often due, in part, to the ongoing need to tend to the requirements of current customers who remain dependent on the company's traditional products and technologies. However, the company must be realistic about the life cycle of its current product line and critically review the sustainability of its market share and profit margins in light of anticipated development of new emerging technology solutions by competitors. Moreover, the company must be willing to look at the way an emerging technology might allow it to enter new markets and establish relationships with new customers. If companies hesitate too long they may find that they have lost significant market shares to more aggressive competitors that were willing to make an early investment in the new technology.

Finally, established firms, often burdened by maintenance of a wide range of existing product lines and traditional technologies, tend to lack the persistence necessary to successfully pursue emerging technologies. This risk is particularly high for public companies, since they are under substantial pressure to meet short-term financial goals and objectives that are often inconsistent with the long-term effort required for breakthroughs with emerging technologies. One way to confront this problem is to build an institutional structure that recognizes the different measurements that need to be used in order to evaluate emerging technologies. In many cases, companies may create a new division, or even a totally new outside venture, to house the emerging technology initiative. In so doing, the company can insulate the project from the day-to-day pressures facing the current businesses. If the company is not patient and is not able to overcome initial setbacks it will ultimately miss valuable opportunities and may find itself hopelessly behind its competitors if and when it eventually becomes clear that what was once an emerging technology has become an industry standard.

§8 --Guidelines for successful exploitation of emerging technologies

While identifying and commercializing emerging technologies is a difficult and challenging task the rewards for the company can be substantial and failure to embrace new technologies and integrate them into the company's business model can have significant adverse consequences. It is important, therefore, for all companies, from start up businesses to established global enterprises, to understand and apply the following basic guidelines for successfully exploiting emerging technologies:

- Companies must steadfastly embrace wide-ranging scanning of the technological landscape and should invest in the resources needed to identify potential emerging technologies at the earliest stage possible. It is also important to develop procedures for assessing such technologies and monitoring their development. Even if a new technology does not appear to have immediate use the company should keep an eye on it since technical or scientific breakthroughs and/or changes in customer requirements may open up new product development and marketing opportunities.
- Senior management should encourage employees to pursue their curiosity about new ideas and technologies and develop an organizational culture in which the pursuit of knowledge is valued and risk taking to achieve innovation is tolerated and celebrated. Company personnel should be encouraged to experiment and challenge current assumptions regarding the direction of the business and its underlying technology.
- Investment decisions in the technology area should be made with an eye toward continuously expanding the range of future options available to the business, as opposed to unduly narrowing the focus of the company.
- Senior management must be willing to balance the desire for predictable long-term planning with the ability to embrace flexible organizational forms that may be needed to pursue opportunities created by emerging technologies. Organizational flexibility is essential for companies to be able to change course quickly to exploit emerging

technologies or, in some cases, pull back when it eventually becomes clear that the path will not lead to the desired result.

Companies must be creative when following the guidelines established above. For example, identification of potential emerging technologies typically requires attention to a number of fairly subtle signs and indicators such as an increase in the number of researchers and new businesses focusing on a particular problem or technical or scientific area. Breakthrough insights on customer desires can be obtained from primitive solutions that fail when there is evidence that a large number of customers were willing to try a new technology or product that ultimately failed because the bugs associated with the first versions could not be overcome. A good example of this phenomenon was the buzz created by the frenzied download of MP3 files by college students using technology created by Napster and similar upstart firms. While few of the first generation companies survived the information obtained about these customers eventually led to more sophisticated solutions that have revolutionized the music industry. With regard to aligning the organizational structure to active pursuit of emerging technologies, senior managers must become comfortable with using different organizational units, with unique procedures and cultural values, to focus on and nurture entrepreneurial businesses based on the emerging technologies.

§9 Strategic aspects of technology management

Companies involved in technology-based industries and markets must understand the importance of approaching technology management as an essential element of the firm's overall competitive strategy. This requires an appreciation of the potential competitive advantages offered by technology and the need to integrate technology into the analysis of the company's competitive position. In addition, an effort should be made to evaluate the strength of the company's core competencies in the technological areas that are most relevant to businesses that the company wishes to pursue and the products and services necessary for the company to be competitive in those business areas. Once the relationship of technology to the goals and strategies of the company is clearly understood senior management must develop the company's technology strategy and establish procedures for implementing and monitoring that strategy.

§10 --Competitive advantages of technology

Among the main competitive advantages offered by technology are the following:

- Technology can be used to produce and distribute products less expensively and more efficiently than competitors, thereby allowing the company to achieve success based on cost leadership. For example, using technology that allows the company to efficiently produce high volumes of product can lead to the advantages of economies of scale.
- Technology can be used to develop product features that can positively differentiate the company's products from those of competitors. For example, technology can be

the foundation for features that allow the company to claim that its product provides higher performance or quality or that is more reliable or durable.

- Technology can be used to overcome competitive advantages of other firms and allow a new entrant to challenge the position of experienced firms with greater market share and resources. For example, if a smaller company can develop a technological innovation that spontaneous reduces the company's costs of production, it can quickly overcome the advantages of economies of scale and experience that may have been built up by larger market incumbents.
- Technology can also be used a way to effect a radical change in the key factors that will govern competition in a particular industry. For example, a smaller firm that is able to use technology to substantially reduce production costs can force entrenched competitors to adopt similar changes, often at substantial expense given the need to retool existing systems and procedures. Also, "just-in-time" manufacturing, while not strictly a form of technology as defined above, is a way in which firms were able to "change the rules of the game" in their industries.

Of course, the value of any of these potential competitive advantages depends on a number of factors. For example, a differentiation strategy based on technology will only be successful if the company will be able to adequately protect the technology from imitation by competitors. Moreover, while technology allows a company to develop interesting product features the effort is only worth it if customers recognize the value and are willing to pay for it.

§11 --Technology-based definition of the company's business portfolio

Technology management assumes that the company has made the decision to integrate technology into the formulation of its overall business strategies. For this to occur, it is necessary that the company expand its analytical framework for strategic formulation beyond business and market considerations to include technological capabilities. In order to do this it is useful to imagine a matrix that combines the elements of the company's business portfolio with the firm's technological capabilities identified during the course of a technological audit. Using this type of model, the business activities of the firm can be classified by reference to measures of the following variables:

- External measures of the potential of a particular business area, including the current size of the market, projected growth potential, opportunities for appropriate of profits and the presence of competitors;
- Assessment of the company's internal strengths and weaknesses in relation to the particular business area, including the company's current market share, distribution capabilities, brand equity and experience with the customer base; and
- Evaluation of the company's competencies in the technologies that are considered to be most important to success in the particular business area.

By combining measurements of each of these factors, company strategists can begin to develop a picture of the firm's current business portfolio and identify the choices that will need to be made with respect to allocation of resources and the methods that may be used in order to acquire and exploit technological capabilities. While it is rarely possible to make a clear assessment of the company's position with regard to a particular factor, the use of this type of analytical system can be illustrated by using either "strong" or "weak" as the applicable measure in each area and then identifying possible strategies for combinations of those measures.

Obviously the most attractive business areas are those in which the measurements are strong on all three dimensions. If, for example, the company already has a strong market and technological position and it is expected that the area will continue to enjoy significant growth over the projected planning period, it can be expected that the company will opt to invest significant resources to maintain its current position, develop improvements to existing technologies and acquire the complementary assets necessary to allow the firm to growth along with the market. Existing products that fall within this combination of factors are sometimes referred to as "stars" in several of the popular frameworks for strategic analysis and the inclusion of a technological dimension really does little to change the recommended course of action. At the other extreme is the case where a business has a low growth potential and the company currently has a poor market position and lacks the technological resources needed to be competitive. Existing products that fall within this category are often referred to as "dogs" and will typically be abandoned unless there is some way for the firm to continue to produce them profitably without additional investment.

The most challenging decisions lie in those grey areas between the "stars" and the "dogs" and the relative position of the company with respect to technological capabilities can be an important factor. For example, consider a company with a strong technology position evaluating opportunities in the following market and growth potential situations:

- If the current market position is strong, but the projected growth potential is weak, consideration must be given to identifying alternative uses of the technology, including licensing to outside parties and the internal deployment of the technology in high growth areas.
- If the current market position is weak, but the projected growth potential is strong, consideration might be given to a strategic alliance with an outside partner that might be able to provide the necessary market-based assets to make the technology competitive, particularly access to distribution channels.
- If, unfortunately, the company finds itself with a strong current technology position in a weak market with low projected growth potential, efforts must be made to license the technology to third parties that can deploy the technology in businesses with high growth potential. These relationships can be used to generate cash flow and gain access to non-technology assets and capabilities.

The other side of the analysis is determining what to do about a weak technology position in the face of each of the following scenarios:

- If the current market position is strong, but the projected growth potential is weak, the company finds itself in a very difficult situation that illustrates the dangers of

allowing technological advantages to erode. In this case, the company must preserve cash flow while searching for new technologies that can provide a quick infusion to profitability and assist the company in maintaining its market position.
- If the current market position is weak, but the projected growth potential is strong, the issue is whether to make the required investment to acquire the needed technology, a decision that often is based on the company's prospects in other attractive markets and its ability to develop the necessary complimentary assets to shore up its market position.
- If the current market position is strong and the project growth potential is high, the company must seriously investigate ways to acquire the technology necessary to take advantage of its experience and credibility in the target market, which generally includes a proven distribution channel network. While the company may elect to invest in internal development, it is often quicker and more cost-effective to look outside through acquisition or licensing.

§12 --Developing the technology strategy

Effective technology management requires the development and implementation of a clear technology strategy that defines the role that technology is expected to play in the overall business strategy of the firm. The technology strategy will determine the focus of the company's internal R&D activities, as well as the need to look to outside sources for technology, and also impacts the selection of market sectors for the company's new products and the way those products are positioned in the eyes of potential customers. As described below, responsibility for developing the technology strategy, as well as oversight of the procedures for implementing and monitoring the strategy, may be vested in a chief technology officer who is part of the senior management team of the company; however, given the importance of strategic decisions in this area input must be solicited from all senior managers and other key technology specialists throughout the company.

Formulation and execution of technology strategy cannot occur in a vacuum and companies must act in a manner that is consistent with the external environment in which they are operating. The success of any technology strategy depends upon diffusion and adoption of new technologies or innovations, both within companies and among their customers. A variety of factors influence diffusion and adoption including politics and governmental policies; societal culture; understanding of, and experience with, elements of information systems (i.e., people, hardware, software, communications networks and data resources); and economic, geographic and geopolitical factors, particularly income levels and characteristics of populations (i.e., skills, educational qualifications, literacy rates, productivity and the cost of labor).

There is no single method for defining and determining the technology strategy of a company or business unit. One possibility is to focus on the degree to which the company is dedicated to becoming a "technology leader," as opposed to pursuing a "follower strategy." A technology leadership strategy means that the company has elected to compete on the basis of technological innovation and high technical performance in its chosen market sectors. The emphasis on innovation means that the company is willing to invest heavily in expensive, high risk projects to become the first to develop and commercialize "leading edge" technologies and products based on those technologies. Notable examples of technology leaders among larger firms include Hewlett Packard and Xerox, each of which have thrived on a continuous stream of innovative, high performance technology-based products accompanied by competitive pricing and extensive service and support.

A follower strategy is the preferred approach of firms that are uncomfortable with taking on the risk of technical and/or market failure that accompanies any effort to be a pioneer in a particular area. Followers come in a variety of forms and pursue several different core strategies based on exploitation of technology developed by the leader. For example, IBM has been known to pursue a "fast follower" strategy based on introducing follower products soon after the technology leader. IBM is able to compete effectively based on its marketing strengths, brand name and the ability to observe reaction to the leader product and make appropriate modifications and enhancements to the leader product. Other companies, notably original equipment manufacturers, focus their efforts on developing and commercializing specific applications of the leader's technology. While the resulting products are generally not as technologically sophisticated as those developed by the leader, they typically offer sufficient reliability, quality and cost-effectiveness to suit the needs of a sizable number of customers.

Just because a firm elects a follower strategy does not mean that it does not have to make substantial investments in R&D. In order for a "fast follower" strategy to be successful, IBM and others must still maintain a high level of internal technological competence to be sure that it understand the leader technology and is able to move quickly to deploy the technology once it is clear that there will be an acceptable market. Moreover, a follower strategy is not necessarily less risky than seeking to be a technology leader. For example, while a follower will generally have sufficient time to "catch up" when market conditions are relatively stable, this strategy may be problematic in volatile markets unless the firm is able to track rapid and unforeseen changes in customer requirements and respond to them quickly. Followers may also encounter difficulties with overcoming barriers to entry created by the technology leader, including intellectual property rights or access to complimentary assets and products.

In selecting between a technology leader or follower strategy, senior management must remember that the choice does not necessarily guarantee commercial success of the technology and its associated products. While it would appear that, all things being equal, a leadership strategy would be preferred over a follower approach, there is substantial evidence of technology leaders that have failed and followers that have achieved notable success, often eclipsing the pioneer companies. For example, while a company may develop a leading-edge technology product that offers performance and quality well above existing products, it may fail unless it is able to successfully manage the marketing and support the product. In fact, technology leaders lacking sufficient marketing resources are often prime acquisition candidate for larger companies. On the other hand, IBM, a "fast follower" as described above, has generally done well with its delayed entry into the personal computer market in spite of occasional problems that might have been averted had the firm taken a stronger leadership approach.

At the earliest stages of their life cycle, technology-based growth companies have a limited universe of choices with respect to technologies and products and the decision between a leadership or follower strategy would, by definition, apply company-wide. As the firm grows, however, and the company expands into multiple markets and creates new divisions and business units, strategies must be established for each of these areas. As a practical matter, only the largest global businesses can reasonably follow a technology leadership policy on a company-wide basis and the more common approach is for maturing businesses to adopt a leadership strategy in some markets and follow in others. The challenge, of course, is achieving and maintaining the appropriate balance and making sure that adequate resources are available, and properly allocated, to successfully pursue the chosen strategy in each area.

Selecting the appropriate technology strategy is difficult regarding of the type of technology involved; however, companies are particularly challenged when emerging technologies are involved. In situations where it is concluded that full-scale development work may be too risky given the current uncertainties associated with the emerging technology, the company may nonetheless continue to monitor the progress and keep the preliminary technology assessment team in place. This strategy makes sense when it appears that the emerging technology may have applications in a business area that is attractive to the company but the company itself is confronted with financial obstacles or otherwise involved in other projects. The natural progress from this position is for the company to eventually enter the market as a "fast follower" once others have made the investments required in order to further develop and test the technology and establish initial standards. There are, of course, risks associated with this strategy if the company waits too long and competitors are able to establish a proprietary position.

A more proactive strategy involves establishing relationships with outside parties that allows the company to continue learning about the emerging technologies and to quickly move forward with commercialization opportunities as the technology evolves. The most common example of this type of approach would be a strategic alliance with a small firm or university research department pursuant to which the company provides funding for all or a portion of specified development work in exchange for an option to license or buy the resulting technology for use in specified applications or markets. A significant part of these relationships is the exchange of information and experience between researchers from the company and the alliance partners. In addition, strategic alliances can be used to neutralize similar efforts of competitors.

Rather than rely on others to continue the necessary development work, the company can, of course, move forward on its own and commit various levels of resources to the project. In some cases, the company is comfortable with its assessment that the technology will indeed by an important element of the future competitive landscape and will establish a dedicated unit of researchers and product development specialists to create a business and market plan based on the technology. While this is certainly a significant commitment, the initiative will be one of several being pursued by the company at any given time. At the other extreme, however, is the more aggressive "bet the company" approach in which the firm establishes a course bent on making it the technical and market leader.

The transitional nature of technology strategy for emerging companies is illustrated by the findings of researchers from the University of Chicago who looked at the evolution of technology-based companies from "birth" through their maturation as a public company.[32] Proprietary intellectual property rights, such as patents, and physical assets became more important as time went by for these companies. While 29% of the companies in the study group owned, or had exclusive license rights, to patent at the time of the early business plan, this percentage increased to 49% at the time of their initial public offering ("IPO") and 62% on the date of the third annual report following the IPO. The researchers argued that this finding was consistent with anecdotal evidence and the expressed desire of many emerging companies to differentiate themselves from their competitors by developing and commercializing unique products and technologies which must, by their very nature, be surrounded and protected by strong and enforceable intellectual property boundaries.

§13 --Implementing and monitoring the technology strategy

Once the technology strategy for the company has been established, it is essential that senior management take the necessary steps to ensure that the strategy is effectively implemented and monitored. As discussed below, primary responsibility for ensuring that the technology strategy is executed is often vested in a chief technology officer who will be charged with carrying out many of the tactical activities discussed elsewhere in this Part, such as selection and management of R&D projects and ongoing scanning of the technological environment. However, all members of the senior management team should be involved in actively overseeing the following aspects of the company's technology strategy:

- Senior management must match technology strategy to the long-term business strategy initiatives of the firm. Divisions and business units are generally preoccupied with meeting short-term goals and maximizing return on existing assets and only senior management can authorize the large, long-term investment in new technology projects required in order for the company to seize technology-based opportunities or mitigate threats based on technology trends that will render the company's resources obsolete. Also, senior management is the only group able to determine whether the level of investment in technology is appropriate in relation to other investment activities of the firm.
- Senior management must ensure the company establishes and maintains a balanced technology portfolio across all of the firm's departments, business units and product and market sectors. For example, if one business unit is making a substantial investment in a high-risk R&D project in pursuit of potential high rewards, senior management should be sure that other units balance the risk by taking on smaller,

[32] S. Kaplan, B. Sensoy and P. Stromberg, What are Firms?: Evolution from Birth to Public Companies (2005).

low-risk and low-cost projects that will push the overall rate of return on technology investment to an acceptable level. Balance also refers to the timing of various projects and senior management should guard against taking on too many expensive long-term projects at one time.

- Senior management, through its company-wide budgetary and strategic planning process, must ensure that resources required for technology development are efficiently allocated throughout the firm. This means diverting funding to those areas of the business that must invest in technology to meet the goals and objectives of the company's technology policy. In addition, departments and business units should not be allowed to invest in technology that does not fit within the company's technology policy even if they have extra resources to take on the project.
- Senior management is best positioned to identify opportunities for technological cooperation between departments and business units engaged in independent development activities that might lead to technology synergies. Care must be taken not to force collaboration to the point where the end product is so diluted that it fails to meet the requirements of either department or business unit; however, senior management can encourage communication and resource-sharing in appropriate situations. For example, two or more departments or business units may be willing to share the costs of basic research in a particular area, either internally or through an arrangement with an outside R&D contractor.
- Senior management should be centrally involved in creation and management of any technology-based joint venture or strategic alliance with an outside partner, even those that only involve a single department or business unit. While the day-to-day aspects of the arrangement will be left to lower level managers in most cases, a joint venture or strategic alliance requires senior management participation because of the broader impact the partnership typically has on the perception of the company in the marketplace and relationships with customers, suppliers and other business partners.
- Senior management must be responsible for determining the best way for the company to actually achieve the goals and objectives of its technology policy. Among other things, this means designing the most effective organizational structure for R&D activities and determining when and how to acquire technology from outside parties.
- Senior management must develop and administer measurement and benchmarking tools to compare the firm's technology investment activities against those of any actual and potential competitors in all relevant markets.

As part of the administering the technology strategy for the entire company, senior management must also conduct regular assessments of the individual technology policies of each internal department or business unit. The goals for these reviews include evaluation of the performance of department or business unit managers with respect to technology development and collection of information to determine whether the activities of the various parts of the company are consistent with, and support, the overall technology policy established by senior management. Many of the questions posed during these assessments mirror concerns for the company as a whole. For example, the portfolio of technology development projects for each department or business unit should be reviewed to determine whether it is appropriately balanced and an effort should be made to calculate the net financial impact of the development activities. In addition, the evaluation should include the specific systems and procedures used to manage development projects. Special attention should also be paid to gauging the correlation between technology policy and business strategy. Among other things, this dictates inquiry into whether the development work is based on demonstrated market needs and whether past technology development projects have contributed to the growth of the firm.

§14 Management of technology activities

For most companies, management of "technology" involves both engineering/product development activities (i.e., incorporating technology into products and/or the processes used to manufacture products) and information technology ("IT") activities that include internal and external communications and other projects and support.[33] In some instances, these companies will create separate management structures for each of these functions, although a single senior executive, generally referred to as either the "chief information officer" ("CIO") or the chief technology officer ("CTO") will still retain ultimately responsibility and the leaders of each function will report to that executive. For example, a company might have separate vice presidents or senior directors of engineering and IT. The engineering group might be a centralized source for standards and assume responsibility for support functions, technology initiatives and engineering career development. The day-to-day work of the engineers is often organized into decentralized project teams in various business areas. In contrast, the IT activities are typically fully centralized and organized by function (i.e., support, service, infrastructure etc.) that carry out their activities through project teams.[34]

Advances in technology have changed the ways that all companies and public agencies conduct their businesses and identifying and implementing the best organizational structure for managing technology activities has become a key issue for chief executive officers and members of organizational governing boards. Management activities not only include oversight of IT assets and managing the integration of technology into the design and manufacture of products, but now extend to developing an IT strategic planning process; integrating IT management operations and decisions with organizational planning, budget, financial management, human resources management, and program decisions; coordinating the technology strategies and activities of divisions and business units; and providing information and advice to the senior management group and other company managers regarding technology-related issues.

The term "chief information officer", or "CIO", was first used in the 1980s, a time in which the position was generally thought to be the ideal integration of an experienced

[33] For further discussion of management of technology activities, see "Management of Technology Activities" in "Technology Management: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.
[34] S. Hart, "Inside the Minds—The Role of the CTO in a Technology Company" in Achieving Success as a CTO: Leading CTOs on Building IT's Reputation, Capitalizing on Employee Strengths and Creating a Productive Environment (Boston MA: Thomson/Aspatore, 2008).

business manager with a knowledgeable information system ("IS") technician.[35] According to Synnott and Gruber, the CIO was the "senior executive responsible for establishing corporate information policy, standards, and management control over all corporate information resources".[36] Benjamin et al. described the CIO as the "corporate officer who truly understands the interconnection of the information flow to the business".[37] In a different study, Synott said that CIOs were a "new breed of information systems managers": businessman first, managers second and technologists third.[38] Sprague and McNurlin's list of CIO responsibilities included understanding the business; establishing credibility with the systems department; increasing the technical maturity of the firm; creating a vision of the future and selling it; and implementing IS architecture.[39] Each of these definitions and descriptions highlighted the challenges that CIOs faced in successfully balancing their technical and managerial job roles, a dilemma that eventually led to debate about the appropriate training and career path for a prospective CIO.

During the 1990s, the pressures on, and expectations of, the CIO position began to change as companies became more focused on leveraging their IS to support both operational and strategic goals of the firm. Research conducted about the period found that the CIO position had risen to the top levels of the organizational hierarchy and that CIOs were more involved in strategic decision making with the CEO and other members of the executive team. This meant that the job description of the CIO, which was already quite broad, got even bigger and that the high-level responsibilities or issues confronting the CIO included meeting the changing technical needs of the organization (i.e., the "architecture manager"); building a reputation as a knowledgeable business executive (i.e., being perceived as a "proven businessperson"); orchestrating the successful implementation of the IS strategy (i.e., an "operations supervisor"); and maintaining the proper IS staff (i.e., acting as a "personnel developer").[40]

According to Mullins and Klinowski, the CIO is responsible for ensuring that the company's IT investments are aligned with its strategic business objectives, which means that he or she is the key executive for information assets, operations, and policy.[41] In

---

[35] R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1.
[36] W. Synnott and H. Gruber, Information Resource Management (New York: John Wiley & Sons, 1981).
[37] R. Benjamin, C. Dickinson and J. Rockart, "Changing Role of the Corporate Information Systems Officer", MIS Quarterly, (9) (1985), 177.
[38] W. Synnott, "The Emerging Chief Information Officer", Information Management Review, 3(1) (1987), 21.
[39] R. Sprague and B. McNurlin, Information Systems Management in Practice (Englewood Cliffs, NJ: Prentice Hall, 1993).
[40] R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1, 2 (citing B. Ives and M. Olson, "Manager or Technician?: The Nature of the Information Systems Manager's Job", MIS Quarterly, 5(4) (1981), 49; L. Applegate and J. Elam, New Information Systems Leaders: A Changing Role in a Changing World, MIS Quarterly, 16(4) (1992), 469; and C. Stephens, W. Ledbetter, A. Mitra and F. Ford, "Executive or Functional Manager? The Nature of the CIOs Job", MIS Quarterly, 16(4) (1992), 449).
[41] S. Mullins and J. Klinowski, Defining the complimentary job roles of the CTO and CIO (April 18, 2003), http://www.techrepublic.com/article/defining-the-complementary-job-roles-of-the-cto-and-cio/ [accessed September 12, 2016]

many cases, the CIO is also responsible for the oversight management of various office automation tasks including desktop architecture and support, network implementation, software development and information management. They noted that as technology has become more important for businesses, the duties of the CIO have expanded to include both strategic and tactical duties, a development which has made the CIO's role more stressful, more business-oriented, and less "hands-on". The desired skill set of a CIO has evolved and now includes both a core technical background and a strong business background. Mullins and Klinowski cautioned that the CIO should not be the lead engineer or programmer, but rather he or she must accept the role of, and be perceived as, the business executive who is responsible for synchronizing IT initiatives to the company's overall goals. Mullins and Klinowski noted that in order to be successful, the CIO must be a positive leader; an effective communicator, skilled in both listening and speaking; a persuasive negotiator; and a customer-orientated individual.

The actual and potential roles and responsibilities of the CIO grew to be quite extensive and easily went beyond what any one person could realistically handle. As such, in order for the CIO to be effective he or she needed to have the resources to put together a staff of people with the requisite competencies and, of course, it was the responsibility of the CIO to make sure that his or her group was motivated and that staff members collaborated effectively. Management skills became essential since the areas of interest for the CIO were so broad, spanning managing the existing IT infrastructure, scanning the environment to identify new technological trends and participating in decision making and planning as part of the executive team (including making sure that other executives understand the technology-related issues upon which they are asked to decide). Not surprisingly, the pressures of the position led to high turnover rates among CIO's, a situation that made it difficult for companies to maintain stability in an area that was indisputably crucial to their success.

The new pressures on the CIO led to a call for reconsideration of the traditional model and creation of a new "chief technology officer" ("CTO") position that could assume some of the growing responsibilities of the CIO. The role of the CTO goes beyond managing specific R&D and product development projects to include overall planning and coordination of the company's R&D activities; coordinating the technology strategies and activities of divisions and business units; acting as the functional manager of the activities of the technology managers for each of the company's divisions and business units; overseeing technology sales, purchase and licensing activities; providing information and advice to the senior management group and other company managers regarding technology-related issues; and supporting new technology-based business initiatives launched by the company.

The activities and responsibilities of the CTO will vary depending on the size and business focus of the company and the skills, experience and job descriptions of the other members of the senior management group. That said, however, a strong CTO will generally be actively involved in the development and implementation of a technology strategy for the company; planning and coordinating R&D activities to support the company's technology strategy; coordinating the technology strategies and activities of divisions and business units; acting as the functional manager of the activities of the technology managers for each of the company's divisions and business units; overseeing technology sales, purchase and licensing activities; providing information and advice to the senior management group and other company managers regarding technology-related issues; supporting new technology-based business initiatives launched by the company; conducting technology audits and benchmarking the company's technology portfolio in relation to competitors; establishing and maintaining processes for technology forecasting and defining the strategic technology requirements of the company; and establishing procedures and practices for keeping informed of new developments and acquiring and protecting those technologies that are crucial to the business strategies of the company.

Berray observed that the CTO role, while arguably the least important of the C-suite positions at the time that it was first recognized, was destined to become more important as companies realized the importance of technology to their competitive strategies and that the CTO operated at the elusive nexus of technology and leadership.[42] Berray and a colleague conducted an extensive study over a three year period at the end of the 1990s and early 2000s that involved discussions with hundreds of CTOs and CIOs and a written survey of approximately 30 CTOs. The results of this survey allowed him to propose answers to two fundamental questions: What were the then-current models in companies for the role of the CTO and which model would be most appropriate for particular companies based on its specific business activities, requirements and processes?

Berray found that there were many variations on the specific roles of the CTO across the industries and companies that he surveyed and that it was not possible to develop a profile of a "typical" CTO and his or her responsibilities. He noted that this finding did not mean that the CTO lacked power or influence in relation to other members of the executive team (i.e., the CEO, COO and CFO), but rather that it highlighted the challenges that companies are having in incorporating technology into their competitive strategies and determining the best way to relate technology to optimal decision-making at the top of the organizational structure. He argued that the information collected during his survey pointed to the existence of four general CTO models: the "infrastructure manager", the "big thinker", the "technology visionary and operations manager" and the "external facing technologist".

The 'infrastructure manager": Responding to the what Berray referred to as the "escalating complexity of information technology ("IT")"[43], many of the companies opted for an "infrastructure manager" role for the CTO in which the CTO took on the "line" responsibilities formerly associated with the CIO and oversaw the infrastructure and operations of IT: data center operations, network operations, applications development & maintenance, security, and other line functions. The primary job of the CTO for these companies was to keep the IT organizational operating efficiently. At the same time, the CIO continued to perform the "staff" role with respect to IT, which included overseeing technology strategy, executive-level relationships, budgeting, and

---

[42] The discussion of Berray's studies and finding in this section is adapted from T. Berray, The Role of the CTO: Four Models for Success (April 2002).

[43] Id. at 2.

the fusion of IT and business processes. While operational efficiency of the IT organization was important to the CIO, his or her key mandate was to continuously work to improve the effectiveness of the IT organization and determine how technology would be used to support the company and its pursuit and achievement of its overall strategic goals.

Not surprisingly, the "infrastructure manager" CTO typically reported directly to the CIO, who was a member of the executive team who reported directly to the CEO or the president of the company. While the role often came with an "officer" title, he or she was generally not considered to be an officer of the company or a member of the executive team. To be effective as an "infrastructure manager", the CTO needed to have good operational skills, a keen sense of managing technology and the ability to lead a large and diverse organization. Noting that this model separated the "executive" and "enabler" functions relative to technology, Berray cautioned about the repercussions for organizational behavior, design and integration for the company and seemed to question whether or not using the model adversely impact the company's ability to perform at a maximal level.

The 'big thinker": The "big thinker" CTO plays a more strategic and visionary role and focuses on how technology can be used internally by the company to enable new business models and business lines, increase revenues and preempt attempts by competitors to use technology to disrupt or dislodge the company's market position. Consistent with the strategic emphasis, the CTO is actively engaged with identifying and understanding advanced technology, competitive analysis, technology assessment, lab prototyping, partnering relationships, planning and developing architecture standards. A "big thinker" often works with a small, elite staff and reports directly to either the CIO or the CEO; however, he or she generally does not have direct control in the same way as a line manager and his or her effectiveness depends in large part on the ability to influence the decisions of others. Given this, a "big thinker" role works best for someone who has been with the company for a long period of time and who has developed a strong and trusted relationship with the CEO, CIO and other members of the executive team. In limited cases, a "big thinker" is brought in from outside the organization, but this only works if he or she brings along a tremendous public reputation. The main advantage of this model is having someone who can think independently and concentrate on long-term innovation; however, without direct input into decision making a "big thinker" must be able to influence senior executives to consider new information or different paths to accomplish key goals and must be patient about progress as it will typically take a long time for his or her ideas to catch on.

The 'technology visionary and operations manager": The "technology visionary and operations manager" CTO was common among the "dot.com" and other technology-oriented companies included in the survey and combined determination of how technology can be used to implement business strategy with actual responsibility for integrating and running the technology. Berray noted that this type of CTO needed to have a strong combination of business and technical skills and must be recognized as a member of the senior executive team. A "technology visionary and operations manager"

CTO was often a co-founder of a technology-oriented startup or brought into the business very early in the development of the company when it was crucial to get the business up and running and establish a core competence with respect to technology. At the start up stage, this type of CTO reports directly to the CEO and may even partner with the CEO as a co-chairman of the organization. The CTO must be prepared for expansion of the company and must be able to manage larger organizations while still being able to devote time to designing, building and running the technology. Over time, a CIO may be brought in to report to the CTO and take on some of the day-to-day duties and responsibilities of the "infrastructure manager" side of the CTO position.

Berray observed that it takes a special person—someone with both strong technology vision and the practical ability and experience to design, build, and run the technology while managing an increasingly larger organization—to pull off the "technology visionary and operations manager" role. While many CTO candidates demonstrate a capacity for vision and technology innovation, the reality is that the organization cannot change as fast as the CTO would like and it takes time for companies to put the IT management and infrastructure in place that is needed in order to implement new ideas and technologies. A consultant interviewed by Berray cautioned that visionary technologies must also have the skill to be successful managers, which meant that they must be able to understand how technological instruments functioned in complex contexts that included relationships among other assets (i.e., human, social, knowledge, and financial capital, communications, marketing, branding, customer relations, etc.).[44]

The 'external-facing technologist": According to Berray, an "external facing technologist" CTO "focuses his/her efforts on using technology to provide better products and services to external customers or clients" and his or her "main role is to develop the strategic technology plan for the organization by identifying, tracking, and experimenting with new and potentially disruptive technologies ... [and] … project and assess [their] impact on the corporation and its customers".[45] Berray noted that this type of CTO role is commonplace in IT consulting companies and in those companies the CTO is typically at least an equal peer of the CIO, whose role is focused on identifying and implementing the technologies that companies need to support their internal systems and management operations. The "external-facing technologist" is generally supported by a separate group that allows him or her to engage in a range of activities including technology research and development, technology transfer and change management, intellectual property, knowledge management and/or best practice management, and advanced specialized technology centers. In addition to his or her strategic role, this type of CTO is also expected to share best practices for exploiting key technologies across the company's front line to its customers.

The "external-facing technologist" CTO typically reports directly to the CEO, President or COO and is appointed to the position based on his or her reputation among the other executives or the public as being someone with both a broad knowledge of the potential value in emerging technologies and a keen understanding of how these technologies can

[44] Id. at 3.
[45] Id. at 4-5.

affect the company's business and business processes. The impact of the "external-facing technologist" CTO will depend largely on his or her influence as a key advisor to the members of the executive team and, as such, he or she must have strong communication and interpersonal skills in order to be an effective influencer. While this type of CTO is often directly involved in decision making, it is also not uncommon for him or her to serve mainly in a broad, advisory function that includes helping senior executives to evaluate different paths to achieving the company's business goals. The "external-facing technologist" CTO may be tapped to act as an external spokesman for the company.

Having made his arguments about categorizing CTO into one of the four models described above, Berray turned to the more practical question of how companies can align the role, characteristics and strengths of their CTO to their specific organizational needs. The first approach that he suggested involved mapping the different CTO models against two forces that play an important part in driving organizational needs: the amount of business change affecting the company from either internal or external pressures and the percentage that "information", as opposed to physical assets, represents in the company's portfolio of products and services. The second approach was based on identifying the company's most important business requirements and processes and then comparing the relative capabilities of each CTO model with respect to each of the key requirements and processes.

Using the two driving forces mentioned above, Berray identified four different prototypes of organizations: (1) low pressure for business change and low dependence on information as an element of the product/service portfolio; (2) high pressure for business change but low dependence on information as an element of the product/service portfolio; (3) low pressure for business change but high dependence on information as an element of the product/service portfolio; and (4) both high pressure for business change and high dependence on information as an element of the product/service portfolio. He then argued that the best model for these situations was as follows: (1) the "big thinker"; (2) the "infrastructure manager"; (3) the "external-facing" technologist"; and (4) "the visionary and operations manager". The following paragraphs discuss the reasoning behind his recommendations.[46]

The first prototype organization—low business change pressures and low dependence on information as an element of its products and services—is likely operating in a relatively stable industry where change occurs slowly and typically takes the form of mergers and acquisitions that expand current business capabilities as opposed to bringing in new products, services or technologies. For these companies, information is not a critical element of the products and services that they offer; however, information is important for building and supporting those products and services. Berray argued that companies operating in the food services, chemical and raw materials industries fell into this organizational prototype. A "big thinker" CTO made sense for these companies since he or she could provide valuable support in evaluating how information and technology could be used internally to enable new business models and business lines, increase

[46] Id. at 6-8.

revenues and preempt a competitor's attempts to use information or technology to disrupt of dislodge the company's market position.

The second prototype organization—low dependence on information as an element of its products and services but high business change pressures—is often extensively engaged in mergers and acquisitions activities and in searching for new products and services that can help maintain competitive advantage. Even though information is a relatively small element of the products and services of these companies, it is still important for them to have an effective IT organization that is capable of leveraging the existing structure across existing and new business units. The "infrastructure manager" CTO is the most appropriate model for this situation and he or she can take "line" responsibility for managing and enhancing IT infrastructure and operations and ensuring that the company's IT systems support better communications and collaborations across an organizational structure that is continuously growing geographically and in terms of the number of business units.

Examples of the third prototype organization—high dependence on information as an element of its products and services but low business change pressures—include established research, information technology consulting, software and hardware companies. For these types of companies, the best choice among the CTO models is the "external-facing technologist" focused on how the company can use technology to provide better products and services to its external customers and clients. The CTO can and should also provide value by acting as a reputable and experienced spokesperson for the company in communications with customers, clients, industry organizations and the general media.

The fourth prototype organization—both high dependence on information as an element of its products and services and high business change pressures—presents a challenging and dynamic situation for the CTO role that calls out for someone able to serve as both "visionary and operations manager". The CTO will be continuously involved in supporting the information and technology elements of a rapidly growing portfolio of products and services beginning with the design phase and moving forward through implementation (i.e., making the technology work in terms of reliability and availability and planning for seamless scalability of the technology). The "visionary and operations manager" CTO of this type of organization will also be actively involved in identifying and entering new markets and forging strategic technology-based alliances.

In addition to, or in tandem with, matching the CTO model to the company's external environment as defined by the two "driving forces" discussed above, companies should make sure that the capabilities and responsibilities of the CTO are aligned with their key business requirements and processes. Berray proposed the following list of ten key business requirements and processes[47]:

- Identifying new technologies
- Exploiting new technologies

[47] Id. at 8.

- Integrating new technologies
- Leveraging technology across business units
- Driving the business strategy
- Driving revenues
- Reducing costs
- Enhancing client relationships
- Enhancing communications and collaboration
- Building out or leveraging existing IT infrastructure

He then ranked the relative capabilities of all of the CTO models for each of the business requirements and processes using a continuum of "high", "medium" and "low". For example, when it came to integrating new technologies, the "visionary and operations manager" CTO was the only model ranked "high" while the "infrastructure manager" and "external facing technologist" CTO models ranked "medium" and the "big thinker" CTO model ranked "low". All this would indicate that companies placing a high strategic priority on integrating new technologies should strongly consider recruiting someone who can fulfill the responsibilities and provide the skills associated with the "visionary and operations manager" CTO model.

The rankings could be used to develop ideas on what types of strategic and operational situations, in terms of current or desired business requirements and processes, might be best suited for each of the four CTO models. For example, the "infrastructure manager" CTO model would presumably be a good fit when the key business requirements and processes for the company aligned with those that the capabilities of this model were scored as "high": leveraging technology across business units, reducing costs and building out or leveraging existing IT infrastructure. In the same way, the strengths of the three other CTO models were as follows: "big thinker": identifying new technologies and driving the business strategy; "visionary and operations manager": exploiting new technologies, integrating new technologies, leveraging technology across business units, driving the business strategy and building out or leveraging existing IT infrastructure; and "external-facing technologist": identifying new technologies, exploiting new technologies, driving the business strategy, enhancing client relationships and enhancing communications and collaboration.

In general, "visionary and operations manager" and "external-facing technologist" CTO models were stronger (i.e., ranked "high") in more areas, a sign that these models could provide companies with more flexibility in selecting and pursuing business requirements and processes and a deeper range of capabilities. In contrast, the "infrastructure manager" CTO model, while well suited for building and leveraging existing IT infrastructure and technology across business units and reducing costs, was not a good choice when a company was looking to identify and exploit new technologies to drive its business strategy and increase revenues. Companies looking to use the rankings for help in designing their CTO positions and identifying appropriate candidates could select the business requirements and processes that were most important for execution of their strategies and then see which of the CTO models had the most relevant capabilities. For example, when a company is looking to drive its business strategy through identification, exploitation and integration of new technologies, the "visionary and operations manager" and "external-facing technologist" CTOs are probably the best fits and the "infrastructure manager" CTO would be the weakest choice, although someone with the skills of that model might be brought in to report to the CTO and oversee the build out and leveraging of the new technology that will be required in the future.

Smith argued that it was possible to identify and describe five distinct "patterns" of a CTO based on the skills and responsibilities assumed by the person holding that office and the manner in which the person addresses the unique issues confronting a CTO.[48] Smith believed that the patterns facilitated greater understanding of the diversity within the position and could be used as a means for selecting a CTO who was the best match for the particular business situation and issues confronting a specific firm. He noted that the CTO position was relatively new and many of the tasks now being assigned to the CTO had traditionally been performed by others in the organization including persons who took on activities such as technology forecasting in a somewhat informal fashion outside of their regular job descriptions. Smith pointed out that the CTO position can be found in a wide range of industries and that given the diversity of business models among those industries it is unlikely that a universal definition of what a CTO does can be established. Nonetheless, Smith was surprised at what he perceived to be the dearth of research on the CTO position and set about the task of studying the backgrounds, responsibilities and missions of a number of persons acting as CTO. The result was the following patterns, each of which were driven in large part by the evolutionary stage of the business conducted by the firm and the technological and competitive environment of the industries and markets in which the firm is operating:

- ***Genius:*** The Genius CTO is the seemingly larger-than-life legend who conceives and champions an idea that fuels a technological revolution. Persons in this category are few and far between and would include Thomas Edison, Steve Wozniak of Apple and Sergey Brin of Google. While the Genius CTO is usually skilled at creating something new, possessing vision and confidence and exploiting a unique opportunity, all invaluable traits for an emerging company, he or she often encounters difficulties in managing teams, creating and administering organization-wide processes and working with other executives on long-term business and technology strategy. The Genius CTO is invaluable at crucial, generally early stages, of the firm's evolution; however, this pattern may not be appropriate once the firm has moved beyond the initial technological breakthrough to tackling the problems associated with building and maintaining a larger and more formal set of practices and procedures.
- ***Administrator:*** The Administrator CTO is someone with a keen understanding of both technology and the financial impact of technological issues that the firm must resolve as it grows. Smith noted that the CTO is not only involved in identifying and developing new technologies he or she must also assume responsibility for defending the budgets established by the firm for technology products, services and project labor. The Administrator CTO is someone who understands the technical needs of

[48] The discussion in the following paragraphs is adapted from R. Smith, "5 Patterns of the Chief Technology Officer", Research Technology Management (2006).

the firm's research team and is able to negotiate with outside vendors and service providers to ensure that the firm has access to the resources that it needs on terms that are fair and reasonable from a financial perspective.

- ***Director:*** The Director CTO, often referred to as the Director of Research and Development, is typically a scientist or researcher with a strong individual understanding of the relevant technology who also demonstrates a talent for organization and leading exceptional people and is willing to reduce the time that he or she spends on direct, hands-on research in order to oversee the activities of the entire R&D team. The role of the Director CTO certainly includes budgetary oversight in the same way as the Administrator CTO; however, the Director CTO demonstrates a specific understanding of the need to be well versed in the technical aspects of the firm's products and processes and ensure that the firm's R&D activities are aligned with the firm's overall strategies and focused on generating results that lead to profitable products for the firm. This last point is particularly interesting and important: the Director CTO will almost certainly have the technical skills to understand, and be curious about, a wide range of ideas and potential projects but must be able to pass on those projects that may be challenging and exciting yet hold little hope for resulting in products that will be profitable and contribute to the execution of the firm's then-current business strategies.[49]
- ***Executive:*** The Executive CTO pattern is seen most often among larger firms and features integration of the CTO position into the senior executive team with particular responsibility for guiding strategic decisions involving technology and managing the firm's overall innovation process. Smith succinctly described the Executive CTO as "a businessperson who measures innovation, research, and experimentation by the contribution it makes the company's revenues and future competitive advantage". The Executive CTO may have a scientific or research background; however, he or she has clearly made a shift into a number of different areas of strategic important including responsibility for the firm's research projects, technology forecasting and collecting and disseminating knowledge that can be used for improving research activities.
- ***Advocate:*** The Advocate CTO pattern finds the CTO focusing on the experience that customers have when using the firm's product and services and how the firm interfaces with its customers. Smith noted that the Advocate CTO is most commonly found in retail and service firms and typical areas of interest would be identifying and implementing technology-based solutions for improving customer service (e.g., improving the firm's e-commerce tools to facilitate easier online ordering by customers). The Advocate CTO is focused on selecting and combining the best products and solutions for meeting customer needs and generally assigns implementation of new technologies and upgrades to information technology systems

[49] While the Director CTO spends a good deal of time evaluating project ideas and, as such, accumulates a good deal of knowledge about how a particular project is intended to evolve to the point where it can generate a profitable product or process the Director CTO relies on R&D managers, often directed by a Director of R&D who reports to the CTO, for execution and sponsorship of important R&D projects.

to other specialists within the firm, many of whom are often directly accountable to a Chief Information Officer with whom the Advocate CTO works closely.[50]

Smith also noted that many firms make a conscious decision not to create a CTO position, a situation that Smith referred to as "void". Smith observed that this appears to be a common approach for businesses that are generally stable and believe that technology plays a relatively minor role in their operations and/or that new technology will only become important once a stable solution has been defined by the entire industry. However, he argued that even "non-technical" businesses can benefit from designating someone who can act in one or more of the ways described above such as vetting, recommending and overseeing implementation of new computing systems to track inventory, thereby reducing costs, or collecting and analyze data about customers, thereby creating opportunities to improve customer service increase customer satisfaction. Relatively stable businesses, such as grocery stores, must now understand new technologies such as the ability to deliver advertisements and coupons to their customers through their smart phones while they are onsite.

As discussed above, the escalating duties of the CIO created pressures for incorporating a new CTO position that could assume some of the growing responsibilities of the CIO. Beatty et al. noted that the key question was just how to introduce the CTO position into the hierarchy described above in a way that benefitted the organization while avoiding unnecessary and inefficient disruption to established operating dynamics. One conceptualization of the "typical" organizational hierarchy for management of the various IS functions in the 1990s was suggested by Parker and Cash and included the following positions, reporting relationships and levels[51]:

- The CIO was at the top of the hierarchy, responsible for all aspects of IS, and oversaw two main groups—telecommunications and data administration—each of which had a director on the second level of the hierarchy who reported directly to the CIO and who were formally expected to collaborate with one another.
- Another director, for data processing, was on the third level of the hierarchy and reported directly to the CIO. The data processing director had three functional managers on the fourth level of the hierarchy reporting directly to him or her and overseeing systems development, programming and operations, respectively.
- Two other functional managers on the fourth level of the hierarchy also reported directly to the CIO and oversaw the information center and office automation, respectively.

---

[50] Smith noted that firms needing the skills and interests of someone suited to the Advocate CTO pattern may assign the responsibilities of the CTO to a Chief Information Officer ("CIO") given that many of the initiatives are grounded in improvements to information technology systems; however, it should be noted that the traditional role of the CIO is focused on the internal needs of the firm and that a CTO (or a CIO taking a broader view that incorporates customer requirements and interfaces) is still needed in order to ensure that the firm uses technology effectively with respect to its products, services and customer relationships.

[51] C. Parker and T. Case, Case Management Information Systems: Strategy and Action (Watsonville CA: McGraw-Hill Publishing, 1993).

While this structure had worked well for a number of years, it was becoming clear that it was simply unreasonable to expect that one person could effectively carry out both the traditional responsibilities of the CIO and deal with the rapidly escalating changes in technology and the organizational IS requirements. Beatty et al. suggested that it would be useful to compare and contrast three possible approaches to a "CIO/CTO Organizational Hierarchy": placing the CTO in a direct line under the CIO; placing the CTO on a parallel footing with the CIO; and eliminating the traditional CIO position and allocating all of the executive leadership responsibilities of the IT function to the CTO.[52]

Beatty et al. explained that the somewhat radical proposal to eliminate the traditional CIO position was based on the assumption that information was already being managed with different structures in all organizations, thereby reducing the need for any executive-level involvement in that area, and that the real issue that organizations needed to confront was managing "technology", a task that required a dedicated C-level technology executive.[53] Beatty et al. expressed concern that this move might be seen as little more than a change of title and that the CTO would need to work to re-establish the status and acceptance that had taken such a long time for the CIO position to achieve in the eyes of the other executives and the rank-and-file of the company.[54]

The CTO would serve as the single person responsible for all of the traditional technically-related responsibilities that were previously overseen by the CIO including the information center, office automation, operations, networking and telecommunications. The CTO would also be responsible for several of the newer technological functions such as technology assessment and workgroup environment. All of the senior managers of the functions mentioned above would report to the CTO. The CIO would retain responsibility over the remaining functions such as systems development, programming and data administration, and the senior managers of those functions would report to the CIO.[55]

It is conceivable, however, that the CIO and CTO would both have C-suite status and serve as members of the executive team of the company. Beatty et al. cautioned that this approach will likely be meant by opposition from other executives who will be worried about the disruption to the balance of interests at the top of the hierarchy. In addition, senior management coordination may become more unwieldy—the CEO's span of control would be broadened--and clear guidelines will need to be established with respect to who reports to whom. Beatty et al. concluded that the benefits of this approach would be outweighed by the challenges and recommended that just one of the C-level positions, the CIO in their view, be included on the executive team. As to concerns about having a C-level position that did not come with executive team status, Beatty et al. responded that

---

[52] R. Beatty, K. Arnett and C. Liu, "CIO/CTO Job Roles: An Emerging Organizational Model", Communications of the IIMA, 5(2) (2005), 1, 3.
[53] Id.
[54] Id. at, 4, 7.
[55] Id. at 4.

this approach was consistent with the then-emerging popularity of similar positions in other areas such as chief privacy officers and chief security officers.[56]

Banker et al. conducted extensive research on the optimal CIO reporting structure, specifically the factors that should be taken into account in deciding whether the CIO should report to the CEO or the CFO.[57] Based on analysis of longitudinal data from two periods (1990-1993 and 2006) they found support for their hypothesis that a company's "IT orientation" determined its CIO reporting structure. Specifically, companies that used sales over assets as a success measure, an indication that they used IT primarily for strategic differentiation, and had superior results on that measure tended to have their CIO report directly to their CEO. On the other hand, companies that used average operating income over sales as a success measure, an indication that they leveraged IT for operational excellence, and had higher results on that measure generally had their CIO reporting to the CFO. Banker et al. also confirmed that companies that correctly aligned their IT orientation with their CIO reporting structured enjoyed superior performance over time. Specifically, companies with a strategic differentiation IT orientation (i.e., high sales over assets) that had their CIO report to the CEO had superior performance over time as compared to companies with the same IT orientation that used a CIO-CFO reporting structure, a result that was also achieved by companies that opted for an operational IT orientation (i.e., operating income over sales) and a CIO-CFO reporting structure as compared to companies with the same IT orientation that selected a CIO-CEO reporting structure. They argued that the results supported both Chandler's strategy-structure paradigm and Galbraith's strategy-structure alignment perspective it is not a question of which CIO reporting structure was superior but rather whether or not companies did the right job in aligning their structures with their strategic positioning.

In addition to the CIO and CTO positions, there has been increasing interest in the creation of a position of "chief innovation officer". The primary job a chief innovation officer had been described as leading their companies' efforts to find and develop ideas for new products and ensuring that other executive officers recognize and support initiatives to encourage innovation.[58] While a chief innovation officer often comes up with ideas, he or she is not expected to be the only one working on idea generation and, in fact, his or her focus should be on establishing processes that empower others, both inside and outside the company, to contribute. For example, the chief innovation officer should set up an internal website that can be used by employees to submit suggestions for improving existing products or developing new ones. Ideas from outside the company may come from customers, either directly or through product review sites, and relationships with universities and organizations that conduct research in areas of interest

---

[56] Id. at 5, 8.

[57] See R. Banker, N. Hu, P. Pavlou, IT Orientation, CIO Reporting Structure, and Firm Performance: To Whom Should the CIO Report?, http://opim.wharton.upenn.edu/wise2004/sun112.pdf [accessed September 15, 2016] and R. Banker, N. Hu, J. Luftman and P. Paylou, CIO Reporting Structure, Strategic Positioning, and Firm Performance: To Whom Should the CIO Report? (February 23, 2010), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1557874 [accessed September 15, 2016].

[58] The discussion in this paragraph and the next paragraph is adapted from I. Linton, Chief Innovation Officer Responsibilities, http://work.chron.com/chief-innovation-officer-responsibilities-17017.html [accessed September 13, 2016]

to the company. The chief innovation officer might even set up an incubator for technology-focused startups that provides them with resources and other support to work on ideas that might eventually be picked up and used by the company.

Once the ideas have been identified, the chief innovation officer ensures that they are all evaluated and that the most promising ones are passed on for further development and testing and eventual release into the marketplace. The chief innovation officer should oversee the incubation of new ideas, making sure that a business case is developed when appropriate, driving collaboration among different business units when necessary, championing new products and services among other members of the executive team to be sure they receive adequate funding and other resources, and working with product and marketing managers to bring new products and services to market as quickly as possible in order to realize a return on the investment associated with the development efforts. Once new innovative products and services have been released, the chief innovation officer should monitor customer feedback and service requests.

Interest in, and calls for, creation of a chief innovation officer position has increased substantially in recent years. Di Fiore argued that large companies often lack a mission and framework with respect to their innovation activities.[59] In many cases, innovation efforts are distributed among several different groups, none of which are supporting what is actually needed at the business unit level. Even worse, these groups are competing internally for scarce resources and duplicating efforts. Another fact of life that often hampers innovation is that most line managers are too focused on pursuing and achieving short-term goals, which means focusing on what they are doing or selling at the present moment, and have little time or incentive to take the longer-term approach that is typically needed in order to bring truly innovative ideas into practice. In the same vein, companies and managers may be reluctant to change what appears to be going right, an understandable reaction but also one that puts the company at risk for being suddenly overtaken by competitors that have been more proactive in anticipating the need for continuous change and innovation.

In order to address the problems discussed above, Di Fiore recommended that companies, particularly larger ones, needed to create the position of chief innovation officer on their executive team to focus on driving the changes that are often resisted at lower levels of the organizational hierarchy, organizing the company's innovation activities and designing what Di Fiore referred to as "a more innovation-friendly organizational environment". Based on work he had participated in at the European Center for Strategic Innovation, Di Fiore proposed seven key roles in the mission of the chief innovation officer: supporting best practices, developing skills, supporting business units in new product and service initiatives, identifying new market spaces, helping people generate ideas, directing seed funding and designing shelter for promising projects.

---

[59] The discussion in this paragraph and below is adapted from A. Di Fiore, A Chief Innovation Officer's Actual Responsibilities, Harvard Business Review (November 26, 2014), https://hbr.org/2014/11/a-chief-innovation-officers-actual-responsibilities [accessed September 13, 2016]

Another important topic relating to management of technology activities is the evolution of responsibility for technology in startup companies. In their earliest stages of development companies generally adopt traditional organizational structures that follow a functional approach based on creation of separate groups or units to manage and perform key business activities. With respect to technology-based activities this means that various aspects of technology development and exploitation would be distributed among separate functional departments focusing primarily on R&D, product development and engineering. In addition, companies will form dedicated groups for other activities in the product value chain, including manufacturing, marketing and technical service and support and all of these functions would interact with so-called "corporate" functional activities such as finance, human resources and legal and regulatory affairs. While each functional group or unit would have a designated lead manager, such as an R&D director or chief engineer, the traditional structure vests senior management responsibility for a number of key technology-based activities in a single office. This person, sometimes referred to as a "technical director" or a VP Development, is responsible for management and oversight of all activities relating to R&D, product development and engineering. In some cases, depending on the size and type of operations of the company, this position might also be involved in procurement, particularly if technology is a significant factor in purchasing decisions; standards compliance and quality assurance programs.

Combining all of the aforementioned activities under the control of a single manager is an attractive, and often necessary, choice for small companies in their early stages of development. In that situation, the firm lacks the financial resources to recruit and support a large layer of managers for each listed activity. Moreover, assuming the company is involved in no more than a handful of technology and product development initiatives at this stage, integrating all of these activities is a sensible approach since it is likely that employees from all areas will be working together closely and the firm has not reached the point where strict and formal departmental lines have been drawn. Resolving technology strategy issues that cross functional lines is generally not that difficult in the early days after the company is launched because those issues can be and usually are, discussed at regular meetings of senior management leaders from all areas of business, including the CEO, the technical director and directors from finance, operations, manufacturing and marketing. This group, still relatively small and closely involved with the modest number of initial product development efforts can easily share information that normally goes into decisions regarding technology strategy, including R&D priorities, requirements for new product development and manufacturing and engineering issues. These discussions will lead to basic decisions about technology strategy that will guide actions throughout the firm until operations become too complex to be supported by informal communications and lines of authority.

As the company grows, however, the role and value of the technical director position becomes more problematic. For example, the authority of the technical director begins to erode as the various areas assigned to position begin to expand and develop their own unique departmental cultures, which often results in resistance to efforts to coordinate activities with other departments even if they all report to the same senior manager. Also, as companies attempt to combat the inefficiencies that a strict functional organization structure creates for new product development by adopting a matrix or product manager structure, the resources previously assigned to the technical director will be transferred to the control of a product manager who assumes responsibility for all aspects of the innovation process for new products, including design, development, production and marketing. In that situation, the role of the technical director is substantially diminished and is typically limited to tasks that are largely administrative, such as recruitment and making sure that R&D and engineering personnel have the resources necessary to perform the tasks assigned to them by the product manager.

The traditional role of the technical director is also inappropriate for technology-based companies for another important reason—it fails to recognize the need for a member of the senior management team to assume responsibility for the development and management of an overall technology strategy for the company. The primary focus of the traditional technical director role is on managing the activities of various functional areas, such as R&D and product development. While this is important, many of these duties can be delegated to managers within each functional group who would provide specified reports to a member of the senior management team with overall responsibility for all elements of technology development and use by the business. Recognizing the overriding importance of technology issues to the company, it is recommended that this senior management position be designated as the "chief technology officer" ("CTO") and should be placed on the same level as the CEO, chief financial officer ("CFO") and chief operating officer ("COO"). In fact, given the strategic role of technology for these types of companies, a strong argument can be made for designating a CTO when the business is launched or, at the very least, formally assigning certain of the responsibilities below to one of members of the senior management group to ensure that the need for technology strategies and policies is taken seriously. Interestingly, 77% of the companies in a study of technology-based emerging companies conducted by researchers from the University of Chicago had someone serving in a position comparable to CTO at the time of their earliest business plan, clearly a nod to the importance of technology to those companies at the beginning of their lives; however, while the popularity of the CTO position held at 77% at the time the survey companies were completing their IPO it fell dramatically to just 47% on the date of their third annual report following their IPO.[60]

Glasser provided an interesting and straightforward catalogue of what he saw as the key roles of a CTO of a startup company operating in the high-tech arena.[61] His list began with ensuring that the company had the best technology to carry out the specific technology-related activities that were required in order for the company to competitive and this meant creating and continuously engaging with the appropriate suppliers and other allies and making sure that the technology requirements for each company project were clearly understood among the members of the teams working on those projects. In that regard, he noted that "[t]he greatest leverage is when the project is in its earliest phases, when we are deciding on architectures in the context of market requirements and

[60] S. Kaplan, B. Sensoy and P. Stromberg, What are Firms?: Evolution from Birth to Public Companies (2005).
[61] The discussion of Glasser's arguments in this paragraph is based on L. Glasser, What Does a CTO Do? (2011).

when technology choices are being made". The second item on his list was creating options for the company—either for existing businesses or launching new businesses—and being heavily involved with other functions, such as business development, in incubating opportunities that are based on exploiting technological breakthroughs. Glasser's third activity for the CTO was attending to the health and well-being of the technical community including acting as the public face of technology for the company and making sure that technology optimization is taken into account in all decisions and activities throughout the organization. Finally, the CTO needs to be involved in the formulation and execution of the company's overall business strategies given that Silicon Valley companies are competing by forging technical excellence in the products and in the processes used to create those products. Glasser's ideas were similar to those described by Ries a few years earlier when he argued that "[t] CTO's primary job is to make sure the company's technology strategy serves its business strategy" and then suggested that the effective CTO need to be adept at several specific skills including platform selection and technical design; seeing the "big picture"; providing options; finding ways to "get 80% of the benefit for 20% of the cost; growing technical leaders; and owning the development methodology.[62]

§15 Creation of the technology strategy

The primary role of the CTO is to act as the company's chief scientist and technology expert. As such, the CTO should take the lead among the members of the senior management team in developing the technology strategy of the company discussed above. The CTO should have a strategic planning horizon that extends well into the future and should be able to identify the principal technologies the company needs to develop or otherwise acquire in order to achieve its business objectives, establish priorities for action and allocate responsibilities among various departments and business units within the company. In the course of developing an overall technology strategy for the company, the CTO must also assume responsibility for coordinating the research and technology development activities of each division and business unit throughout the company and making sure that those activities fit within the selected strategy. In addition, as described below, the CTO should ensure that the company's technology development initiatives, particularly those projects that are funded and supported by corporate, satisfy the strategic requirements of each division and business unit.

Creating and monitoring the company's technology strategy is a time-consuming process and requires constant communication with business and R&D managers from each department and business unit. When the company is small, the CTO or other senior manager responsible for technology strategy can generally collect the information informally from other functional managers; however, as the company grows a formal technology planning group is usually formed. This group may be managed by the CTO or by a technology planning manager who reports to the CTO and group members will be responsible for collecting and evaluating information from each division or business unit regarding their current research and technology development activities and their requirements for the future. While a technology planning group may be necessary

---

[62] E. Ries, What Does a Startup CTO Actually Do? (September 30, 2008).

because of the size and scope of the company's operations, the CTO must manage the group effectively to be sure that its activities remain focused and that the output of the group has value.

§16 Planning and coordinating research and development activities

As mentioned above in connection with creating of the company's overall technology strategy, the CTO should assume responsibility for planning, coordinating and monitoring R&D activities throughout the company's divisions and business units.[63] While each division or business unit should be given the freedom to identify and pursue R&D projects that are closely allied to their core business mission and strategies, the CTO must be sure that R&D resources are channeled efficiently and that individual projects fall within the scope of the direction established by the senior management group and the board of directors. Among the specific duties of the CTO in this area are the following:

- Determining with inter-disciplinary research projects are worth pursuing;
- Determining the scope and objectives of long-term R&D initiatives;
- Allocating R&D activities and resources between the corporate R&D group on the one hand and dedicated R&D teams within the divisions and business units on the other hand;
- Monitoring and coordinating R&D activities within the divisions and business units to eliminate duplication and facilitate sharing of research results;
- Collecting and evaluating requests for R&D funding from the divisions and business units and allocating corporate R&D funding;
- Monitoring and evaluating the risks and rewards associated with the company's overall R&D portfolio;
- Determining which R&D projects should be outsourced (e.g., contract R&D companies and universities) and the amount of funding to be provided for outsourcing activities; and
- Planning and monitoring technology-based joint ventures and strategic alliances with outside parties.

In order to successfully fulfill the duties and responsibilities in this area, the CTO must have clear and strong support from the CEO and other members of the senior management group. This is particularly true in situations where the CTO is forced to allocate scarce resources among several divisions and business units, since the decision will necessarily have a significant impact on the ability of the division or business unit to pursue what it believes is the best business and technology strategy. The CTO must be able to explain the rationale for these decisions and also create an environment in which relatively autonomous business groups will share technology-based information, as well

[63] For further discussion of the activities within a company's dedicated R&D group, as well as a discussion of management of particular internal R&D projects and outsourcing arrangements with third parties, see "Research and Development" in "Product Development and Commercialization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.

as the end products of their R&D activities, with other divisions and business units within the company.

One of the decisions the CTO must make is how to allocate the technical resources of the company equitably and properly among the following common R&D activities: development and design of new products; improvement of existing products; technical sales support; and after-sales service and support. While larger companies may be able to establish and maintain separate staff for each of these activities, smaller firms rarely have that luxury. The resource allocation problem is made even more difficult by the fact that time demands associated with each activity is different. For example, technical sales support obviously requires the shortest lead time while development of new products takes the longest period of time. The CTO must carefully analyze how much of the available resources is allocated to each of these activities, rather than simply bundling the salaries and related overhead of technical specialists into a single line item, since it often turns out, much to the surprise of senior management, that relatively little effort is devoted to new product development.

§17 Technology forecasting

Technology forecasting is an important, yet highly controversial, aspect of technology management. Simply put, companies need to make educated guesses about the nature, extent and timing of changes in the technologies that will serve as the foundation for the various business activities of the firm. This not only requires identifying the changes in technology that are expected to occur, but also placing some measure of value on each of these changes so that the company can establish which areas should be given priority when allocating scarce R&D funding.

Forecasting methods can generally be broken out into three major categories, including expert opinions or judgments, trend analysis and "alternative options" analysis, the most popular of which would have to be scenario planning. Each method has its own unique advantages and disadvantages and companies generally rely on two or three methods for forecasting, in many cases relying primarily on monitoring and expert opinions and then using the information to create specific ideas and propositions that might be subjected to trend analysis and scenarios.

Regardless of the methods that are deployed, managers must use sensitivity analysis to challenge the assumptions that form the foundation for each forecast. The use of models allows an analyst to quickly measure the impact of a change in a particular variable. In most cases, proper use of sensitivity analysis will generate alternative pictures of what the future might look like, thereby creating a broader array of choices for managers. One area in which sensitivity analysis can be particularly valuable is when there is uncertainty regarding the actual rate of diffusion and adaptation of a particular technology once the decision has been made to move forward with development and commercialization.

§18 --Technology monitoring and expert opinions

One of the most popular, and perhaps the easiest to implement, techniques for technology forecasting is extensive monitoring of areas of potential interest to the company. Monitoring involves several stages of increasing activity and begins with obtaining an overview of the current "state of the art" of a specific technology derived from reviews of recent literature and consultations with leading experts. The goal is to identify the actual and potential functions of the technology, the forces driving further development, the key obstacles to success and the relevant stakeholders in the progress of the technology. As the interest of the company becomes more focused, a more comprehensive model of the innovation process for the technology can be developed. This will allow the company to track the key factors relating to success of the development process.

Companies may also use a variety of survey techniques to tap into the opinions of scientists and other experts in the field of interest. Information can be collected in a number of different ways, including interviews, written surveys and review of published materials. In some cases, groups of experts can be brought together for brainstorming and to debate, in "real time," specific issues that might come up during the evolution of the technology. Expert input is also important for obtaining feedback on models of the technology process constructed using one of the other forecasting methods. In each case, expert input should be taken with due recognition of obvious shortcomings, such as the biases that experts often bring to often controversial debates in this area.

§19 --Trend analysis

Sophisticated tools of statistical analysis have also been applied to technology forecasting. For example, companies often use "trend analysis" based on statistical techniques, such as linear projections and regression analysis, which are based on the extension of time series data into the future; however, the accuracy of this method is somewhat limited given that it is often difficult to collect a sufficient amount of accurate data with many infant technologies. Notwithstanding these problems, researchers have found that many processes associated with technological innovation do line up nicely with known and commonly used equations. For example, processes often progress along a “straight line” or a constant rate of “exponential growth” (e.g., the continuous doubling of microprocessor capabilities at predictable intervals). In most cases, however, these models generally hold for only a limited period of time. An “S-curve” also fits well in many cases and one can identify situations where a technology began slowly, then grew rapidly and eventually slowed and leveled off.

§20 --Scenario planning

One of the challenges with emerging technologies is that they generally defy analysis under the traditional linear strategic planning and forecasting methods that are used in relation to established technologies. As a result, companies often turn to more complex forecasting tools, including scenario planning, that are designed to expand the horizons of planners and forecasters and assist them in thinking “outside of the box” with respect to identifying the technologies that will be of greatest interest to consumers at some point in time in the future.

Scenario planning first achieved notoriety based on its deployment by Shell International and SRI International. One of the most important aspects of scenario planning is the need to think beyond the traditional issues and environmental factors that are commonly covered in the usual type of business planning exercise. For example, business plan preparation generally involves the description and analysis of industries and markets, products, customers, suppliers and existing technologies. The end product of this process will typically be detailed list of steps that will need to be taken in order for the company to pursue its business objectives over the planning period. While there will be some contingency planning, the context for making most of the decisions is generally fixed.

In contrast, scenario planning is based on the assumption that the future is complex and inherently uncertain and that business decisions must be made in a manner that respects the need to be flexible and open to change during the planning process. The end product of scenario planning is a limited number of "educated guesses' about how the world may look at some point in the future. In building these scenarios, planners must look beyond those industries, products and technologies that are essential to the current business of the firm. Instead, consideration should be given to the broader forces at work in those areas that are typically mentioned in describing traditional "environmental analysis" as part of the business plan preparation process. These would include, for example, identification and examination of social, political, economic, technological and legal factors.

Scenario planning is a complex process that requires input from a wide range of sources, as well as sophisticated analysis. Companies that use scenario planning are now able to take advantage of computer programs that can generate future scenarios and perform the sensitivity analysis necessary to evaluate the impact of changing certain assumptions. In any case, the process generally begins by identifying an issue that will be material to the business decisions that the company expects to be making within a specified period. For example, the company may need to examine the price level of a specific natural resource or the extent to which consumers will adopt a new technology (e.g., online shopping). It is not a simple matter to identify the most important issues for the company and input may be sought from several sources, including customers and other business partners.

Once the issue is selected, the next step in the scenario process is identification of the parties that will play the most significant role with respect to the actual outcome of the issue under consideration. In the case of natural resources, the group may include domestic and foreign politicians, special interest groups, regulators with legal authority to make rulings that will impact pricing and availability and firms that are known to be involved in the development of viable alternatives. When evaluating the prospects for growth in online shopping activities, notice should be taken of customer requirements, business models of traditional "bricks-and-mortar" retailers and the availability of capital to support new entrants.

Planners must then consider the impact that changes in social, political, economic, technological and legal factors might have on the issue. In particular, planners should attempt to identify known trends that will influence a particular factor in the future. For example, the aging population in the United States dictates that health care concerns will be an important consideration in evaluating social and political factors. With respect to online shopping, the appetite of potential customers might be enhanced by their desire to have access to goods and services while they are "on the go"; however, the enthusiasm may be dampened by concerns regarding protection and privacy of personal information that may be exchanged in the course of e-commerce transactions.

For each factor identified in the manner described in the previous paragraph, consideration must be given to identifying key "uncertainties" that make it difficult to predict the future with certainty. For example, in the political arena, events may be very different depending on the outcome of the next election and the economic policies that are implemented by a new administration. The direction of new technology may hinge on completion of specific development projects or the willingness of regulators to grant patents for a new innovation. For each of these "uncertainties," a range of possible outcomes should be created and probabilities should be assigned to each outcome.

Once all these steps are completed, the planner should, perhaps with input from top management, select the two most important "uncertainties" and then use a two-by-two matrix to develop an initial set of four possible scenarios for further evaluation. Once these scenarios are framed, the planners might select six or eight additional "uncertainties" and posit how they might look in each scenario. The idea is to build each scenario to the point where it provides a rich, narrative picture of a feasible "state of the world" as of some date in the future. Before placing too much reliance on any scenario, care must be taken to check that each scenario is internal consistent and the forecasted situations are plausible and based on credible assumptions regarding the actions of each of the interested stakeholders. As noted above, software programs can be useful at this stage. For example, a program can be used to conduct "cross impact" analysis in order to determine which trends might accelerate or reduce the speed of other trends.

The richness and diversity of scenarios are attractive in their ability to communicate complex technological issues to managers who are not experts in the area. A drawback to this approach is that the sheer breadth of the information needed to create the scenarios means that significant pieces of the picture may be based on assumptions and forecasts that are incomplete. Moreover, scenarios do not, in and of themselves, provide the firm with a blueprint for action, nor do they generate the optimal strategy. The main purpose of scenario planning is to create a broader and richer context for planning activities. The results can be shared with various stakeholders to obtain their feedback on the likelihood each outcome and insights on how they might react in each of the situations described. At that point, the discussion turns to devising solutions for coping with each scenario. For example, consideration can be given to strategies for acquiring the resources that would be required for the company to be competitive in the marketplace suggested by each scenario.

§21 --Predicting the rate of diffusion of emerging technologies

One of the most difficult issues that must be confronted when evaluating any new emerging technology is predicting the rate of diffusion and adoption within the industry, including both customers and competitors. Unlike traditional technologies, which are fairly stable, emerging technologies often rise up like flash fires and spread quickly into unexpected areas. The technology may be adopted quickly in one market while failing to catch on in what ultimately becomes a much larger market until well into the future. When attempting to predict the rate of diffusion, consideration should be given to each of the following factors:

- The perceived advantages of the new product in terms of benefits and value in relation to the available alternatives.
- The degree of risk in the minds of potential customers about using and adapting the new product, including concerns about performance.
- Potential barriers to adoption by potential customers, including the costs associated with the decision to change from current solutions.
- The opportunities provided to potential customers to obtain information about the new product and use the product before making a final purchasing decision.

While the perceived advantages of the emerging technology will ultimately be the most determinative factor in whether or not the technology is successful, firms would be well advised to focus on creating opportunities for potential customer to use the products that are based on the technology. In so doing, the company can accelerate the learning curve and concentrate its resources on refining the technology in response to the actual critical feedback from the marketplace. A related method of fine-tuning the evaluation process is close observation of the experiences of the early adapters of the new technology.

§22 Technology selection

Technology selection refers to the procedures that the company follows to identify and select the technological resources that are need in order for the company to pursue and achieve its overall business objectives. The choices made during the selection process will ultimately impact how the company allocates available funds, as well as the type of products and services that will become the focus of development activities.

Technology selection must take into account several different factors and requires input from throughout the company. For example, the choice of which technologies to pursue clearly has strategic consequences and, as such, input from senior management is always an essential element. In addition, input from finance and human resources is necessary to determine whether the company has, or can obtain, the capital and personnel that will be need in order for the initiative to succeed. Finally, technical and engineering experts must be able to provide their advice regarding the choice under consideration and the likelihood that the company will be able to achieve its objectives in light of any specific constraints as to budget or timing.

§23 --Technology scanning

The selection process generally begins with a comprehensive evaluation of the relevant technological framework for the company's business activities. The goal at this point is to gain a better understanding of the answers to the following types of questions:

- What technologies are currently being used by the key participants in the company's industries and markets?
- What information is available about new technologies that may be under development by current or potential competitors?
- What other technologies might be relevant to the company's operations and the markets in which the company intend to compete in the future?
- What available technologies currently in use in other markets might be suitable for transfer and adaptation to the company's proposed business activities?

Needless to say, this process, sometimes referred to as "technological scanning," can be a daunting task, since it requires that time and attention be spent on gathering information on scientific and engineering activities conducted well outside of the company's current businesses. The resources expended on technological scanning are in addition to, and not in lieu of, R&D expenses; however, there is often some overlap in those areas. Estimates from the mid-1980s posited that Japanese firms spent, on average, approximately 1.5% of their sales revenues on scanning and that some company invested as much as 5% to 6% of sales on collecting scientific and technical information. It is well documented that Japanese firms felt that it was an inefficient use of time and capital to independently develop technologies that were already available from other sources.

While there is not sufficient space to describe in detail the various strategies that may be used during the scanning process, it is clear that there are a number of sources that might be useful. Depending on the circumstances, use information can be gathered from one or more of the following external sources for technology:

- Informal discussions with current and prospective business partners, including customers, suppliers and outside distributors. Companies often generate new product ideas through communications with the ultimate end users. For example, a firm that develops diagnostic tools in the medical field may make inquiries to physicians regarding their unsatisfied needs.
- Informal or formal liaisons with universities known to be involved in research activities that are related to the firm's field of interest. In most cases, local universities are the best candidates given their proximity and the ease of arrangement face-to-face communications and other exchanges of information.
- Creation of one or more advisory boards or committees of outside experts that can be used to continuously generate and evaluate information about emerging trends in specified technological areas and product markets and segments. For example, university researchers are often a good source for staffing a scientific advisory board.
- Acquisition of needed or promising technologies, either by purchasing an existing business or recruiting a team of technology specialists who may have been working with another firm that has no interest in pursuing the specific technology.

- Licensing technology that has already been developed from other companies for integration into the company's products.
- Collaborative R&D projects with other firms to create new technology that can be exploited by both parties, either together or in separate markets.
- Funding R&D activities of an outside party, such as a university laboratory or an independent "R&D" entity, in exchange for the exclusive right to commercialize the results of the research project.

Other sources of information include personal relationships with colleagues at competitors; public and private research centers and university laboratories; scientific and technical journals and other publications; conferences, symposia and trade shows; and information available through government resources, including patent applications. Companies will generally focus on specific sources depending on their line of business. For example, companies that are heavily involved in the development and manufacture of specialized types of equipment often receive most of their ideas from their customers. On the other hand, firms lacking the capital to invest in the development of new technologies "from scratch" may concentrate their search efforts on patented technologies that can be licensed from their original developers.

§24 --Evaluation and selection

Once the company has collected information regarding promising technologies, a decision must be made regarding which technologies are most suitable for the firm and warrant further evaluation and development. It is the rare company that has sufficient resources, financial and otherwise, to pursue every technological opportunity. Accordingly, procedures should be developed to screen the candidates in order to select those technologies that have the best chance of technical and commercial success.

One method that can be used is to evaluate new technologies based on their potential competitive impact and the likelihood that the R&D efforts can be successfully completed within the resource constraints imposed by management. If, for example, the company's technical experts are highly confident about their ability to commercialize a new technology and it is anticipated that the end product will create a significant competitive advantage for the company, then the project obviously warrants serious consideration. In turn, concerns about the likelihood of success among the technical staff may cause the company to avoid a project even if the potential market is appealing. In that situation, the company may be content to allow competitors to take on the initial technical risks and wait to see how the relevant science develops before making a final decision on allocation of resources to the area.

A similar analytical approach weighs development uncertainties against the "business risk" associated with the actual commercialization of the projected technology. Using this type of analysis, the fact that the company's engineers and scientists believe a new technology can be successfully developed may not be sufficient to overcome the discomfort that senior management may have about entering a new market, which may be required in order for the technology to achieve the highest rate of return. In that case, the company may look for ways to reduce the business risk, such as partnering with another firm that is better positioned to exploit the technology in the identified market.

Each of these methods relies on objective measures of technical and business risk to determine the most promising potential development projects. Obviously, companies may refine these tools to suit their unique circumstances. For example, a company may calibrate each identified risk by reference to its own experience in a particular area. In that situation, a company may be willing to invest in the development of technologies that are closely related to their existing technological competencies or that are related to potential new products that fit well within the firm's current product portfolio. On the other hand, development projects that break new technological ground for the firm and which would ultimately require deployment in new and unfamiliar markets are probably too risky for the specific company, regarding of the chances of success or the projected return on investment.

Still another popular method for selecting new technology development projects is to determine which projects will ultimately provide the company with the largest array of product alternatives once the initial development is completed. For example, if a specific project really has a single possible positive outcome it is probably more risky than another project that is likely to lead to several different applications, even if each of them does not carry the attractive rate of return associated with the first project. This allows the firm to commit a smaller amount of resources at the beginning and then continuously revisit the work to identify the most promising areas for the next round of investment.

§25 Acquisition of new technologies

Once the company has selected those technology prospects that appear to be most promising in light of the firm's specific business goals and risk tolerance, a decision needs to be made regarding the best way for the company to develop or otherwise acquire the specific technologies. Obviously, the company may elect to develop the technology on its own using internal resources. This strategy means that the company must bear the entire cost and risk of the development effort; however, the company does gain maximum flexibility and will ultimately be able to harvest all of the benefits if the work is successful. Traditionally, internal research and development ("R&D") activities have been carried out in a single functional department or unit that coexists with other functional-focused groups devoted primarily to marketing, manufacturing, sales and customer service. However, alternative organizational structures assign scientists and engineers to product- or market-focused groups where they can collaborate directly with other functional specialists Companies may also pursue internal development of new technologies through "intrapreneurship," which involves the establishment of a separate business unit within the firm that can be dedicated to pursuit of the specific technological and/or product objective. The premise for this strategy is that the team can be more creative and innovative if it is freed from regular procedures and the day-to-day demands placed on team members by their existing functional assignments.

It is unrealistic, however, for any company, regardless of its size and the scope of its resources, to believe that it can successfully and efficiently fulfill all its technology requirements through internal R&D. The cost of acquiring and maintaining the necessary human and tangible assets would be prohibitive and even if the assets were available the company cannot expect to be able to shift it technology strategy quickly enough to keep up with technology specialists firms dedicated to leading-edge R&D in a particular area. Accordingly, as the company establishes its priorities with respect to R&D, consideration must constantly be given to the feasibility of outsourcing all or a portion of the required work. When discussing "outsourcing" in this context, we include not only looking to third parties for technical skills and knowledge to conduct R&D, but also acquiring the right to use finished technology already embedded in products and components that can be integrated into the company's own product line.

§26 --Internal research and development

There are several different approaches to categorizing internal R&D activities. For example, traditional models of R&D follow a linear view similar to the stages of new product development and include pure research, which is akin to basic scientific exploration; applied research, which addresses a specific problem or issue; and activities that are closely related to the commercialization of a particular product (e.g., engineering, testing, manufacturing and support). Other models of the R&D function focus on the strategic context and business purpose for the activity and break out the work of the R&D team into fundamental R&D, which is similar to pure or basic research in the linear model; radical R&D undertaken with the specific objective of creating a new product or process, although often the end result cannot be accurately anticipated at the outset; incremental R&D to improve or enhance an existing product or process; compliance activities carried out to satisfy specific regulatory or industry requirements; and support activities (e.g., warranty repairs and "patches" to address technical issues that have arisen in products already released into the market).[64]

In general, each category of R&D activity carries a different risk profile. For example, incremental work typically has a fairly high likelihood of success, given the limited objectives and the assumed familiarity of the researcher team with the product that is the focus of the project. The anticipated returns from incremental work are usually relatively modest and can be predicted with a greater degree of certainty than other types of research activity. On the other hand, radical R&D is quite risky and outcomes are extremely difficult to predict on both the technical and the marketing dimensions. The decision as to whether or not a specific R&D activity should be carried out "in house" should be made strategically with an eye toward obtain the best return on the resources allocated to the technology portfolio of the company. Certain things, such as compliance activities, are essential and must be taken on and usually must be carried out in a way that allows the company to have a high level of control over the content and timing of the project. On the other hand, radical R&D activities pose challenging issues for senior

[64] For further discussion of the activities of the R&D functional group, see "Research and Development" in "Product Development and Commercialization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.

management given that it is often necessary to aggressively pursue emerging technologies while still guarding against an overly risky allocation of capital and other resources to the pursuit of a goal which is often difficult to identify with a high degree of clarity before the project is actually launched. Basic research, while often necessary, raises legitimate concerns about whether the expenditure of company funds can be justified given that it will be difficult for the company to appropriate the results of the work as proprietary. The issue is important in light of the increasing challenges in relying on universities to perform this type of activity. Advocates of commercial support for basic research argue that it provides companies with greater access to technical information that is of importance to the company's business strategies and that it will enhance the ability of the company to scan and evaluate the surrounding technical environment and make better decisions about technology strategy.

Most companies do allocate at least a portion of their technology requirements to their own internal R&D department or unit staffed by skilled and trained professionals from a wide range of scientific and engineering disciplines and it should be expected that the internal R&D team will make a significant contribution to the knowledge base of the company and the quality and level of innovation of the company's products and services. In general, the following situations dictate an in-house development approach:

- Technology that has a significant impact on product performance and, in turn, the company's competitive advantage, should probably be developed and managed internally even if it is only a base technology. The company should be wary of becoming overly reliant on an outside supplier unless it is comfortable with the security of the relationship or alternative sources are readily available.
- Technology that represents a large portion of the cost associated with a particular product should also be managed internally to allow the company to maintain control over decisions relating to the ultimate price of the finished product.
- Technology that is only available for a single source may not be suitable for outsourcing, at least on a long-term basis, since the company runs the risk of over-dependence and the loss of leverage in bargaining with the third party regarding the terms and conditions of transfer.

Technology that falls within these situations is generally considered to be part of the company's "core competencies" and thus warrant the attention of the in-house R&D group. However, R&D, like most of the other activities that occur within the company, consumes capital and other resources that might be channeled to alternative uses and it is therefore essential for the company to carefully manage its internal R&D projects and measure the performance and productivity of its R&D team. Moreover, the role of the internal R&D department should be continuously evaluated against outsourcing alternatives as the company grows and the scope of its technology needs expands. For example, while a small pharmaceutical company may want to handle the compliance work for its first product internally larger firms in that industry eventually find it is more cost-effective to outsource that work to third parties. Contract R&D arrangements also become more important as the company's product line expands and the necessary technology becomes too complex to build all of it "in house."

§27 --Methods for outsourcing technology development

There are several common methods that may be used for acquiring new technologies from outside parties, including the following:

- The company may commission the needed R&D work from an outside party, such as a university, independent laboratory or research center. This option allows the company to gain access to dedicated teams of skilled specialists that will “build” the desired technology and turn the rights thereto over to the company in exchange for a research fee. One downside of this strategy is that it does not necessary develop the internal skills and resources of the company, making it difficult for the company to further advance the technology on its own.
- If the technology is already available and in use by other firms, the company may be able to acquire a license to use the technology in exchange for payment of licensing fees and/or royalties based on the revenues received by the company from the use of the licensed technology. Licensing can definitely be used to accelerate the product development process; however, licensors generally impose a number of constraints on how the licensee can use the technology. Moreover, the licensor must be willing to provide technical assistance to ensure that the technology can be properly deployed by the licensee.
- The cost and risk of a technology development project can be shared with one or more outside business partners through a bilateral cooperative technology development arrangement or formation of a joint venture or other type of strategic alliance. There are a number of business structures that can be used and the relationship can extend beyond pure research to include manufacturing and distribution of the products created during the development phase. The projected benefits from such an arrangement are only achievable, however, if the parties are able to communicate clear about their goals and contributions and remain committed to the venture through its entire term.
- The company may attempt to acquire a firm that already has the desired technology if such a firm is available for purchase. Obvious problems with this strategy include the potential costs of an outright acquisition and the uncertainties associated with integrating the target into the company’s business. Extreme care should be taken to ensure that the members of the target’s research team will be able to work efficiently with the company’s personnel. In the same vein, the company might acquire minority ownership interests in businesses engaged in relevant R&D programs.

Other non-transactional methods for tapping into external sources for new technologies including hiring individuals and/or teams of specialists; purchasing products, materials or equipment in which the desired technology is imbedded, although care should be taken not to unwittingly copy the technology in a manner that infringes the rights of others; bargaining with suppliers for them to invest in the development of technologies that can improve the cost or effectiveness of parts delivered to the company; obtaining external funding for new R&D projects through limited partnerships and similar investment vehicles; and increased investment of time and financial resources in “technical intelligence" activities, including attendance at research conferences and ongoing scanning of publications. For example, the benefits of an innovative and entrepreneurial culture can be accessed through strategic investments in smaller firms that concentrate on the areas of interest to the company. This "corporate venturing" provides the sponsoring firm with a window into new technology development and management practices, as well as an opportunity to direct the development efforts toward applications that would be best suited to the sponsor's core competencies.

Companies, particularly as they grow, can obviously opt for several of these development and acquisition strategies depending on the then-current competitive environment and their own available resources. For example, acquisition and/or licensing may be used to gain rapid entry into one area while other areas may be addressed through internal development, perhaps using funds accumulated from being able to penetrate the first area so quickly.

§28 ----Contract research and development arrangements

In general, contract R&D projects should require the least amount of management time and effort and the level of interaction and interdependence between the parties is lower than in any of the other outsourcing methods discussed herein. Simply put, the contractor is asked to provide a deliverable defined by the company within agreed scheduling and budgetary specifications. The project may focus on a wide array of items, including a feasibility study, experimental results, a pre-production prototype or a part or component to be used in the manufacturing process. The key to successful contract R&D is investing time and effort at the beginning of the project to be sure that the goals are clearly defined and that the end result will suit the specific technical and business requirements of the company. This can be a delicate process since the company does not want to unduly restrict the creativity of the contractor; however, the company also needs to know that the finished product can actually be put to use. Contract R&D is not a "risk free," or guaranteed, procurement method and the parties need to make a realistic assessment of the probability of success at the beginning of the project in order to objectively evaluate the project as work moves forward.[65]

In addition to R&D contracts with "for profit" businesses, another strategy for gaining access to new technologies is through affiliate programs with universities and independent research centers. For example, a company may elect to sponsor basic research being coordinated by a leading scientist and his colleagues at a local university by providing funding and opportunities for research students to serve as interns at the company's facilities. While the company may receive an option to exploit the results of such research, it may simply be content to receive regular progress reports and opportunities for its own technical staff to interface with university scientists and exchange information regarding emerging technologies and innovative R&D techniques.

[65] For discussion of the terms and conditions of an R&D contract arrangement with an outside party, see "Research and Development" in "Product Development and Commercialization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.

§29 ----Purchasing and licensing arrangements

While contract R&D projects produce technology that is customized to the requirements of the commissioning party, purchasing and licensing arrangements can be used to acquire technologies that are essentially finished. At the highest level, the challenge for the company is to identify opportunities for purchasing and licensing, determine whether the available technology fits the company's requirements, and then negotiate an acceptable price for the acquisition or license. As a practical matter, however, these relationships often become much more complex. The main reason is that technology rarely comes in a neat and complete package and more often than not the purchaser/licensee must receive assistance from the seller/licensor in the form of service and support to ensure that the technology is successfully transferred. This element is so crucial, in fact, that technology pricing, generally in the form of royalties, should be tied to actual results based on the volume of usage by the purchaser/licensee in its products and processes. Other important issues may arise in the context of licensing arrangements, including the permitted uses of the technology the licensee and the rights of the licensor to license or sell the technology to other parties, including competitors of the licensee. As these are strategic issues that extend beyond the immediate use of the licensed technology, senior technology managers need to closely monitor licensing practices throughout the company.

Before entering into a technology transfer arrangement, the company must also guard against the possibility that it may become unduly dependent on the transfer partner. In particular, attention must be paid to establishing the boundaries of any restrictions that may be imposed on the company's use of the transferred technology. Certainly it can be understood that the transfer partner would not be interested in creating a competitor for its current products; however, the company will want to be able to use the technology in non-competitive activities and will also want to be able to supplement the technology by conducting its own independent R&D.

§30 ----Joint development arrangements

Joint development projects in collaboration with business partners, such as suppliers, represents still another avenue for outsourcing technology requirements. Under a typical scenario, the company will provide its suppliers with specifications for desired improvements and enhancements to key components and processes and ask the suppliers to create and implement appropriate solutions as an inducement to continuing the supplier relationship. More and more companies now base their decisions regarding supplier relationships on the willingness and ability of the supplier to provide customized solutions to their customer's requirements. While finding and selecting the vendor with the lowest cost is still appropriate for many situations, companies are also developing a network of long-term supplier arrangements that feature intense interaction between the parties, including consultation among engineering personnel and funding to the supplier to support special development projects. When done well, this approach can reduce development times, limit the burden on the company's internal R&D and engineering groups and simplify management burdens by reducing the number of outside vendors.

The potential downside, of course, is that the company becomes overly dependent on the engineering resources of a particular supplier and is vulnerable to changes in the supplier's business strategy and operations.

§31 ----Joint ventures and strategic alliances

Joint ventures and strategic alliances may also be used to access the R&D and engineering resources of third parties, including companies that normally compete directly with firm in other areas. While a joint venture requires formation of a separate legal entity and the implementation of an entirely new formal management structure for the project, a strategic alliance is based on one or more contractual relationships among the participants. Regardless of the structure, these arrangements provide opportunities for the participants to access the unique technological resources of the other partners, thereby substantially reducing the investment and risk associated with developing a desired new technology. Small companies pursue this type of strategy to gain access to complementary assets and resources that they are not yet able to fund on their own. In turn, larger companies often see alliances with smaller partners as a way to access the benefits of an innovative and entrepreneurial culture, obtain a window into new technology development and management practices, and direct the development efforts of the smaller firm toward applications suited to the larger company's core competencies.

An alliance or joint venture can be limited to technology development or extend into other functional areas, notably manufacturing and distribution. While such arrangements can be extremely powerful and provide the company with access to technology well outside of the capabilities of the internal R&D group, they also require must more involvement from senior management than the other outsourcing options and it is also likely that some of the company's internal R&D resources will need to be allocated to the activities of the alliance or joint venture. From a technology management perspective, an attempt should be made to provide company scientists and engineers with opportunities to work with their colleagues from other participants in order to gather intelligence on how competitors manage their R&D activities.

While strategic alliances can be extremely valuable for smaller firms they also create a number of challenges and risks that cannot be ignored. First and foremost, the founders of small technology-based companies often lack the skills and experience necessary to successfully negotiate and administer a complex partnership arrangement. As a result, the company is in danger of surrendering valuable rights and resources to the other party and management may discover that its time is dominated by the alliance while other independent activities are neglected. Second, the alliance may cause the company to lose control over an essential aspect of its business at the most critical stage. Third, the company may become overly dependent on a single business partner. Fourth, in the course of the alliance, the company may need to disclose proprietary technology to the partner before the company has been able to stake out the necessary intellectual property protection. Finally, while the alliance may be structured in a way that generates initial revenues for the company that can be used for other purposes, the time and effort necessary to complete the project may divert the attention of the development team from focusing on the needs of, and ongoing trends in, the company's own primary marketplace.

Addressing, and minimizing, the aforementioned risks is not an easy matter and many small companies ultimately collapse under the weight of a one-sided relationship with a larger partner. Smaller companies that have thrived because of their early business partnerships are generally those that have been able to do the following:

- Recruit managers that have experience in working with specific partners and/or negotiating the terms of strategic alliances.
- Maintain a strong focus on developing a diversified approach to R&D activities, including independent projects and collaborations with multiple partners.
- Emphasize technological leadership in their R&D work in order to establish and maintain a proprietary advantage.
- Provide outstanding product and service support to alliance partners, thereby increasing partner loyalty and the costs and risks to the partner of terminating the arrangement on terms that are not favorable to the small company.

Some small companies have built successful and cooperative relationships with larger partners by permitting the partner to have a small equity stake in their business. An equity position is intended to ensure that the partner has the interests of the small company in mind as the arrangement unfolds since the larger partner would benefit from an increase in value of its investment.

§32 --Advantages of technology outsourcing

There are several advantages associated with outsourcing technology, including the following:

- By accessing technology that has already been developed and validated by a third party, the company can save time and significantly reduce the risk typically associated with technology development.
- Using an outside source can reduce or avoid the costs of creating and supporting the human and physical infrastructure that is required to develop new technologies and frees internal resources to work on other projects.
- The quality of the technology is generally much better since the source will typically be a company that specializes in the particular area or has experience with the development and commercialization of comparable technologies.
- Outsourcing is almost mandatory in cases where the company is looking to launch products based on a number of technological developments since there is no way that the company can successfully and efficiently replicate the results achieved by so many outside parties.
- A negotiated arrangement with an outside party is often necessary when that party owns patents and other intellectual property rights that might impair the ability of the company to continue its own development efforts without risking an infringement claim.

On the other hand, however, the ability of the company to use outsourcing as an effective way to acquire new technologies depends on the several key factors, not all of which can be controlled by the company, such as the external availability of the technology; timing requirements; the resources available for internal development of the technology; the ability of the company to obtain and protect a proprietary position with respect to the technology; the ability of the company to assimilate the technology; the long-range strategic needs of the company to develop internal capabilities in the areas related to the technology; the degree to which the technology can be easily and fully appropriated, an issue that is particularly problematic in cases where use of the technology depends on communication of know-how or access to specialized complimentary assets; the quality and openness of communications from the firm providing the technology, including their willingness to share information and allow the recipient's personnel to observe how the technology is actually used in practice; and the ability and willingness of the recipient organization to receive and understand information about the technology, an issue that covers not only the skill level of the persons involved in the disclosure process but also their attitude toward technology that was not developed internally.

Companies need to be mindful that there may be difficulties in efficiently transferring the technology from the outside source and that technology that is licensed or otherwise subject to the control of the provider does not provide the same sense of certainty and autonomy as technology that is proprietary to the firm. In the worst case situation, a dispute between the company and a key technology supplier may delay, or even terminate, a new product development effort. Still another possible drawback of over-reliance on outside sources is that the strategy slows the development of in-house capabilities that will ultimately be needed if the firm is going to continue to grow and develop a broader business and technological strategy in the future.

The most successful companies, regardless of size or stage of development, are those that are able to strike a suitable balance between in-house technology development and reliance on outside sources. In the beginning, many companies rely on two or more of the external sources described above. For example, a company founded as a "spin-off" of a university department may enter into a funded R&D contract with that department which, in effect, makes the department the captive R&D group for the firm. At the same time, the company may license other needed technologies from established firms, perhaps with the understanding of a broader business relationship once the new company has moved farther along with the development efforts. While this approach may be adequate in the early stages of the business, resources should still be allocated to in-house technology specialists who can both evaluate and integrate the work and technology being provided by outside sources and launch their own projects to stay abreast of broader technological developments that will impact the business beyond the initial product.

§33 --Identifying and evaluating technology outsourcing opportunities

Given the wide array of technologies that a company may require for its products and manufacturing processes, it is almost inevitable that outsourcing will become a part of the firm's overall technology management strategy. Since the amount of the investment associated with "buying in" technology often exceeds the amount spent on internal R&D, companies clearly need to establish formal procedures for identifying and evaluating outsourcing opportunities.

The key question in this area, of course, is which technologies are the best candidates for outsourcing. At the extreme, companies could probably purchase or license most, if not all, the technology required for execution of their business strategy. In fact, some commentators suggest that companies actually look at in-house development as the exception, rather than the rule, when determining the best way to acquire necessary technology. This may be a difficult premise to accept in some cases, particularly for small companies formed to pursue commercial applications of technologies as to which one or more of the founders have been heavily involved in early discoveries and developments. In those situations, the founders may be wary of relying on the R&D skills of others even when confronted with evidence that an in-house development strategy will be more costly and time-consuming. Eventually, however, senior management must be convinced to embrace technology outsourcing as a viable alternative in order to maintain pace with competitors and avoid getting bogged down attempting to manage numerous in-house projects of negligible value to the company.

One way to look at the outsourcing decision is to identify where the technology fits within the company's current core product and technology strategies. For example, a requirement that fits within the company's current core product applications and/or technologies would be best suited to fulfillment internally or through a customized short-term contract with an R&D specialist that can be easily managed. As a general rule, these are small projects that need to be completed fairly quickly and which fit well within the existing competencies of the company's internal R&D team. Moreover, the cost and risk associated with these projects can be easily managed and the ROI is readily ascertainable. As the company embarks on attempts extend its core products or technologies into new markets and applications, the costs and risks associated with technology development begin to escalate and the project becomes more complex. For these types of initiatives, serious consideration should be given to collaborative R&D arrangements and strategic alliances with those key business partners most likely to benefit from the success of the development work. In many cases, a customer or supplier may be willing to share a portion of the development costs. Finally, a development project that goes well beyond the core and takes the company into new technologies or product applications is may require a licensing arrangement, a partnership with a government laboratory or university, a joint venture or even an acquisition.

Critics of making technology outsourcing decisions based on the relationship of the project to the company's core business and capabilities argue that they may lead to excess, if not complete, dependence on outsiders for the successful and timely development of technologies that the company is counting on for growth once today's core products and technologies become mature or even obsolete. They argue that the choice between in-house development and outsourcing should be based on evaluating the trade-off between the cost to the firm of going it alone and the potential strategic importance of the technology to the company. For example, the most cost-effective way to acquire a base technology, which typically low strategic value, is normally through a licensing arrangement or purchasing a component or subassembly that already integrates the technology. In each case, internal resources are freed for projects with greater strategic value to the business. In turn, low cost development work on key technologies usually should be done in-house since the R&D group will more efficient than outsiders and the risk/return profile on the project is quite attractive. Commercial, or applied, R&D falls into this category since it close to the current product line and customer base. An added advantage of staying in-house is that the company can preserve any patent or other proprietary rights that it may have built up during the earlier stages of development. High cost development work on key technologies present the greatest challenges. Outsourcing may be cost-effective; however, this approach is risky in that it creates dependence on a third party for an element that is important to the overall strategy of the company. In many cases, some sort of collaboration is the best alternative since it permits cost-sharing and also facilitates learning within the R&D group.

While measures of innovativeness and strategic importance of the technology are certainly useful in evaluating a particular “make-or-buy” decision, the managers responsible for R&D and technology management must make a number of decisions in arriving at the optimal mix that ensures that the dollars available for R&D and technology procurement are used effectively. The first step in this process is evaluating the overall technology requirements of the business and ascertaining which, if any, of those needs can reasonably be satisfied through outsourcing. While a large percentage of the necessary technology can be procured from third parties, there are certain situations where it is best to opt for in-house development. In addition, care should be taken not to embrace outsourcing at the expense of maintaining the quality and competitiveness of the internal R&D function. By accepting and successfully completing relevant projects, the R&D function can contribute to the competitiveness of the business and accumulate the necessary know-how and technical ability to create advantages in other areas, notably manufacturing and marketing. Also, while the value of formal intellectual property protection is problematic in many cases, internal technology development allows the company to build its own patent portfolio and establish credibility with business partners.

Some technology managers are reluctant to outsource a requirement due to concerns that it is too difficult to ascertain exactly what is being “purchased.” While this is a legitimate issue, it does not mean that the outsourcing option should be rejected outright. Instead, the manager needs to invest a reasonable amount of time in selecting the partner and defining the subject technology. For example, technology managers need to be able to determine, in advance, just what the particular technology is worth to the company and the form that the technology needs to take in order to satisfy the commercial requirements of the business. If the technology is already “complete,” these questions should be answer; however, if further development is required by the outside party, issues must be resolved regarding timing, cost and quality. There is no question that this can be a time-consuming process; however, the effort may be far more cost-effective than overloading scarce internal resources with projects that fall outside of the core competencies of the business and its personnel.

Outsourcing also requires a decision about the method to use for acquiring the necessary technology. Depending on the circumstances, companies may opt for contract R&D focusing on development of the specified technology; purchasing or licensing the technology; entering into a collaborative arrangement for development of the technology with a supplier, customer or other business partner; or forming a joint venture or strategic alliance. Each method has its advantages and disadvantages and carries its own set of risks and internal resource requirements. It is important for management to make selections with an eye on the overall strategic mix of the company's external technology sources. For example, the company should, if possible, select a single contract R&D firm for projects in related areas rather than attempting to manage several contractors at once. In addition, when selecting a licensing partner, consideration should be given to the feasibility of a long-term relationship with the licensor and steps should be taken to ensure that the relatively simple licensing arrangement is launched and managed appropriately. Finally, joint ventures and strategic alliances require extensive involvement from the senior management group.

In summary, as the company grows it will likely embark upon strategies that will require an increasingly complex network of outsourcing arrangements. While the benefits from outsourcing can be significant, the network is fragile and the pool of partnerships is fluid and continuously changing. Moreover, each type of outsourcing alternative has its own level of investment risk and management complexity and senior management must carefully construct and manage the overall portfolio of outsourcing projects to ensure that the anticipated return justifies the company's time and efforts. In order to be successful in this activity, the technology management function must have access to the experience and resources necessary to make the correct decisions about when to outsource, which outsource partners to select, the goals and boundaries of outsourcing arrangements and when and how to terminate a particular outsourcing relationship.

§34 Exploitation strategies

Once the technologies have been selected and acquired, the company must determine the best way to actually exploit the technology and the products and processes derived from the technology. While this stage is discussed separately, it actually overlaps significantly with the selection decisions that have been discussed above. Needless to say, it makes little sense for the company to pursue a particular technology unless and until it has a fairly good idea of how it will actually be used in the company's future business strategies and activities.

Examples of situations where the company may opt for external exploitation of a new technology include the following:

- Reliance on outside licensees may be more attractive when the company has achieved a strong proprietary position with respect to the technology through patents and copyrights, since it becomes more difficult for the licensees to be able "appropriate" the technology for their independent use.

- A relationship with a local partner may be preferable, or even required, when necessary in order to successfully introduce a new technology or product into a new foreign market. Local partners can provide competence with respect to regulatory compliance, overcoming trade barriers and dealing with the unique characteristics of local distribution channels.
- An aggressive licensing campaign can be used to influence industry standards with respect to the preferred technological platforms. For example, a firm may license its new technology to leading firms in various industries with an eye toward become their leading technology vendor in the future.
- Licensing is often the best and quickest means for gaining access to the complimentary assets that must be deployed in order successfully commercialize the technology. Many small firms must look to outside manufacturers and distributors to launch their first products since these firms lack the capital to manufacture the products in bulk and develop a sizable internal sales force.

Technology assets can be used as a form of "business currency" to gain access to the technology assets of other companies. For example, companies with distribution strengths in different markets may enter into an arrangement that allows each party to sell the technology-based products of the other in those markets in which they are best suited. Also, technology may be licensed to another party with the understanding that the company would have the right to use and exploit any improvements or enhancements that might be developed by the licensee. In addition, companies that have patents covering core technologies in a particular market can attempt to use licensing strategies to restrict the activities of their licensees. For example, a licensee may be prohibited from engaging certain research activities that might lead to technologies that would reduce the value of the licensed patents. However, these types of restrictions must be imposed with great care in light of antitrust and competition laws that generally disfavor such agreements. Finally, technology-based alliances can be formed to facilitate the transfer of a technology that is already in existence or may be used as a cost-effective way to develop new technologies. In many cases, development work will be followed by further collaboration with respect to the actual commercialization of the technology created during the initial phase.

By now it should be clear that licensing partners can be used to assist the licensor in conducting further research and development work, production and manufacturing of products that embody the licensed technology, and the distribution of products that may have been previously manufactured by the licensor or another licensee or manufactured by the licensee/distributor. Given the significant strategic impact associated with a licensing relationship, companies must proceed carefully in evaluating and selecting licensees and should assess candidates in light of the following characteristics:

- The potential licensee should be able to demonstrate ***experience*** in the specific technical area and in the particular function or functions that are at the essence of the particular relationship. For example, if the relationship is being established for the distribution of products, the licensee/distributor should be able to provide proven skills in marketing similar or complementary products in the target market(s).

- The potential licensee should be able to provide a ***formal strategic plan*** setting out in detail the steps that will be taken to fully exploit the licensed technology. The plan should include firm estimates of the licensee's proposed expenditures and the anticipated revenues and income, of which estimates might be incorporated into the license agreement in the form of covenants.
- The potential licensee should have the requisite ***managerial skill and experience*** to ensure that the licensee is able to execute its strategic plans. Such persons should be able to serve as in-house **"**champions**"** for the business relationship in the face of competing opportunities.
- The potential licensee should be able to provide sufficient ***financial resources*** to fund the formal strategic plan, as well as to finance additional work that might be required on the licensed technology.

§35 Protection of the advantages of technologies

Investment in the development or other acquisition of key technologies is only warranted if the company will be able to appropriate and protect the advantages of such technologies. The most commonly used methods for appropriating the gains from innovation include statutory intellectual property rights, including patents and copyrights; secrecy, including reliance on trade secret laws; acquisition and control of complementary assets; reliance on multiple technologies; and "lead time." Companies may rely on one strategy or, as is more typical, may attempt to use a combination of two or more methods at a given point in the development and deployment of an emerging technology.

§36 --Statutory intellectual property rights

While patents command a great deal of attention in the literature, studies show that patents are often a minor factor in many industries.[66] Before embarking on creation of a patent portfolio the following issues should be considered:

- Patents appear to be attractive because of the duration of protection that is available for inventions that are covered by an issued patent. However, in many cases, the life cycle of an invention or process is much shorter than the length of the patent term.
- Patent protection depends, in large part, on public disclosure of the invention in the patent application and before an application is filed companies must determine whether the additional protection that may be available from an issued patent is worth it given the information that will need to be disclosed to competitors who can use such information to guide their efforts to circumvent the stated claims.

---

[66] For detailed discussion of the legal and business aspects of patents, see "Patents" in "Technology Management: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project. Other related guides in "Technology Management: A Library of Resources for Sustainable Entrepreneurs" include "Intellectual Property Rights", "Trademarks", Copyrights", "Trade Secrets" and "Auditing the Company's Intellectual Property Assets".

- Companies typically lack the financial, technical and management resources to build and maintain a strong patent portfolio until they have grown substantially, which means that "startup" firms are particularly disadvantaged in this area. The costs associated with preparing, filing and prosecuting patent applications in multiple jurisdictions can be quite high and it usually takes several years for a company to determine whether all, or any, of their claims will be accepted by the examiners.
- Patent disputes can be quite costly and time-consuming and may neutralize the company's attempts to move forward with innovative research in specific areas. In fact, the costs of commencing patent litigation are beyond the range of many small firms and it is likely that the dispute will drag on for many years in cases where the technology is new and few, if any, precedents exist.
- Even if a strong patent position can be obtained, and this is certainly the exception rather than the rule, it is no guarantee that a competitor will not be able to develop an alternative that is non-infringing and which makes the invention covered by the patent obsolete or that makes it difficult for the original patent holder to continue its own innovation activities without obtaining a license from the late entrant. In many cases it is fairly easy for other companies to design around patents to create new, often more innovative, products or improvements or enhancements that only marginally overlap with the prior patent.
- Patents may not be an appropriate way to protect technologies or products that are based largely on "know how" and trade secrets that do not meet the criterion for patent protection.

From a strategic perspective, misunderstanding about the role and effectiveness of patent protection often leads to poor decisions in the selection of new R&D projects. For example, a company may reject a project out of concerns that it will not be able to secure traditional intellectual property protection; however, this decision may well be flawed if the company can use other strategies to appropriate a sufficient portion of the anticipated benefits from the innovation to justify the proposed expenditure of resources.

§37 --Trade secrets

The United States, and many other countries, recognize a right to prevent others from misappropriating certain proprietary information that has competitive value and which is not generally known to the public. These so-called "trade secret" laws require that companies implement various procedures to preserve the confidentiality of the competitive information, although disclosure is permitted provided that the recipient agrees to protect the confidentiality of the information. Some of the potential issues that might arise with regard to the efficacy of reliance on "secrecy" include reverse engineering; using products as the basis for developing ancillary products and services that are outside of the direct control of the owner of the original product; leakage from employees, interactions with business partners, publications and use in other projects; and limitations of trade secret laws and restraints on competitive activities.[67]

[67] For detailed discussion of the legal and business aspects of trade secrets, see "Trade Secrets" in "Technology Management: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project.

§38 --Complimentary assets

Still another method that is often used for appropriating the advantages of emerging technologies is investment in the means necessary to achieve control over complimentary assets that are required to effectively deploy the technology in specified markets. Complimentary assets might include control of distribution channels; service and support; existing relationships with key business partners, including supplier and customers; and/or control over complimentary products and services. Control over complimentary assets can neutralize, if not eliminate, shortcomings that in the other strategies available for protection of innovation. For example, if a company is in control of the key complimentary assets necessary for exploitation of a new invention, the availability of patent protection may be less important. On the other hand, obtaining a patent may not be sufficient to allow the company to commercialize the invention. This is the pattern typically found among small biotechnology companies that needed to team up with larger pharmaceutical firms to complete the necessary testing for a new drug and push the drugs out through the distribution channels controlled by the larger companies. Companies in other industries, such as IBM, have enjoyed similar advantages based on their strengths in the area of manufacturing and support, as well as their strong customer relationships. Relying on complementary assets can, however, become problematic if the dynamics of competition with respect to those assets changes. In that situation, the gains from use of such assets may diminish and the value may be transferred to others.

§39 --Multiple technologies

Companies may be able to protect their technological position, and eliminate or substantially reduce the risk of imitation by competitors, by integrating multiple technologies into their products. Since small firms generally lack the resources to develop two or more core technologies on their own, complementary technologies are usually obtained from outside sources through acquisition or, more likely, licensing given the prohibitive costs of outright acquisition. While this strategy can be effective, the company must recruit technical specialists that are qualified to understand and integrate the disparate technologies.

§40 --Lead time

In addition to, or in lieu of, protection under patent and trade secret laws, companies sometimes rely on "lead time" to secure the initial advantages that may be associated with mastery of an emerging technology. Lead time includes "first mover" advantages as well as the ability of the leader to move forward quickly with assimilating knowledge. Lead time advantages are greater when the product is durable or the company is able to establish a good reputation and make it more difficult for initial customers to "switch" to other alternatives. Lead time can also be an opportunity to acquire control over the complimentary assets that are necessary in order to realize the benefits from the technology. The higher the level of competition, the more problematic it becomes to rely on "lead time" or patent protection to appropriate the gains from innovation. Lead time is also difficult to gauge with certainty, since not all the actual and potential competitors may be known. Moreover, lead time will only be important if the market is ready for the technology. If customers are not interested, or the investment community is unimpressed, then the advantage of being first is really of little value after all.

§41 Knowledge management

Dana et al. referred to "knowledge" as "the integration of information, ideas, experience, intuition, skill and lessons learned that creates added value for a firm" and noted that researchers such as Nonaka and Takeuchi have divided knowledge into two categories: "explicit knowledge", described as being "easily identifiable, easy to articulate, capture and share – it is the stuff of books, manuals and reports", and "tacit knowledge", described as consisting "predominantly of intuition, feelings, perceptions and beliefs, often difficult to express and therefore difficult to capture and transfer".[68] Dana et al. believed that tacit knowledge carried greater value than explicit knowledge "in that it is the essence of innovation".[69]

Knowledge management refers to the processes and techniques used by an organization to create, acquire, transfer and protect the information and knowledge necessary for the organization to be successful. Knowledge management also includes the steps that must be taken to identify improvements to the existing knowledge base that must be pursued in order to respond to competitive challenges and changes in the operating environment. According to Wilson knowledge management can be simply understood as "managing what we know"[70] and Sahlman defined knowledge management as "identification, creation, codifying, storing and sharing of knowledge to make it available for business purposes of an enterprise".[71] Knowledge management should also focus on strategies for effectively integrating proprietary knowledge into the company's key business methods and practices, including new product development and manufacturing. The goal is to deploy the technology in a way that materially improves the performance of those processes. For example, effective technology management can increase the productivity and speed of product development projects and permit the company to quickly and easily make last-second changes in the product to incorporate advances in technology and changing needs in the marketplace.

Dana et al. conducted a cross-national study and comparison of the organizational knowledge-based practices of entrepreneurial firms in four geographic regions: Silicon Valley in the US, Singapore, the Netherlands and Israel.[72] Their overall findings pointed to a set of common core organizational knowledge practices and supporting cultural beliefs and behavioral norms that were universal across all of the regions including a

[68] L. Dana, L. Korot and G. Tovstiga, "A Cross-National Comparison of Knowledge Management Practices", International Journal of Manpower, 26(1) (2005), 10 (citing I. Nonaka and H. Takeuchi, The Knowledge Creating Company (1995)).
[69] Id.
[70] T. Wilson, The Nonsense of "Knowledge Management", Information Research, 8(1) (2002).
[71] K. Sahlman, Elements of Strategic Technology Management (2010), 40.
[72] L. Dana, L. Korot and G. Tovstiga, "A Cross-National Comparison of Knowledge Management Practices", International Journal of Manpower, 26(1) (2005), 10.

propensity for experimentation collective sharing of knowledge and collective decision making.[73] In addition, however, their conceptual framework for research and analysis provides a useful reference point for comparing the strategies and processes that companies use with respect to managing knowledge and innovation. Specifically, Dana et al. argued that reference should be made to four “inextricably linked” domains[74]:

- Knowledge culture (“knowing who we are”), which can be measured and understood by reference to models of organization culture such as the well-known one suggested by Schein.[75] Specific items within knowledge culture include learning focus, experimentation, participation, openness and trust, and organizational structure.
- Knowledge content (“knowing what we know”), which includes a company’s inventory of “strategically relevant knowledge” that can be found in three forms: formal knowledge, which is very explicit and documented; experimental knowledge, which is highly tacit and derived from previous experience and thus often quite difficult for company personnel to articulate; and emerging knowledge, which is both tacit and explicit and “emerges” through highly innovative and cross-disciplinary interactions such as those that occur during new product development projects.[76] Specific items within knowledge content include where knowledge resides, sources of knowledge, knowledge dissemination and knowledge flow.
- Knowledge infrastructure (“knowing the ‘how’ and the ‘where’”), which includes things such as information and communication technologies that companies can use to support and facilitate the management of knowledge and distribution of knowledge across functional and national boundaries (e.g., project teams). Specific knowledge infrastructure items include access to key knowledge, sharing of knowledge and the degree of interpersonal networking.
- Knowledge processes (“knowing how we know”), which includes the processes adopted for creation, conversion, transfer, application and discarding knowledge (e.g., with respect to conversion of knowledge, “socialization”, “internalization”, “externalization” and “combination”).[77] Specific knowledge process items include strategy process, learning process and gap management.

---

[73] This finding is consistent with conclusions of other researchers that there is a high-technology subculture that transcends national culture boundaries. See, e.g., L. Korot, Technoculture: Leading Edge to European Integration or an Organizational Anomaly? (1989); L. Korot, A Cross-Cultural Comparison of the Organizational Cultures of Hi-Tech Start-Up Ventures (1997); and G. Tovstiga, L. Korot and L. Dana, International Entrepreneurship: A Cross-Cultural Comparison of Knowledge Management Practices (2000).

[74] L. Dana, L. Korot and G. Tovstiga, “A Cross-National Comparison of Knowledge Management Practices”, International Journal of Manpower, 26(1) (2005), 10, 10-11, 13.

[75] See E. Schein, Organizational Culture and Leadership (1988), whose work is described in greater detail in “Organizational Culture: A Library of Resources for Sustainable Entrepreneurs” prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org).

[76] Explicit knowledge is easily identifiable and easy to articulate, capture and share and is generally documented in books, manuals and reports. Tacit knowledge, in contrast, consists predominantly of intuition, feelings, perceptions and beliefs, is often difficult to express and is therefore difficult to capture and transfer. L. Dana, L. Korot and G. Tovstiga, “A Cross-National Comparison of Knowledge Management Practices”, International Journal of Manpower, 26(1) (2005), 10 (citing I. Nonaka and H. Takeuchi, The Knowledge Creating Company (1995)).

[77] I. Nonaka and H. Takeuchi, The Knowledge Creating Company (1995).

§42 --Steps and strategies for effective knowledge management

Effective knowledge management involves several different steps and strategies. First, the organization must conduct what is essentially a diagnostic audit of it knowledge base, including a determination of the knowledge requirements of the organization, a review and evaluation of the current state of the organizations' knowledge, and the identification of any gaps in the knowledge base that must be filled. Next, the company must develop clear and proactive strategies for knowledge acquisition. In many cases, knowledge will be pursued through personal experiences of company employees through their research projects and internal communications. Alternatively, knowledge can be acquired through a wide range of interactions with outside sources, ranging from literature review to a full-blown technology transfer arrangement with an outside party.

Once the knowledge has been created or otherwise acquired, the company must institutionalize the knowledge and make sure that it is disseminated throughout the company and put into practice as part of the company's business procedures. The most effective methods in this area involve face-to-face communications. For example, the company might arrange for regular meetings of peer employees at which each of the participants is asked to share information and the entire group discusses methods for applying the information in like situations that they all confront during the course of their activities. Companies may also share information through formal classes and training sessions or through regular or special broadcasts on the internal Intranet. In cases where the knowledge is acquired from an outside party, perhaps through a license arrangement, company personnel should be allowed to work with representatives of the licensor that might be involved in the technology transfer process.

§43 --Information systems

Knowledge management also involves the creation and management of the firm's institutional memory. The task is to move the information from the minds of those that have acquired it into some form of permanent records that will survive the comings and goings of individuals and allow others to access the knowledge on demand as needed in the course of their activities. Many companies, particularly those that are heavily reliant on technology, are becoming more familiar with the concept of "knowledge sharing," or "expert" systems, which have made possible by rapid advances in the area of information technology. Using these methods, companies are able to record the results of a learning experience, such as an experiment, and integrate that record into a central database that can be retrieved by everyone in the organization.

Storage of a company's institutional knowledge is generally part of the larger project of creating and administering a comprehensive and effective information system, activity that is essential to the success of any business. The term "information system" refers to processes and tools that companies use to collect data, interpret and process it into information, and disseminate the information to those who need it on a timely basis and in a form in which it can be used by the recipient. The elements of an information system include personnel, data collection, storage and processing equipment, communications and dissemination facilities, procedures, security planning, and controls. It is important to distinguish between "data," which is essentially the raw material (e.g., facts and figures describing known events or occurrences) for "information," and the "information" that is created from interpreting the data.

The first functional element of any effective information system is inputting the appropriate data. Managers should establish procedures for timely collection of all data necessary to generate the required information. The data should be checked carefully before it is entered into the system. The second functional element is referred to as data maintenance. The goal of this function is to be sure that data in the system that is no longer current or relevant will be replaced. However, the maintenance function should include the capacity to archive and preserve historical information for future reference. The third functional element is the output function, which focuses on creating and disseminating useful information for consumers within the organization. In order to be prepared for output, the data must be retrieved, selected, processed, and reported in a manner that conforms to the information requirements of the organization. The output can be disseminated in a variety of media, including written reports, newsletters, speeches, and as part of an electronic "infobase" that can accessed as needed.

Once the essential functions of an effective information system are understood, management must proceed with designing and implementing a system that satisfies the unique requirements of the company. This process begins with conceptualization of the goals and objectives of the information system, including the specific types of data generated by the company's activities and the outputs that are most valuable to the managers and employees of the company and outside stakeholders (e.g., regulators, lenders, investors etc.). The next steps include feasibility studies, an analysis of the current systems used by the firm, and creation of a project team to coordinate the effort. The project team must then select one or more vendors to design and construct the system. Before the system goes online, the responsible managers and technical staff should be provide with intensive training, and provision should also be made for further in-house training of other personnel as needed to effectively utilize the system. Also, the system should be thoroughly tested alongside the company's existing systems and procedures to be sure that it works efficiently. An information system is not static and should be regularly evaluated to ensure that it continues to meet the needs of the company as it grows and evolves.

§44 Guidelines for successful technology management

White and Bruton offered the following guidelines for successful technology and innovation management[78]:

- Designate clear technology leaders—individuals who champion change;

---

[78] M. White and G. Bruton, The Management of Technology and Innovation: A Strategic Approach (2007), 29.

- Know how the processes can work to help and to hinder the development of new technology;
- Assess objectively where your firm is on the technology curve;
- Assess the strengths and weaknesses of your personnel and your approach to the management of technology and innovation;
- Set realistic priorities;
- Develop excellent infrastructure to help find and take advantage of potential opportunities;
- Understand what the tasks are and how they are connected and disconnected;
- Be systematic in your search and assessment processes, but review the system thoroughly to be sure it is still applicable;
- Savor every victory and learn from every failure;
- Be confident that once you have made a decision, it is a decision that will move you in the right direction.

In their cross-national study and comparison of the organizational knowledge-based practices of entrepreneurial firms in four geographic regions—Silicon Valley in the US, Singapore, the Netherlands and Israel—Dana et al. found the following practices among those firms that they described as "leading edge" (i.e., highest performing among all of the firms in their survey with "state of the art" technology): extraordinary commitment to constant experimentation, open and collective sharing of knowledge, dissemination of that knowledge through formal and informal networks, flexible strategy, loose organizational structures, dedication to customer needs, and a team centered, participative management culture.[79]

§45 Environmental and institutional influences on technology management

The importance of comparative research relating to technology management has increased as technology itself has emerged as one of the principal factors of production and innovation in business organizations all around the world. As companies, even small firms, have continuously expanded their worldwide operations and established business activities in multiple countries, often widely dispersed in terms of time and distance, they have become necessarily become dependent on acquiring and using the technology that is needed in order for them to coordinate activities across borders and facilitate communication within their global networks of offices, branches and subsidiaries. Globalization has also focused attention on the skills and processes that organizations must develop in order to transfer and diffuse technologies across national borders. In addition, of course, senior management, as well as other personnel involved in new product development activities, must continuously scan domestic and foreign markets to identify technological trends and seize opportunities to gain access to new technologies that can be integrated into products and deployed to improve productivity. Finally, although not the primary focus of this Part, technology management is relevant to national policymakers interested in making investments in technologies that will enhance

---

[79] L. Dana, L. Korot and G. Tovstiga, "A Cross-National Comparison of Knowledge Management Practices", International Journal of Manpower, 26(1) (2005), 10, 20.

the competitiveness of entire countries and improve the economic and social welfare of their citizens.

§46 --Factors impacting the diffusion and adoption of new technologies

An array of empirical evidence has been collected and used to develop various theories regarding the diffusion and adoption of new technologies or innovations.[80] For example, politics and governmental policies, particularly the political structure that is in place a particular country, appear to play an important role in the diffusion of modern communications technologies in that country. It has been suggested that countries in which an authoritarian government is in place are less hospitable to new technologies that might facilitate interpersonal communications such as telephones and the Internet and that governments in those countries can be expected to invest fewer resources in developing the infrastructure needed for these communications technologies to flourish.[81] This suggestion, if true, can explain why the growth of the Internet has been hampered and slowed in countries such as China, Cuba and Syria where the entrenched authoritarian governments have often taken extreme measures to block information that is available to citizens and the ability of citizens to communicate with one another and with persons outside of the country. Theories from sociologists have been used to argue that "Western control of mass media" has been used to drive consumer demand for new technologies in developing countries where citizens have become fixated on imitating what they see happening in the developed world.[82] Other research disciplines have added their own perspectives on diffusion and adoption of new technologies: differences in societal culture explain why particular technologies are more comparable with certain societies than others[83]; understanding of, and experience with, elements of information systems (i.e., people, hardware, software, communications networks and data resources) influence the rate of diffusion and adoption[84]; and diffusion and adoption is heavily dependent on economic, geographic and geopolitical factors, particularly income levels and characteristics of populations (i.e., skills, educational qualifications, literacy rates, productivity and the cost of labor) [85].

---

[80] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595-596.

[81] Id. at 595 (citing A. Groth and W. Hunt, "Marxist-Leninist Communications Systems in Comparative Prospective", Coexistence, 22(1985), 123; N. Kshetri, "Determinants of the Locus of Global E-Commerce", Electronic Markets, 11(4) (2001), 250; and N. Kshetri and N. Dholakia, Impact of Cultural and Political Factors on the Adoption of Digital Signatures in Asia (2001)).

[82] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595.

[83] N. Kshetri and N. Dholakia, "Determinants of the Global Diffusion of B2B E-Commerce", Electronic Markets, 12(2) (2002), 120, and S. Zaheer and A. Zaheer, "Country Effects on Information Seeking in Global Electronic Networks", Journal of International Business Studies, 28(1) (1997), 77.

[84] J. O'Brien, Introduction to Information Systems (8th Ed.) (1996).

[85] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595 (citing S. As-Saber, P. Liesch and P. Dowling, Geopolitics and Its Impacts on International Business Decisions: A Framework for a Geopolitical Paradigm of International Business (2000); S. Cohen, Geography and Politics in a World Divided (1963); and T. Baerwald, "Geographical Perspectives on International Business", in M. Czinkota, I. Ronkainen and M. Moffett (Eds.), International Business (4th Ed.) (1996).

§47 ----Economic factors

Kshetri has argued that economic factors—income level, availability and price structures of information and communication technology ("ICT") products and services, and bandwidth and supporting infrastructures—influence the diffusion of the Internet.[86] This argument is not surprising in light of evidence regarding the significant gap between developed and developing countries on various measures of the costs of securing the equipment necessary for Internet access and accessing the Internet itself. For example, studies announced in 2001 showed that while the cost of a personal computer as a proportion of per capita GDP in high-income countries was 5% the comparable measurement was 300% in low-income countries and that the monthly Internet access charge as a proportion of per capita GDP in 2001 varied from 1.2% in the U.S. to 118% in Sierra Leone.[87] Interestingly the difficulties in affording personal computers and private access to the Internet in developing countries has led consumers in those countries to greater reliance on alternative access methods such as public kiosks, cafes and mobile networks.[88] Finally, Internet diffusion and adoption depends heavily on bandwidth availability and there are stark differences between high-income and low-income countries with respect to the breadth and quality of bandwidth and the price to high bandwidth to consumers. In 2001, for example, it was estimated that North America had 50% of the worldwide bandwidth capacity while the Middle East and Africa had only 3% of the capacity.[89] Moreover, not only did developing countries in Asia, Africa and Latin America have to endure longer data transfer times due to a lack of high bandwidth capacities they also did not have intraregional infrastructures and thus had to route communications with neighboring countries through networks in the U.S. or Europe, a situation that not only increased the time for such communications to be processed but also increased costs.[90] Kshetri et al. noted that South Korea was an example of how the availability of reasonably priced high bandwidth can be a significant driver of rapid Internet diffusion.[91]

§48 ----Institutional factors

Institutional theory has been used to explain diffusion patterns of technologies[92] and two components of formal institutions—the State and international institutions—have had a significant influence on the diffusion of the Internet through their various roles as policymakers, regulators and investors. Perhaps the most well-known example of the

---

[86] N. Kshetri, Determinants of the Locus of Global E-Commerce, Electronic Markets, 11(4) (2001), 250.
[87] International Telecommunications Union, The Internet: Challenges, Opportunities and Prospects (2001).
[88] A. Kirby, "Doing Business in Asia", Credit Management 24 (2002) and K. Stout, Japan Internet Users Up 74 Percent, CNN.com (April 24, 2001).
[89] Frontline.net, Broadband in the Developing World (2001).
[90] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 596.
[91] Id.
[92] N. Kshetri, "The Adoption of E-Business by Organizations in China: An Institutional Perspective", Electronic Markets, 17(2) (2007), 113, and N. Kshetri and N. Dholakia, "E-Commerce Patterns in South Asia: A Look Beyond Economics", Journal of Asia Pacific Business, 6(3) (2005).

role of the State is the initial development of what eventually became the Internet by personnel working inside the Advanced Research Projects Agency within the U.S. Department of Defense.[93] Since then governments all around the world have influenced diffusion of the Internet throughout their countries through political support or lack thereof including the strategies they have adopted with respect to regulatory control of the Internet, investment in research and infrastructure relating to the Internet and permitting/facilitating importation of information communication technologies, products and services.[94]

The potential role of the Internet as "the greatest democratizer the world has ever seen"[95] makes it incompatible with many authoritarian regimes that are concerned about how the flow of information through the Internet in their countries might destabilize their hold on power or otherwise have an undesired influence on the citizens of their countries apart from politics. In China, for example, the State has a long history of tempering the advantages of Internet diffusion for economic modernization by exercising politically motivated control over Internet access including shutting down "unlicensed" Internet cafes and requiring that "permitted" Internet access points install software that denies access to pornographic sites and other sites deemed by the State to be "subversive".[96] Governments in Arab countries, such as Saudi Arabia, have filtered and blocked "sexually explicit" content. Authoritarian regimes appear to be relatively slow to facilitate e-commerce by failing to formally recognize digital and electronic signatures, although it should be conceded that adequate legislation on these matters have often been neglected in developed countries.[97] Some developing countries have persisted in treating information technology products imported from outside as luxury items, or restricted them altogether, thereby inhibiting e-commerce development through the use of tariff/non-tariff barriers.[98] On the other side of the coin, however, are the various initiatives that many countries have launched to encourage the Internet and other types of information technology as a means for achieving sustainable economic modernization. For all of its faults, China has made substantial investments in its ICT infrastructure and

---

[93] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 585-586.

[94] The discussion in this section is adapted from N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 596-597. While the discussion in this section focuses on "formal" institutions, such as central governments, institutions may also be "informal" and grounded in socio-cultural characteristics (i.e., "cognitive" and "normative"). See R. Scott, Institutions and Organizations (2001). With respect to formal institutional impediments to Internet diffusion and use, see also N. Kshetri, "Determinants of the Locus of Global E-Commerce", Electronic Markets, 11(4) (2001), 250.

[95] S. Pitroda, "Development, Democracy and the Village Telephone", Harvard Business Review, 71 (November/December 1993), 66.

[96] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 596. See also S. Kalathil, "China's New Media Sector: Keeping the State In", Pacific Review, 16(4) (2003), 489.

[97] N. Kshetri and N. Dholakia, Impact of Cultural and Political Factors on the Adoption of Digital Signatures in Asia (2001); and D. Stephens, "Digital Signatures and Global E-Commerce", Information Management Journal, 3(1) (2001), 68.

[98] United Nations Conference on Trade and Development, Building Confidence: Electronic Commerce and Development (2000).

other countries, such as Malaysia and Singapore, have taken extraordinary efforts to encourage and attract foreign investment in their ICT sectors.[99]

Kshetri et al. discussed several ways that international institutions—the United Nations, the World Bank and the World Trade Organization ("WTO")—have promoted and facilitated accelerated diffusion of the Internet around the world, particularly in developing countries, and among the various contributions made by these international institutions are the following[100]:

- International institutions have helped to introduce the Internet for the first time in developing countries that lacked the requisite infrastructure.[101] In one instance the United Nations Development Program introduced the Internet to fifteen countries by connecting them to the global network and the World Bank has actively supported and promoted projects specifically focused on the needs of the poorest in developing countries and identifying ways for them to get access to ICT for economic and social development. One of the primary goals of these initiatives was to break what Gatignon and Robertson referred to as the "hierarchical pattern" of Internet diffusion which was based on a slow and arduous trickle-down of innovations in developing countries from the affluent at the top of the hierarchy to the poorest members of the society.[102]
- International institutions have worked to reduce the gap between the skills required for effective Internet use and the existing skills of potential Internet users in developing countries. Projects in this area have included training programs and assistance in creating new websites for governments and civil society stakeholders in developing countries.[103]
- International institutions have exerted influence on national governments in the countries that are assisting to liberalize and increase the levels of competition in their telecom sectors, initiatives that have led to enhanced availability, including through imports, of better quality ICT products and services at lower prices. The byproduct of these efforts has been a commitment among developing countries within the WTO to introduce competition in their telecom sectors and eliminate customs duties on several broad categories of ICT products.[104]
- International institutions have focused on facilitating adoption of the Internet by small- and medium-sized enterprises ("SMEs") in developing countries which might

---

[99] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed., The Handbook of Technology Management (2010), 585, 597.

[100] Id. at 597. See also see also N. Kshetri, "Determinants of the Locus of Global E-Commerce", Electronic Markets, 11(4) (2001), 250; N. Kshetri and N. Dholakia, "World Trade Point Federation: Bringing E-Commerce Capabilities to Developing Nations", International Journal of Cases in Electronic Commerce, 1(1) (2005), 39; and B. Shadrach, "India's Development Information Network: Lessons Learned", Bulletin of the American Society for Information Science, 28(2) (2002), 23.

[101] L. Brown, E. Malecki and A. Spector, "Adopter Categories in a Spatial Context: Alternative Explanations for an Empirical Regularity", Rural Sociology, 41 (1976), 99.

[102] H. Gatignon and T. Robertson, "A Propositional Inventory for New Diffusion Research", Journal of Consumer Research, 11 (1985), 849, 858.

[103] United Nations Development Program, Human Development Report 2000 (2001).

[104] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 597.

otherwise be reluctant to take that step. The idea behind these initiatives is to open up global markets for these SMEs and make it easier for them to become involved in the rapidly growing network of electronic trading platforms.[105]

- International institutions have been involved in various initiatives designed to influence the development of national laws, regulations and policies regarding the use of the Internet in ways that are more conducive to promoting increased acceptance of Internet use. For example, the Model Law on E-Commerce promulgated by the UN Commission on International Trade Law has been a model for many of the new Internet laws enacted by countries all around the world. The World Intellectual Property Organization set up a system that provides basic, and secure, Internet connectivity to intellectual property offices around the world. Other institutions and agencies have developed model contracts for privacy and trans-border data transfers and policies addressing a variety of Internet-related issues including authentication and certification, consumer protection and privacy.[106]

§49 ----Socio-cultural factors

A variety of socio-cultural factors may come into play with respect to achieving increased levels of Internet diffusion and use. For example, authoritarian governance and the associated restrictions on civil liberties create barriers that can be difficult to overcome; however, research shows that higher literacy levels create problems for the efforts of governments to control and block information flows. Improvements in literacy rates also nurtures the skills needed for Internet use. One issue that has caused problems for the growth of Internet use has been the domination of English-language software, interfaces and content; however, new translation tools have been continuously developed for over a decade and localization has become a major topic among international Internet policymakers and pundits.[107] Localization of content is particularly interesting given that citizens of many countries outside of the Western world are inherently suspicious and distrusting of information emanating from the US and other Western countries and see it as a means for imposing what has been referred to as an electronic “Pax Americana”.[108] Still another culturally-based issue for accelerated adaptation of the Internet is the reluctance among people from certain cultures, such as Japan, to accept the asynchronous nature and impersonal style of communication that the Internet provides.[109] In fact, as a general proposition it appears to be accurate that the diffusion patterns of the Internet within a social and cultural system is influenced by the degree of compatibility between the Internet and its various uses and the cultural values and norms of that system.[110]

---

[105] Id. at 597.
[106] Id. See also N. Kshetri, “Determinants of the Locus of Global E-Commerce”, Electronic Markets, 11(4) (2001), 250.
[107] N. Kshetri, N. Dholakia and R. Dholakia, “Global Diffusion of the Internet”, in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 597.
[108] See D. Shabazz, “International Politics and the Creation of a Virtual World”, International Journal on World Peace, XVI(3) (1999), 27.
[109] D. James, “No Tsunami Yet”, Upside, 1(3) (1998), 72.
[110] See, with regard to the relationship between societal culture and diffusion of innovations, E. Rogers, The Diffusion of Innovations (1983).

§50 ----Geography and geopolitical factors

The importance of geography and geopolitical factors with respect to the diffusion and adoption of new technologies, particularly the Internet, cannot be understated. Geography has an obvious influence on the ease of importing new technologies into a country and in the case of technologies, such as telecommunications, that require the construction and maintenance of infrastructure components the geography of the country plays a big role in determining the costs and pace of development and expansion. The geography of a country also determines how people in different parts of the country relate to, and communication with, one another and the introduction of new communications technologies alone does not necessarily transform traditional ways of communication overnight.[111] Geopolitical factors include population as well as a variety of variables associated with the population: skills, educational qualifications, productivity, cost of labor, and literacy rates.[112] Researchers have argued that these skills are associated with both the creation and availability of information and whether or not potential consumers of information in the country have the proficiencies required to understand and use the information.[113] Gatignon and Robertson found that the diffusion of technology was negatively related to the disparity between the skills needed to use the technology and the existing knowledge and technical skills of potential consumers and this relationship has been demonstrated by the difficulties that have been observed in adoption of the Internet in less developed countries.[114] Gatignon and Robertson also found that diffusion of the Internet is influenced by the geographical distance between adopting units. Specifically, greater distance creates more challenging terrestrial barriers that must be overcome, such as making the investments for building the high-bandwidth backbones necessary for high speed and continuous handling of data traffic.[115]

§51 --Factors impacting design and development of global information systems

[111] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595 (citing T. Baerwald, "Geographical Perspectives on International Business", in M. Czinkota, I. Ronkainen and M. Moffett (Eds.), International Business (4th Ed.) (1996)).

[112] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595 (citing S. As-Saber, P. Liesch and P. Dowling, Geopolitics and Its Impacts on International Business Decisions: A Framework for a Geopolitical Paradigm of International Business (2000) and T. Baerwald, "Geographical Perspectives on International Business", in M. Czinkota, I. Ronkainen and M. Moffett (Eds.), International Business (4th Ed.) (1996)).

[113] J. Cassiolato and M. Baptista, "The Effects of the Brazilian Liberalization of the IT Industry on Technological Capabilities of Local Firms", Information Technology for Development, 7(2) (1996), 53.

[114] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595-596 (citing H. Gatignon and T. Robertson, "A Propositional Inventory for New Diffusion Research", Journal of Consumer Research, 11 (1985), 849.

[115] H. Gatignon and T. Robertson, "A Propositional Inventory for New Diffusion Research", Journal of Consumer Research, 11 (1985), 849. The quality and speed of data connections appears to be positively related to the rate of Internet adaptation and Kshetri et al. reported that high-bandwidth backbones were first created in North America, where Internet usage was earliest and most widespread, and then spread to Europe with similar positive impact on Internet usage, while data traffic and Internet usage in less developed areas of the world has been constrained by low-bandwidth connections. N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 596.

Collins observed that there are is wide array of differences between countries which can create challenges for the design and development of global information systems in general and for the software required to operate those systems in particular and that these differences can be usefully categorized as cultural technical, physical, structural and legal.[116] He noted that understanding and managing these differences was crucial to effective implementation of the information systems that have become essential to the success of large and small firms in a globalized economy and cautioned that the differences might have substantially negative effects on development activities and operations once the systems were up and running.

§52 ----Cultural differences

According to Collins there are at least two kinds of impacts that cultural differences among countries have upon global information systems.[117] The first area in which culture plays a significant role is in the actual development of the content of a global information system. Collins illustrated the issue by contrasting the success that a website offering last-minute travel reservations would likely have in the UK against the poorer prospects for such a website in countries where cultural norms included an expectation of advance planning and citizens would therefor likely frown on a website that provided rewards for failing to plan in a manner that was culturally correct.[118] Collins provided other interesting examples of how societal culture might influence content and perceived benefits of the utilities included in the information system: the manner in which women were represented on a website, particularly the way in which they were clothed, would likely need to be different depending on whether the website was focused on Western cultures or on more conservative societies such as those in the Middle East; and software designed to support online meetings, brainstorming, ranking and voting would be appropriate in individualistic societies such as the US where open discussions among persons from different levels in the organizational hierarchy is tolerated and expected but would not be embraced in societies where consensus is built in private meetings, public disagreements are considered inappropriate and superiors are rarely challenged.

Collins also suggested that cultural differences will influence the technical development of global information systems particularly in situations where the development effort relies, as is typically the case, on diverse teams that include members from different functional areas and countries. Collins notes that the inherent diversity of these cross-functional, and cross-cultural, teams creates communications challenges even in situations where everyone on the team can speak a single language. Words may have different meanings to members based on their cultural background and there will also be differences with respect to the level of debate and dissent that is considered to be appropriate as discussions continue regarding the structure of the system and other matters relating to the development project. Still another issue will be how best to

[116] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665.
[117] Id. at 669.
[118] See R. Spiegler, "Globalization: Easier Said Than Done", The Industry Standard (October 2000), 136.

"reward" the members of the team for their contributions and the overall efforts of the team and a balance will need to be structure between individualistic cultures, such as the US, where individual rewards are preferred and expected and collectivist cultures where teamwork is highly valued and individual rewards and recognition may be embarrassing to the recipient and cause strife between him or her and colleagues. Researchers such as Earley and Ang have studied the cultural dynamics of cross-cultural teams and stressed the need to select the members of such teams carefully and train them at the start about cultural differences and ways to ease team communications.[119]

§53 ----Technical differences

While there has admittedly been a striking level of convergence among countries with regard to the availability and affordability of the local ICT infrastructure the actual technical environments in countries around the world remain far from uniform and, as noted by Collins, "there are still significant differences in countries' e-readiness".[120] Among the issues that might need to be addressed in a particular country are the unavailability or specific technologies (or, if they are available, a lack of the robustness seen in countries such as the US) and/or the lack of local expertise to support critical technologies. Differences in the cost and quality of Internet access, particularly with respect to speed, can impair the quality of online content including animation and graphics. Training of IT professionals is also far from uniform around the world, creating wide variation in the overall quality of IT labor from country-to-country[121], and technical personnel in one country may have different ideas than colleagues in other countries regarding the appropriate development tools and the methods that should be used for system analysis and design. Obviously these types of differences will create challenges, if not outright conflicts, when IT professionals from a wide range of countries are working on the developing a global information system.[122] Finally, the educational level of potential users of an information system in a particular country is relevant to the value that the system provides to those users. In many instances potential users suffer from "computer illiteracy" and training and other methods of support must be available in order for them to realize the anticipated benefits from the system.[123]

---

[119] See P. Early and S. Ang, Cultural Intelligence: Individual Interactions Across Cultures (2006). See also C. Koh, D. Joseph and S. Ang, "Cultural Intelligence and the Global Information Technology Workforce", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 828.

[120] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 669-670.

[121] See C. Koh, D. Joseph and S. Ang, "Cultural Intelligence and the Global Information Technology Workforce", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 828.

[122] See, e.g., R. Collins and L. Kirsch, Crossing Boundaries: The Deployment of Global IT Solutions (1999). Koh et al. observed that cross-border development teams working on IT projects will likely need to wrestle with finding culturally appropriate solutions for conflict resolution, collaborative problem solving, communication, goal setting and performance management and planning and task coordination. C. Koh, D. Joseph and S. Ang, "Cultural Intelligence and the Global Information Technology Workforce", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 828, 836-839.

[123] Collins described how the advantages of information on global market conditions was made available to a large group of farmers in India who lacked their own Internet savvy yet were able to rely on one leader-farmer in their village who did understand the technology and shared the information with the other members of the group. Collins noted that this approach was successful since it dispersed the information in

§54 ----Physical differences

Physical differences that may need to be taken into account when developing a global information system stem from differences in language, currency, time zones and, in some cases, the unique geographic challenges in one of more the impacted countries that might impair communications or efforts to build the necessary technical infrastructure.[124] Languages and currency are important variables since they impact both the content of the global information system and the ease of progress of the development effort. While there is technology available that can support multiple languages fairly easily decisions still need to be made about how much content needs to be available to meet the needs of users in each of the countries where the system will be deployed. Collins reminded that cultures have been classified and distinguished as high- or low-context and that these differences should be taken into account both when deciding how much content to make automatically available to users and when information is exchanged between colleagues in different countries (e.g., an employee from a high-context preference country may be disappointed and frustrated at what he/she considers to be inadequate and incomplete information received from a colleague in a low-context preference country). Culture influences how team members perceive their roles and responsibilities with respect to sharing information during the development process: personnel from collectivist countries are more likely to contribute information to the group while personnel from individualistic countries may condition their contributions on satisfactory incentive schemes. Time zone differences make it difficult to convene meetings of all team members when they are dispersed all over the world and development initiatives must include plans for ensuring that information is shared across personnel from various countries that might be working at different times of the day.[125]

§55 ----Structural differences

One of the biggest challenges of designing an effective global information system is identifying and accommodating "structural differences" that encompass differences between business units with respect to their information requirements as well as the need to localize information to fit the unique requirements of business units in individual countries (or even multiple locations in a single country).[126] The balance between "global" and "local" is a difficult one to achieve and the issue arises in a variety of

---

a manner consistent with local cultural norms of collectivism and benevolent guidance by a recognized and respect leader. See R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 666.

[124] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 670.

[125] See, e.g., E. Carmel, Global Software Teams (1999) (discussing the use of "follow-the-sun" or "24/7" development strategies that consist of three appropriately located development teams around the world that continuously pass off development work to the next team at the end of their eight hour shift). Even in the best planned efforts there will be delays in responses to questions posed by team members in one time zone to members in another time zone.

[126] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 670.

contexts not just with respect to global information systems. It is imperative that company-wide and local information requirements be identified early in the development process so that conflicts can be resolved to the satisfaction of all parties in advance and the decisions can be incorporated into the system design and project management strategies. Collins notes that the launch or major redesign of a global information system is often seized as an opportunity to shift away from excessive local deviations to a single, common business process and advises that such an initiative must be carefully planned in advance and include fully integrated common technical standards and education, training for personnel so that they understand why the changes are being made and how they can cope with them and strong support and communication from top management to inform everyone in the organization as to rationale and benefits of the changes.[127]

§56 ----Legal differences

Collins mentioned several important legal differences among countries around the world that could have a significant influence on the development and maintenance of global information systems[128]:

- Companies operating websites and information systems in multiple countries—and relying on Internet service and content providers in different countries—must grapple with uncertainties regarding the countries that might seek to assert legal jurisdiction over online transactions or simple viewing of a website by users. For example, a company in Country A operating a website that can be viewed in Country B might be sued in Country B because the sale of items available on the website is illegal in Country B although permitted in Country A. The company might argue that it can only be sued in Country A; however, courts have not fully resolved proper jurisdiction in such cases.
- Disputes regarding the applicability and enforcement of national intellectual property laws are also a concern for operators of global websites and information systems. Software piracy is a particular concern for development projects since countries vary significantly in their enforcement activities with respect to, and cultural attitudes towards, unauthorized copying of software programs and companies have resorted to their own deterrents (i.e., software audits and technical controls) since local courts and officials often cannot be relied upon for assistance.
- Somewhat related to intellectual property is the growing issue of counterfeiting, which often involves unauthorized use of trademarks, and has led to the loss of billions of dollars of revenues for companies around the world and increased perils for unwitting consumers duped into paying for goods and services that are not from the source they had chosen. Companies have generally experienced substantial difficulties in attempting to track down and obtain legal relief against counterfeiters domiciled in foreign countries. At the same time, legislative initiatives that would appear to strengthen the remedies available to companies have failed in the face of

[127] See also R. Collins and L. Kirsch, Crossing Boundaries: The Deployment of Global IT Solutions (1999).
[128] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 670-672.

concerns that such remedies amount to censorship and excessive governmental control over the Internet.

- A looming, pervasive and potentially unsolvable risk for companies with a global online presence comes from attempts by governments to control access to the Internet and censor online communications. Collins noted that telecommunications costs are higher, and innovation less common, in those countries (primarily in the developing world) where the government either owns the telecommunications infrastructure or has allowed privatization yet retained centralized control over the sector. Governments have been known to engage in heavy surveillance of the Internet activities, censor Internet content that they consider to be inappropriate or threatening and even deny access to the Internet to their citizens for political reasons. The guiding principle for global companies is well expressed in the following quote from the CEO of Google in 2007: "Anyone who thinks the Internet is borderless hasn't been paying attention to people going to jail. We have to pay attention to local laws, we have to work with the governments [and] we have to understand cultural sensitivities."[129]
- The emergence of the Internet and the decision of companies everywhere to use elements of the online world for storing and transferring value data have proven to be fertile ground for the alarming phenomenon referred to as "cybercrime". Examples of cybercrime noted by Collins included "illegal access to, interception of, or interference with data transmissions; interference with system operations; computer-related forgery or fraud; and provision of child pornography".[130] The crimes themselves are bad enough; however, companies encounter further troubles when attempting to investigate crimes in foreign jurisdiction and bring perpetrators to justice if they can be identified.[131]
- A number of countries have enacted data privacy laws that must be taken into account by global companies whenever personal data is processed, collected, maintained and shared including sharing among business units of the same company located in different countries (i.e., "trans-border data transfers"). While the specifics of each law should be carefully reviewed the general themes include provision of notice to individuals regarding the purpose and use of information, providing individuals with choices about whether or not their personal information can be disclosed (either internally or in transfers to third parties), providing individuals with access to their personal information in order to correct, amend or delete it; and adequate security measures.[132]

---

[129] Quote appeared in V. Shannon, "Web Sites with Borders", International Herald Tribune 15 (June 21, 2007).

[130] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 671.

[131] International efforts have been underway for several years to establish universal guidelines that countries can use for creating their own national legislation relating to cybercrimes and attempts have also been made to develop a framework for cross-border cooperation in investigations of alleged cybercrimes and establishing jurisdiction for prosecution activities. R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665, 671-672.

[132] Based on U.S. Safe Harbor Program adopted in response to data privacy and trans-border data transfer laws adopted in the European Union. See also P. Steinbart and R. Nath, "Problems and Issues in the Management of International Data", MIS Quarterly, 16(1) (1992), 55.

§57 --Societal culture and management of technological change

As globalization continues and accelerates researchers have shown increasing interest in understanding how technologies emerge, develop, move outward across borders and adapt themselves to unique local conditions within each country. Inquiries on these issues have focused researchers on the role of national culture in the management of technological change. Arguments for the relevance of societal culture to technological change emphasize that individuals and technologies are embedded in a social context that is heavily influenced by national culture and ideology and that societal culture determines the beliefs, practices and perceptions that individuals from that society bring to their decisions regarding the creation, adoption and use of new technologies. An important byproduct of these arguments is that each society interacts with technologies differently. In other words, "[t]he innovation, adoption, and use of technology is . . . 'an inherently cultural process whereby the same technology has the potential to be constructed in radically different ways across diverse cultures'".[133] Potential differences between countries with respect to technological change attributable to variations in societal cultures have been explored by several research themes including work on national innovation systems, the influence of societal culture on cross-border technology transfers and differences among countries with respect to adoption and use of information and communications technologies.[134]

The concept of a "national innovation system" was developed in an effort by researchers to identify and explain the factors that influence the technology performance of nations. According to Nelson, a national innovation system can be understood as a set of institutions and institutional actors within the nation that, through their interactions, determine the innovative performance of national firms.[135] Researchers interested in national innovation systems argued that there were differences between countries with respect to the configuration and performance of their systems and sought to understand why those differences existed, including how and why the systems developed the way they did, and how changes might be made in those systems to improve overall technological performance.[136] Among other things, researchers attempted to establish universal benchmarks and "best practices" that could be used as reference points for nations interested in making changes to their innovation systems.

Aten and Nardon commented that research work relating to national innovation systems has had a significant influence on policymakers, particularly in the way that it has encouraged the replacement of traditional linear models of innovation with a "systems perspective" that acknowledged the interdependence of institutions, firms and agents in carrying out innovative activities. They also noted that even though technological

[133] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757.
[134] Id. at 758-760.
[135] R. Nelson, "National Innovation Systems: A Retrospective on a Study", Industrial & Corporate Change, 1(2) (1992), 347.
[136] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 758.

research activities have become more and more globalized studies have confirmed that innovation systems do differ across countries and that institutions do have a significant influence on the performance of these systems. However, Aten and Nardon observed that while researchers interested in the study of national innovation systems have routinely argued that such systems are significantly influenced by societal culture the reality is that the actual research work has generally failed to explicitly address the role of culture and when culture has been taken into account it "serves only as a background, homogenous and stable context".[137]

Tylecote et al. compared the role of financial systems and societal culture to technology styles in Japan and the UK by relying on two of the dimensions of societal culture from the Hofstede model—power distance and individualism/collectivism—to create a distinction between two cultural types—"bourgeois" and "aristocratized"—that was based on attitudes about social position.[138] Japan was presented as an example of a bourgeois country while the UK was identified as aristocratized. Tylecote et al. argued that production managers in bourgeois countries were more involved in the innovation process, accorded higher status, awarded higher pay and provided with more training than their counterparts in aristocratized countries. The position of production managers in aristocratized countries was determined in a hierarchical manner consistent with the widely held beliefs in societal culture and it was therefore not surprising to find that they had a much lower social position in their countries than their counterparts in the bourgeois countries. Tylecote et al. went on to assert that societal culture influenced a country's preferred "style of innovation" and that the style determined which industries were best suited for exploitation by firms in that country. For example, they argued that engineering and steel production was the best fit for Japan while the UK should devote its efforts to fine chemicals and pharmaceuticals.

Lee and Ungson studied certain factors associated with Korea's relatively rapid adoption of the Internet and its associated technologies.[139] They noted that two factors—the application of new technologies and an emerging pattern of individual consumption—could be applicable to any technological environment; however, a third factor, which they described as a supporting logic of enterprise that linked the first two factors, was in their view linked to unique Korean cultural values and institutions including rule orientation, high power distance, harmony and affection and monochromic time orientation. Further support for the role of societal culture in technology adoption is provided by the findings of Nardon and Aten that "the wide-spread adoption of ethanol in Brazil is . . . explained by a culture-influenced strategy of flexible adaptation to changing fuel needs".[140]

---

[137] Id. at 759.

[138] A. Tylecot, Y. Cho and W. Zhang, "National Technological Styles Explained in Terms of Stakeholding Patterns, Enfranchisement", Technology Analysis & Strategic Management, 10(4) (1998), 423.

[139] S. Lee and G. Ungson, "Towards a Theory of Synchronous Technological Assimilation: The Case of Korea's Internet Economy", Journal of World Business, 43(3) (2008), 274.

[140] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 759 (citing L. Nardon and K. Aten, "Beyond a Better Mousetrap: A Cultural Analysis of the Adoption of Ethanol in Brazil", Journal of World Business, 43(3) (2008), 261).

International technology transfer—the transfer of technologies across national borders and the absorption and use of those technologies once the transfer process has commenced—has become a focal point of globalization of business activities and thus has attracted the interest of researchers from a variety of disciplines who have looked at technology transfer at several different levels. For example, researchers have analyzed the economic and technological aspects of technology transfer at the national level including steps that governments have taken to regulate inbound technology transfers in the context of foreign investment activities. At the firm level, researchers have focused on a variety of factors that are considered likely to have an influence on how technology is transferred, received and used including organizational factors (e.g., goal alignment, local managerial involvement, communication, power and politics etc.) and social and cultural factors.[141]

Several researchers have compiled indices of societal culture that they have then used to predict the difficulties that might be expected in successfully transferring organizational practices or technologies across national borders. Interestingly, Jensen and Szulanski found that organizations engaged in transferring their organizational practices to an organization in another societal culture that attempted to adapt those practices to fit the societal culture of the receiving organization were less successful.[142] Another study of the influence of societal culture on the granting and receipt of technology transfer among national subsidiaries found that societal culture did not have a significant influence but that organizational culture was important to the success or failure of transfers.[143] In contrast to the results of these studies, however, are the findings of researchers who studied adoption of foreign technologies by Chinese industries and concluded that cultural affinity between the country where the technology originated and the country where adoption is being attempted (i.e., the degree of resemblance of the rules, customs and modes of communication in the two countries) was an important predictor of how well the foreign technology would be accepted.[144]

Adoption and use of information and communication technologies have arguably been the most popular topics for researchers interested in how societal culture influences issues related to technology management. In general, researchers have concluded that Aten and Nardon observed that "research has shown that national culture influences how technologists develop [information and communications technologies], the propensity of organizations and individuals to adopt specific technologies, and how individuals evaluate their use of information technology".[145] Studies in this area have typically relied

---

[141] K. Munir, "Being Different: How Normative and Cognitive Aspects of Institutional Environments Influence Technology Transfer", Human Relations, 55(12) (2002), 1403.

[142] R. Jensen and G. Szulanski, "Stickiness and the Adaptation of Organizational Practices in Cross-Border Knowledge Transfers", Journal of International Business, 35(6) (2004), 508.

[143] A. Cui, D. Griffith, S. Cavusgil and M. Dabic, "The Influence of Market and Cultural Environmental Factors on Technology Transfer Between Foreign MNCs and Local Subsidiaries: A Croatian Illustration", Journal of World Business, 41(2) (2006), 100.

[144] L. Phillips, R. Calantone and M. Lee, "International Technology Adoption: Behavior Structure, Demand Uncertainty and Culture", Journal of Business & Industrial Marketing, 9(2) (1994), 16.

[145] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 760 (citing, for a fuller review, D. Leidner

on two of the dimensions of societal culture found in the Hofstede model: uncertainty avoidance and power distance.[146] Among the findings are that low uncertainty avoidance cultures perceive software projects as less risky[147] and technology evaluations are more favorable in low power distance or low uncertainty avoidance cultures[148]. However, conflicting results were found with respect to the relationship of power distance to technology adoption and diffusion with one set of researchers finding that adoption is more likely in low power distance countries[149] while another group of researchers concluded that high power distance is better suited for effective technology adoption and diffusion[150]. A similar conflict occurs when the influence of uncertainty avoidance on adoption is tested: Leidner and Kayworth found that adoption and diffusion of new technologies is less likely in higher uncertainty avoidance cultures[151] while Galliers et al. came to the opposition conclusion that low uncertainty avoidance was positively correlated to low adoption and diffusion of new technologies[152]. The individualistic/collectivist dimension in the Hofstede model was also used by Tan et al., who determined that people from individualistic societies were more likely to report bad news associated with information technology projects.[153] Finally, researchers relying on the dimensions of societal culture suggested by Hall[154] have argued that polychromic cultures are less likely to be troubled by technology delays and that information overload due to technology is more likely to occur in high context cultures.[155]

---

and T. Kayworth, "Review: A Review of Culture in Information Systems Research: Toward A Theory of Information Technology Culture Conflict", MIS Quarterly, 30(2) (2006), 357).

[146] See generally A. Erumban and S. de Jong, "Cross-Country Differences in ICT Adoption: A Consequence of Culture?", Journal of World Business, 41 (2006), 302. For further discussion of the dimensions in the Hofstede model, see "Globalization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org).

[147] M. Keil, B. Tan, K. Wei, T. Saarinen, V. Tuunainen and A. Wassenaar, "A Cross-Cultural Study of Escalation of Commitment Behavior in Software Projects", MIS Quarterly, 24(2) (2000), 299.

[148] D. Leidner, S. Carlsson, J. Elam and M. Corrales, "Mexican and Swedish Managers' Perceptions of the Impact of EIS on Organizational Intelligence, Decision Making and Structure", Decision Sciences, 30(3) (1999), 633.

[149] H. Hasan and G. Ditsa, "The Impact of Culture on the Adoption of IT: An Interpretive Study", Journal of Global Information Management, 7(1) (1999), 5.

[150] G. DeVreed, N. Jones and R. Mgaya, "Exploring the Application and Acceptance of Group Support Systems in Africa", Journal of Management Information Systems, 15(3) (1998), 197.

[151] D. Leidner and T. Kayworth, "Review: A Review of Culture in Information Systems Research: Toward A Theory of Information Technology Culture Conflict", MIS Quarterly, 30(2) (2006), 357.

[152] R. Galliers, "Information Systems and Culture: Applying "Stages of Growth" Concepts to Development Administration", Information Technology for Development, 8(2) (1998), 89.

[153] B. Tan, J. Smil, M. Keil and R. Montealegre, "Reporting Bad News About Software Projects: Impact of Organizational Climate and Information Asymmetry in an Individualistic and Collectivist Culture", IEEE: Transactions on Engineering Management, 50(1) (2003), 64.

[154] E. Hall and M. Hall, Understanding Culture Differences: Germans, French and Americans (1990). For summary description of the dimensions suggested by Hall, see "Globalization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org).

[155] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 760-761 (citing K. Calhoun, J. Teng and M. Cheon, "Impact of National Culture on Information Technology Usage Behavior: An Exploratory Study of Decision Making in Korea and the USA", Behavior and Information Technology, 21(4) (2002), 293, and G. Rose, R. Evaristo and D. Straub, "Culture and Consumer Responses to Web Download Time: A Four-

While Aten and Nardon acknowledged that the evidence is strong that societal culture influences the management of technological change they also argued that important research questions remain unresolved.[156] For example, they pointed out that technology and innovation management scholars have conceived of technological change as occurring in a non-linear process and this means that societal culture likely influences technology in varying degrees and at different points in time.[157] If this is true, more research should be done on the factors that determine how and when culture influences the technological change process. For example, studies that have already been conducted have provided support for the possibility that certain sophisticated technologies develop and change relatively free of cultural influences and cultural differences have a larger impact in technology transfers when the technology importer is from a developing country.[158] Another interesting question is how national and organizational cultures, working simultaneously and in tandem, influence technology adoption and under what circumstances does the culture at one level take precedence over the culture at another level. Finally, research relating to technology transfer might be expanded to include more emphasis on how the use of technology by an importing organization influence the development and subsequent transfer of the technology throughout the broader society in which the importing organization is operating. Still another thing that needs to be considered is that societal culture is often measured at a single point in time, a practice which eases the research hurdles but ignores factors that have been recognized by scholars adopting a socio-cognitive approach to societal culture: culture is dynamic, multi-layered and non-deterministic. It is also recommended that due attention be given to the interactive influences of technology on culture and vice versa: in other words, how technological change influences societal culture.[159]

§58 --Cross-cultural perspectives on information management

Martinsons and Davison examined the influence of societal culture on information management by looking specifically at the role that culture plays in business process

---

Continent Study of Mono- and Polchronism", IEEE: Transactions on Engineering Management, 50(1) (2003), 31).

[156] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 760-766.

[157] According to Garud and Rappa: "While cursory observations . . . suggest a linear progression from the conceptions of an idea to its commercial application, a more probing examination exposes a complex web of interactions between those who develop the technology, the physical artifacts they create, and the institutional environments they foster." See R. Garud and M. Rappa, "A Sociocognitive Model of Technology Evolution: The Case of Cochlear Implants", Organization Science, 5(3) (1994), 344.

[158] See L. Phillips, R. Calantone and M. Lee, "International Technology Adoption: Behavior Structure, Demand Uncertainty and Culture", Journal of Business & Industrial Marketing, 9(2) (1994), 16 (sophisticated technologies); and B. Kedia and R. Bhagat, "Cultural Constraints on Transfer of Technology Across Nations: Implications for Research in International and Comparative Management", Academy of Management Review, 13(4) (1988), 559 (technology transfers into developing countries).

[159] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 765 (citing S. Barley, "Technology as an Occasion for Structuring: Evidence from Observations of CT Scanner and the Social Order of Radiology Departments", Administrative Science Quarterly, 31(1) (1986), 78 (discussing how introduction of CT technology influenced work group culture at two hospitals).

reengineering ("BPR"). The researchers chose BPR as the focus for their study because it represented a strategic change in the way that an organization manages its information and provided opportunities for organization to realize the potential benefits that information technology ("IT") can provide to organizational operations and performance.[160] The results of their study were based on data relating to BPR initiatives[161] undertaken by organizations in six different countries chosen to ensure a diverse mix of societal cultures: Brazil, China, France, Japan, Sweden and the US. In interpreting the data the researchers used five of the dimensions of societal culture identified by Hofstede and concluded generally that "each of the five dimensions or culture was found to affect the strategy used to manage information both during and after the business process change initiatives took place".[162] These findings caused them to advise that "the adoption of local, multidomestic, or glocal approaches to information strategy lead to more successful business outcomes than attempts to institutionalize a globally homogeneous strategy" and they also noted that there is no "ideal culture" for implementing BPR point out, for example, that while it is relatively easy for managers in a high power distance societal culture to mandate BPR in a directive fashion the implementation phase in that context will be muddled by the inability or unwillingness of employees to assume additional personal responsibilities.[163]

§59 ----Power distance

Martinsons and Davidson noted that the level of power distance ("PD") in the societal culture in which an organization operated had a significant influence on the involvement of employees in planning and decision making associated with BPR initiatives.[164] In high PD cultures, such as Brazil and China, final authorization and initiation of BPR projects clearly came from the top of the organizational hierarchy, although recommendations for various changes may have originally been proposed by senior managers in the IT function. Martinsons and Davidson noted that employees in Brazil rarely questions the

---

[160] M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 660.

[161] The researchers explained that they limited their study to "genuine" reengineering projects that ". . . (1) aimed to significantly improve one or more key measures of business performance; (2) focused on broad, cross-functional processes, such as employee development, product/service innovation and /or customer relationship management; (3) intended to take a fresh view or a complete review of these processes; and (4) used IT as the primary enabler". See M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 660.

[162] M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 660. For discussion of the dimensions in the Hofstede model, see "Globalization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org).

[163] M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 663.

[164] The discussion of the influence of power distance on information management is adapted from M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 660-661. The countries in their study were categorized as follows with respect to PD: Brazil (High); China (High); France (High); Japan (Moderate); Sweden (Low); and the US (Low). Id. at 655.

decisions made by their superiors and cited an outside consultant to a Chinese organization for the observation that projects proceed quickly, and with full employee support, in that country once approval comes down from the "big bosses". In general, BPR was easier to authorize and initiate in the more centralized organizational structures typically found in high PD societies. In contrast, line managers and employees in low PD countries such as Sweden and the US were highly involved in both the planning and redesign associated with BPR initiatives including collection and analysis of data and were also an integral part of the ultimate decision making processes on the scope and content of the initiatives. All of this tended to slow the pace of BPR projects in the low PD countries; however, the countervailing benefit was that a sense of involvement motivated employees to work harder for quick and smooth implementation.

PD also played a role in the degree to which employees were ready and willing to embrace some of the changes associated with BPR initiatives. The researchers observed that employees in Brazil and China were not as interested in efforts to empower them or in taking on new responsibilities that also carried additional risks. Martinsons and Davidson observed that employees in high PD countries often engaged in "passive resistance" to changes implemented as part of a BPR initiative such as failing to stop a faulty re-engineered assembly line process. It was also noted that employees in high PD countries were less interested in, and even anxious about, sweeping formal changes in organizational information systems given that they were used to operating in a centralized hierarchical structure that required much less in terms of formality and distribution/sharing of information. The situation was decidedly different in the low PD countries, such as Sweden and the US, where employees had a generally positive attitude regarding reengineering and were much more adaptable to IT applications that were designed to enhance information access given that they were used to working in strong information-sharing cultures.

A final area in which PD played a significant role was in how employees accepted and adopted the new information systems ("IS") that are a typical part of BPR initiatives. Martinsons and Davidson found that organizations in higher PD societies, such as China and France, were less likely to tap into some of the purported benefits of the tools made available to them in their new IS. For example, they observed: "Firms operating in high PD cultures were less likely to develop and make use of formal IS plans or process models. Information systems in these contexts were used primarily for vertical communications to reinforce the hierarchical control of business activities." Martinsons and Davidson also noted that IS was seen by firms in high PD societies more as a tool to "monitor" operations in a growing business rather than to share information, a finding they believed to be consistent with what they referred to as an "autocratic information management strategy". In contrast, firms in low PD societies, already used to extensive sharing and wide dissemination of key information, used updated IS as a means for greater employee empowerment and improving informed decision making "close to the customer". In addition, employees in Sweden and the US were quick to adopt and implement e-mail and instant messaging applications for peer-to-peer communications that led to improvements in the efficiency of peer-to-peer activities and teamwork.

§60 ----Uncertainty avoidance

Martinsons and Davidson noted that organizations in societies where the level of uncertainty avoidance ("UA") was high often turned to IT as a means for reducing uncertainty through the implementation of forecasting and planning processes and that the level of UA also influenced the amount of planning involved in BPR initiatives.[165] They reported that managers in Brazil, France and Japan, all high UA countries, implemented extensive and detailed planning processes for their BPR projects in an apparent attempt to reduce project risks. In contrast, organizations operating in lower UA countries appeared to take a more flexible approach to their BPR initiatives and Martinsons and Davidson found that such organizations used project teams with comparatively looser structures and were less concerned with standardizing there IS across the entire organization and preferred to maintain a higher degree of flexibility with respect to management of information. Another interesting finding was that managers in several of the countries, such as China, appeared to resist enterprise resource planning ("ERP") systems on the grounds that they would impose and enforce business methods that were inconsistent with traditional practices in those countries; however, this issue was not seen in countries such as the US where organizations perceived implementation of ERP as consistent with scientific management ideology. The researchers offered the following summary conclusions regarding the influence of uncertainty avoidance on information management: "Our findings suggest that a systematic approach to information management will be accepted more easily in cultures where uncertainty avoidance and scientific management are high valued. Organizations that operate in cultures that are more comfortable with uncertainty would be less likely to invest in a detailed information management 'strategy'. They would also be less inclined to implement IS that specifically aim to reduce the level of uncertainty that would be faced by decision makers."[166]

§61 ----Masculinity/femininity

Martinsons and Davidson suggested that many elements of BPR, including rhetoric based on military metaphors such as "blow up the old" and "shoot the stragglers", were consistent with a highly masculine ("MAS") societal culture and that implementation of BPR often conflicted with ideas that were highly valued in countries that scored low on the masculinity measure such as cooperation and secure employment.[167] Not surprisingly, while the researchers observed some form of resistance to BPR in all of the

[165] The discussion of the influence of uncertainty avoidance on information management is adapted from M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 661-662. The countries in their study were categorized as follows with respect to UA: Brazil (High); China (Fairly Low); France (High); Japan (Very High); Sweden (Low); and the US (Moderate). Id. at 655.

[166] Id.

[167] The discussion of the influence of masculinity/femininity on information management is adapted from M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 661-662. The countries in their study were categorized as follows with respect to masculinity: Brazil (Moderate); China (High); France (Fairly Low); Japan (High); Sweden (Very Low); and the US (Fairly High). Id. at 655.

countries that they studied the levels of resistance in high-MAS countries such as China, Japan and the US was characterized as "manageable" while resistance was greatest and most problematic in the low-MAS countries (i.e., France and Sweden). The level of masculinity played a role in the strategies that firms used to overcome employee resistance to the changes implicit in BPR initiatives. In China, a high-MAS country, financial incentives (i.e., bonuses tied to objective measures of improvements in performance) were used; however, firms in low-MAS countries such as France and Sweden opted for altering the pace of implementation so that organizational changes were introduced more gradually. All in all, Martinsons and Davidson recommended that military metaphors and financial incentives would likely be helpful in building the sense of commitment and cooperation needed implementing BPR initiatives in high-MAS countries but that these approaches should be replaced by compassion and cooperation in low-MAS countries.

§62 ----Time orientation

According to Martinsons and Davidson the dimension of societal culture referred to as "time orientation" influences both the attractiveness of BPR philosophy and the preferred manner for implementing BPR initiatives, particularly the pace at which changes are introduced and integrated into operational activities.[168] Not surprisingly, the researchers found that the sometimes radical changes associated with BPR initiatives were perceived as attractive by US managers operating under short-term time pressures to achieve and announce performance accomplishments (i.e., a short-term oriented cultural context) but that managers in countries such as China and Japan with a long-term time orientation preferred to avoid what they referred to as "quick fixes that may be disruptive" and pursue a course of smooth and steady progress and gradual building of new internal capabilities (rather than bringing in outside consultants to push change). Martinsons and Davidson noted that while firms from long-term oriented societies may have sacrificed short-term improvements by moving slowly and carefully with BPR they also benefitted from avoiding the costs and disruptions of "trial and error" by taking a more strategic and planned approach to BPR. In addition, firms from long-term oriented societies were more likely to conduct periodic reviews of the progress of their BPR initiatives to determine what was working and what was not and make interim changes to the initiatives to improve performance.

§63 ----Individualism/collectivism

Interestingly, the presence of high individualism in the societal culture, such as the cases of France and the US, often had a disruptive influence on implementation of BPR initiatives because it undermined the authority of managers in firms in those cultures to take the directive actions necessary to launch the changes thought to be necessary for

---

[168] The discussion of the influence of time orientation on information management is adapted from M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 662. The countries in their study were categorized as follows with respect to time orientation: Brazil (Moderate); China (Fairly Long); France (Moderate); Japan (Long); Sweden (Short); and the US (Short). Id. at 655.

BPR to be successfully implemented.[169] Managers in high individualism cultures complained that those under their supervision wanted to retain the right to manage information "in their own way" and that this made it difficult to introduce and establish information management systems intended to promote consistency and uniformity across the entire organization. In contrast, BPR initiatives in high collectivist countries such as Brazil, China and Japan were driven by cohesive leadership teams and real efforts to seek and obtain a consensus on actions before they were implemented. The process teams needed BPR to be successful understandably flourished in high collectivist countries, although there were variations among countries about the role of team leaders with options ranging from "facilitator" to "benign autocrat". In turn, firms from high individualism cultures such as France and the US needed to use a mix of team incentives and individual performance-based rewards in order to form and maintain product BPR teams. Finally, differences related to individualism versus collectivism were observed with respect to how well certain types of IS tools were accepted. For example, group communications tools were welcomed and readily adopted by firms in high collectivist countries while persons from high individualist cultures preferred new applications based on personal computers.

§64 --Transfer of technology and innovation processes across borders

Cuoto and Vieira noted that the emergence of a global knowledge-based economy had led multinational corporations ("MNCs") to consider significant changes to their R&D strategies including an increase in the transfer of the innovation processes from headquarters to foreign subsidiaries (i.e., "decentralizing R&D") in order to facilitate adaptation of technology and technology-based products to local needs and tap into the growing body of local technology available in the countries in which foreign subsidiaries had been established and operating.[170] The importance of R&D activities within foreign subsidiaries to a firm depends on a variety of factors including the drivers for the internationalization process; the geographic orientation of the firm on R&D activities; and the strategic role of the subsidiary.[171] The scope of R&D activities at the subsidiary

[169] The discussion of the influence of individualism/collectivism on information management is adapted from M. Martinsons and R. Davison, "Globalization and Information Management Strategy: Cross-Cultural Perspectives", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 653, 662-663. The countries in their study were categorized as follows with respect to individualism: Brazil (Low); China (Low); France (High); Japan (Fairly Low); Sweden (High); and the US (Very High). Id. at 655.

[170] J. Couto and J. Vieira, "National Culture and Research and Development Activities", Multinational Business Review, 12(1) (2004), 19. For further discussion of the processes and benefits of decentralized R&D, see J. Birkinshaw, Entrepreneurship in the Global Firm (2000); U. Holm and T. Pedersen (Eds.), The Emergence and Impact of MNC Centers of Excellence: A Subsidiary Perspective (2000); G. Jones and H. Davis, "Implications of National Culture on the Location of Global R&D", Management International Review, 40(1) (2000), 11; R. Pearce, Global Competition and Technology Basingstoke (1997); J. Birkinshaw and N. Hood, "Multinational Subsidiary Evolution: Capability and Charter Change in Foreign-Owned Subsidiary Companies", The Academy of Management Review, 23(4) (1998), 773; J. Birkinshaw and N. Hood (Eds.) Multinational Corporate Evolution and Subsidiary Development (1998), 268; and J. Birkinshaw and N. Hood, "An Empirical Study of Development Processes in Foreign-Owned Subsidiaries in Canada and Scotland", Management International Review, 37 (1998), 339.

[171] M. Casson and S. Singh, "Corporate Research and Development Strategies: The Influence of Firm Industry, and Country Factors on the Decentralization of R&D", Research & Development Management, 23(6) (1993), 91; A. De Meyer, Internationalizing R&D Improves a Firm's Technical Learning, Research

level varies from simply being a receiver of technology from other locations on the multinational network, to an adaptive role to local needs, or an autonomous activity.[172] In fact, Hedlund suggested the following typology of subsidiaries: “local creator”, “global creator”, “local explorer” and “global explorer”.[173] In addition to the factors mentioned above, Cuoto and Vieira argued that it was important to consider the effects of national culture on the process of innovation and on the establishment of R&D activities in the subsidiaries of MNCs and set about doing that by collecting and reviewing information from a sample of 222 subsidiaries of industrial MNCs in five European countries (the UK, Sweden, Germany, France and Portugal, representing different groups of European nations: Anglo-Saxon, Nordic, Germanic, Central Europe and Southern Europe).

Couto and Viera relied on the dimensions of societal culture created and popularized by Hofstede and reported that among the firms in their survey the higher the uncertainty avoidance and individualism and the lower the power distance and masculinity in the societal culture in which a subsidiary was operating the higher levels of R&D activities that were performed by that subsidiary. They noted that this finding was not completely surprising in light of how prior researchers had identified linkages between Hofstede’s dimensions and invention and innovation[174] and new product development.[175] For example, these studies suggested that low power distance and uncertainty avoidance and high masculinity and individualism can foster higher innovation and Hofstede himself had predicted that lower power distance societies and lower uncertainty avoidance would have positive influence on innovation. Jones and Davis had counseled that differentiation from locally oriented support and adaptation to a globally oriented R&D would mean a

& Development (1993), 42; A. De Meyer, “Management of International R&D Operations”, in Grandstrand, Ove et al. (Eds.), Technology Management and International Business (1992), 163; J. Dunning and R. Narula, “The R&D Activities of Foreign Firms in the United States”, International Studies of Management and Organization, 25(1) (1995), 39; J. Cantwell, “The Internationalization of Technology Activity and its Implications for Competitiveness”, in Grandstrand, Ove et al.. (Eds.), Technology Management and International Business (1992), 75.

[172] L. Davis, “Multinational Research Subsidiaries”, in Denmark in Holm, Ulf, Pedersen (Eds.), The Emergence and Impact of MNC Centers of Excellence: A Subsidiary Perspective (1997); J. Taggart, “R & D Complexity in UK Subsidiaries of Manufacturing Multinational Corporations”, Technovation, 17(2) (1997), 73.

[173] G. Hedlund and D. Rolander, “Actions in Heterarchies: New Approach to Managing the MNE”, in C. Bartlett, Y. Doz and G. Hedlund (Eds.), Managing the Global Firm (1990). According to Hedlund “local creators” included the start-up companies of Silicon Valley in the US; “local explorers” would be firms in the building and construction industries; “global creators” would be the transnational companies and “global explorers” would be global hotel and restaurant chains and global franchising operations.

[174] S. Shane, “Cultural Influences on National Rates of Innovation”, Journal of Business Venturing, 8 (1993), 59; S. Shane, “Why Do Some Societies Invent More Than Others?”, Journal of Business Venturing, 7 (1992), 29.

[175] C. Nakata and K. Sivakumar, “National Culture and New Product Development: An Integrative Review”, Journal of Marketing, 60 (1996), 61; and M. Morris, D. Davis and J. Allen, “Fostering Corporate Entrepreneurship: Cross-Cultural Comparisons of the Importance of Individualism and Collectivism”, Journal of International Business Studies (1994), 65.

change from high power distance, uncertainty avoidance and masculinity to a lower level of these indicators.[176]

Couto and Viera also confirmed their hypothesis that the type of management model that was typically associated with the country where the parent was located could influence the manner in which R&D activities of its foreign subsidiaries were organized and conducted. They began by adopting the assumption that is was reasonable to classify survey participants into one of three "models": European, American and/or Japanese.[177] They then found empirical evidence to support the idea that Japanese MNCs were more likely to centralize their R&D activities than MNCs with headquarters in Europe or the US and commented that these findings were consistent with those of other researchers who had reported that a globally oriented R&D would be associated with a low power distance, uncertainty avoidance and masculinity and higher individualism[178] and that the preferred organizational model for Japanese global companies was a "centralized hub" due to historical heritage that included a reluctant to grant local subsidiaries the freedom to create new products and define their own strategies.[179]

§65 Technology management in developing countries

While natural resources, infrastructure, capital and labor were traditionally the most important economic factors for countries and companies, it is now clear that technology also plays an essential role in the success of a national economy or a corporate business plan. Goods and services may be technology-based, which means that their success will depend on the value of the goods and services to purchasers and their ability to understand and use the items in their daily activities. Even in those cases where a business is not developing and distributing technology-based goods and services, the company is likely to be reliant on technology to increase the efficiency of its own internal manufacturing, marketing and operations functions.

Technology and technology-related tasks and activities are among the most cited and important factors for achieving progress in industrializing developing countries and there is consensus that developing countries must act to build industrial skills and technical mastery, support research and development ("R&D") and create their own engineering centers. The challenge, of course, is that acquiring and mastering technology is not something which can easily be learned with assistance from those that have experience.

---

176 G. Jones and H. Davis, "Implications of National Culture on the Location of Global R&D", Management International Review, 40(1) (2000), 11.

177 For discussion of the characteristics of each of these models see R. Calori and P. De Woot, A European Management Model - Beyond Diversity (1994); M. Orru, G. Hamilton and M. Suzuki, "Patterns of Inter-Firm Control in Japanese Business", Organization Studies, 10 (1989), 549; R. Whitley, European Business Systems – Firm and Markets in their National Contexts (1992); and G. Yip, J. Johansson and J. Roos, "Effects of Nationality on Global Strategy", Management International Review, 37(4) (1997), 365.

178 G. Jones and H. Davis, "Implications of National Culture on the Location of Global R&D", Management International Review, 40(1) (2000), 11. See also S. Shane, Cultural Influences on National Rates of Innovation, 8 Journal of Business Venturing (1993), 59; and C. Nakata and K. Sivakumar, "National Culture and New Product Development: An Integrative Review", Journal of Marketing, 60 (1996), 61.

179 C. Bartlett and S. Ghoshal, Managing Across Borders: The Transnational Solution (1989).

This is particularly true with respect to the conceptual skills needed to use technology for mass production of goods, which requires application of knowledge and information to design, production, and maintenance.[180]

In order for developing countries, and companies operating from those countries, to move forward with becoming more fully integrated with the global economy it is necessary to introduce, at an appropriate pace, principles of "technology management". This is by no means an easy task since it involves national policies and investments as well as firm-level decisions and strategies, all of which should be created and implemented with the goal of developing technological capabilities to shape and accomplish the strategic and operational goals of the country and its entrepreneurs. Technology management involves acquisition of basic knowledge, or science, and transforming that knowledge into products that have practical and commercial utility in the marketplace and/or otherwise improve the lives of the country's citizens. This process is also often referred to as "innovation" and has been the subject of analysis and commentary by a wide range of academics and business consultants, particularly as to those industries that are grounded in continuous advances in scientific knowledge. Technology management also includes the steps that need to be taken to protect technology that has been developed including the creation of a system of intellectual property rights and enforcement of such rights.[181]

As a country develops, it is common to see a fairly modern and technology-advanced sector emerge next to the traditional labor-intensive and low technology manufacturing sectors; however, progress is often slow and lacking in continuity and depends on a variety of factors including economic resources and governmental policies relating to technology-related issues such as education, training and inbound technology transfers. The umbrella of "economic factors" will vary and change as countries develop and, of course, there will be individual exceptions that may arise due to unique factors (e.g., natural resources will remain a dominant economic factor for oil-producing countries regardless of the overall stage of economic development). In general, however, development tends to decrease the importance of natural resources to an economy, expand the pool of skilled human resources, increase the amount of income available for domestic consumption and investment, strengthen the country's physical infrastructure and internal flow of information and bolster the country's technology levels.

One economic strategy that has frequently been used by developing countries, "import substitution," has often had an unexpectedly adverse impact on the acquisition and development of local technological skills and assets. For example, many of the factories and plants used for import substitution have been "turn-key," meaning that little or no understanding of the actual operations of machinery and other technical inputs was imparted into the local knowledge base. In addition, no attempt was made to link the facilities to the existing indigenous technology, eventually resulting in higher

---

[180] E. Tiagha, "Technology Management and Technology Transfer in Africa", in J. Waiguchu, E. Tiagha and M. Mwaura, Management of Organizations in Africa: A Handbook and Reference (1999), 246, 248.

[181] For further discussion of the reasons that persons and organizations should be concerned about technology management see M. White and G. Bruton, The Management of Technology and Innovation: A Strategic Approach (2007), 18.

maintenance costs and expense of spare parts. Finally, since most of the factories and plants were government-controlled, there was little opportunity to nurture local entrepreneurs who could truly take the lead in developing economic self-sufficiency over the long term.[182]

Technological mastery is achieved only when a country is able to consistently design its own new products and processes and introduce new technologies. Unfortunately developing countries typically lack the human resources and innovative infrastructure needed to achieve these objectives on their own. For example, when "high level" technology is imported, developing countries must also rely on expensive personnel from the provider in order to use the transferred technology. This not only raises the costs associated with the technology, it also builds an ongoing system of dependence. Efforts to develop new technologies through domestic research centers and local universities are problematic for developing countries given the lack of financial resources and the dearth of experience in conducting and managing research and development projects.[183]

Due to their lack of domestic resources to support home-grown R&D developing countries often rely on one or more inbound technology transfer strategies including licensing arrangements that might cover process and product know-how, patent rights, trademarks, technical services and managerial expertise, and access to raw materials; purchase or long-term lease of technology-based equipment; purchase or license of know-how in the form of detailed specifications; acquisition of know-how through recruitment of skilled human resources; build-operate-transfer arrangements; and strategic alliances.[184] Unfortunately, the efforts of developing countries with respect to technology transfer and exploitation are often significant hampered by shortcomings in the local infrastructure. For example, a survey taken in the early 1990s revealed that there was little or no access to telephone lines in many parts of Africa at that time, Africa had no local capacity for the manufacture of telecommunications equipment and remained almost totally dependent on equipment that was designed and manufactured outside of the continent without any technology transfer.[185] An interesting recent development is R&D internationalization by companies in developing countries that are beginning to proactively reach out for available technologies abroad through the establishment of R&D facilities in foreign countries.

---

[182] E. Tiagha, "Technology Management and Technology Transfer in Africa", in J. Waiguchu, E. Tiagha and M. Mwaura, Management of Organizations in Africa: A Handbook and Reference (1999), 246.
[183] Id. at 248-249.
[184] Id. at 251-252.
[185] Id. at 255. For further discussion of international technology transfer and the factors influencing the absorption and use of technologies once a cross-border transfer process has commenced see "Globalization: A Library of Resources for Sustainable Entrepreneurs" prepared and distributed by the Sustainable Entrepreneurship Project (www.seproject.org). See also K. Munir, "Being Different: How Normative and Cognitive Aspects of Institutional Environments Influence Technology Transfer", Human Relations, 55(12) (2002), 1403 (noting that a variety of factors are likely to have an influence on how technology is transferred, received and used including organizational factors (e.g., goal alignment, local managerial involvement, communication, power and politics etc.) and social and cultural factors.

As is the case with studies of product development in developing countries, research regarding technology management in those countries is relatively scarce in relation to the tremendous interest in the topic among researchers and consultants in the US and other developed countries; however, it is apparent that policymakers in the selected developing countries are keenly aware of the importance of science and technology for socio-economic development and global competitiveness of the firms. While developing countries have been active in new technologies performance has been relatively poor and serious questions remain as to which technologies should be adopted by developing countries and how their development and use should be managed. Technology management in developing countries is arguably distinguishable from the situation in industrial countries given that developing countries have large and pressing needs in basic areas and sectors including telecommunications, sanitation and healthcare which can and should be addressed through thoughtful use of technology. Technology management in developing countries is no different than in advanced economies in that it also requires communication and cooperation among public and private organizations.[186]

§66 --Factors impacting the diffusion and adoption of new technologies

An array of empirical evidence has been collected and used to develop various theories regarding the diffusion and adoption of new technologies or innovations.[187] For example, politics and governmental policies, particularly the political structure that is in place a particular country, appear to play an important role in the diffusion of modern communications technologies in that country. Consider, for example, how authoritarian governments in countries such as China, Cuba and Syria have often appeared to be creating barriers to free and open used of communications technologies such as the Internet. Other research disciplines have added their own perspectives on diffusion and adoption of new technologies: differences in societal culture explain why particular technologies are more comparable with certain societies than others[188]; understanding of, and experience with, elements of information systems (i.e., people, hardware, software, communications networks and data resources) influence the rate of diffusion and adoption[189]; and diffusion and adoption is heavily dependent on economic, geographic and geopolitical factors, particularly income levels and characteristics of populations (i.e., skills, educational qualifications, literacy rates, productivity and the cost of labor) [190]. With respect to developing countries it is important to note that international

[186] For further discussion, see H. Sun, Management of Technological Innovation in Developing and Developed Countries (2012).
[187] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595-596.
[188] N. Kshetri and N. Dholakia, "Determinants of the Global Diffusion of B2B E-Commerce", Electronic Markets, 12(2) (2002), 120, and S. Zaheer and A. Zaheer, "Country Effects on Information Seeking in Global Electronic Networks", Journal of International Business Studies, 28(1) (1997), 77.
[189] J. O'Brien, Introduction to Information Systems (8th Ed.) (1996).
[190] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in, H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 595 (citing S. As-Saber, P. Liesch and P. Dowling, Geopolitics and Its Impacts on International Business Decisions: A Framework for a Geopolitical Paradigm of International Business (2000); S. Cohen, Geography and Politics in a World Divided (1963); and T. Baerwald, "Geographical Perspectives on International Business", in M. Czinkota, I. Ronkainen and M. Moffett (Eds.), International Business (4th Ed.) (1996)).

institutions—the United Nations, the World Bank and the World Trade Organization—have attempted to promote and facilitate accelerated diffusion of the Internet around the world.[191] However, the design and development of an information system for any country is complicated by an array of cultural, technical, physical, structural and legal differences.[192]

§67 --Societal culture and management of technological change

Researchers have been interested in the role of national culture in the management of technological change and many have argued that individuals and technologies are embedded in a social context that is heavily influenced by national culture and ideology and that societal culture determines the beliefs, practices and perceptions that individuals from that society bring to their decisions regarding the creation, adoption and use of new technologies. Potential differences between countries with respect to technological change attributable to variations in societal cultures have been explored by several research themes including work on national innovation systems, the influence of societal culture on cross-border technology transfers and differences among countries with respect to adoption and use of information and communications technologies.[193] The results have been interesting including, for example, the findings of Lee and Ungson that Korea's relatively rapid adoption of the Internet and its associated technologies could, in part, by linked to unique Korean cultural values and institutions including rule orientation, high power distance, harmony and affection and monochromic time orientation.[194] Further support for the role of societal culture in technology adoption is provided by the findings of Nardon and Aten that "the wide-spread adoption of ethanol in Brazil is . . . explained by a culture-influenced strategy of flexible adaptation to changing fuel needs".[195]

§68 --Barriers to invention

Much of the discussion regarding innovation and technology management in developing countries inevitably focuses on the challenges that those countries and their companies

---

[191] N. Kshetri, N. Dholakia and R. Dholakia, "Global Diffusion of the Internet", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 585, 597. See also see also N. Kshetri, "Determinants of the Locus of Global E-Commerce", Electronic Markets, 11(4) (2001), 250; N. Kshetri and N. Dholakia, "World Trade Point Federation: Bringing E-Commerce Capabilities to Developing Nations", International Journal of Cases in Electronic Commerce, 1(1) (2005), 39; and B. Shadrach, "India's Development Information Network: Lessons Learned", Bulletin of the American Society for Information Science, 28(2) (2002), 23.

[192] R. Collins, "Global Information Systems", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 665.

[193] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 758-760.

[194] S. Lee and G. Ungson, "Towards a Theory of Synchronous Technological Assimilation: The Case of Korea's Internet Economy", Journal of World Business, 43(3) (2008), 274.

[195] K. Aten and L. Nardon, "International Technology Management and National Culture", in H. Bidgoli (Ed.), The Handbook of Technology Management (2010), 757, 759 (citing L. Nardon and K. Aten, "Beyond a Better Mousetrap: A Cultural Analysis of the Adoption of Ethanol in Brazil", Journal of World Business, 43(3) (2008), 261).

face in becoming and remaining competitive in an increasingly technology-driven global economy. Among the barriers to invention identified in a 2013 global survey conducted in both mature and emerging markets were a poor educational system, lack of resources, lack of governmental protection of inventors' rights, a weak economy, a fast pace of life that stifles creativity, a lack of incentives for invention and political instability.[196] The same survey found that among respondents from emerging countries the attributes of prospective inventors that were perceived to be most important included imagination, curiosity, persistence, scientific reasoning skills and self-belief.[197] Each of these attributes was similar recognized among respondents from mature countries; however, there were notable differences between mature and emerging countries with respect to the perceived importance of several attributes: respondents in mature countries attached more significant to both persistence and good problem solving skills than respondents in emerging countries while scientific reasoning skills were believed to be much more important in emerging countries than in mature countries. While a poor education system was seen as a barrier to invention, respondents from both mature and emerging markets did not necessarily believe that education was absolutely necessary for innovation to flourish but did agree that the educational methods used should tilt toward encouraging creative thinking as opposed to mastering and memorizing large amounts of material for regurgitation on exams. Another interesting theory from the survey was that innovation in both mature and emerging countries would flourish in the rapidly growing cities in those countries since the close proximity of people in urban areas encourages communication and sharing of ideas.[198]

§69 --Improving innovation and technology management in developing countries

Ali et al. noted that while innovation has historically been the province of industrialized nations such as the US, Japan and countries in Europe it has become an increasingly important topic in developing countries like China and India but they also pointed out that the innovation and technology environments in developing countries "are by nature, problematic, characterized by poor business models, political instability and governance conditions, low education level and lack of world-class research universities, an underdeveloped and mediocre physical infrastructure, and lack of solid technology based on trained human resources".[199] The first thing that developing countries interested in improving their innovation systems need to do is select appropriate measures for creating and assessing their technology development strategies. This generally requires looking at several different complimentary indicators of inputs to technological development (e.g., research and development ("R&D") and education) and outcomes of technological efforts

[196] J. Kluger, "TIME Invention Poll: The Spark of Invention", TIME (November 25, 2013), 84, 88. Respondents came from 17 countries—seven mature markets (including the US, Germany, Korea and Singapore) and ten emerging markets (including China, India, Kenya Mexico, Russia and the United Arab Emirates)—and included middle-income adults, well-educated and high-income "broad elites" and "business decision-makers" with responsibility for managing at least one department in a large firm with more than $10 million in global sales. Id. at 86.

[197] Id. at 87.

[198] Id. at 90-91. Kluger noted that many metropolitan areas around the world are investing in "innovation zones" and commented: "Proximity and competition seem to bring out the clever in us." Id. at 91.

[199] M. Ali, S. Ullah and P. Khan, Managing Innovation and Technology in Developing Countries (2007).

and activities such as productivity and the range of manufactured exports.[200] The next step is to select and implement appropriate solutions for overcoming the challenges that have historically faced with respect to the innovation process and technology management including the following ideas suggested by Ali et al.[201]:

- Companies in developing countries have failed to understand and embrace the concept of innovation manager or technology manager and the lack of availability of technology executives and managers has often caused companies to fail in their efforts to develop a technological infrastructure and processes for identifying, acquiring and assimilating imported technology. These shortcomings need to be addressed through professional education and new attitude regarding organizational structure.
- Educational levels in the developing countries are often quite low and this necessarily inhibits the ability of companies to efficiently deploy technical tools and equipment. Developing countries must move beyond basic literacy, which sufficed in the pre-industrial phase of development, and invest resources in developing more technical and professional skills sufficient for coping with the post-industrial phase of development.
- Innovation requires a well-developed economic and social infrastructure and the generally poor conditions of infrastructure in the developing countries must be remedied by investments in the telecommunication infrastructure (i.e., telephone, mobile, Internet, broadband, digital subscribers links DSL, wireless and VOIP technology), physical and economic infrastructure (i.e., roads, highways, trains, intercity trains, buses, airports and water and power supply) and social infrastructure (i.e., schools, housing and healthcare facilities).
- Basic education and schools have already been mentioned; however, particular attention should be paid to higher education institutions that are responsible for training scientists, engineers and entrepreneurs interested in launching technology-based ventures. Colleges and universities in developing countries should be able to perform basic research and collaborate on appropriate applied research initiatives with business and industry.
- Various initiatives should be launched to improve the innovation systems of developing countries including increased public and private investment in R&D, improvements in intellectual property rights accompanied by wider dissemination of research results through publications and strategic alliances and promulgation of national innovation policies that include support for grass roots innovation and exploitation of indigenous knowledge.

Other ideas were provided by Tiagha who argued that an effective strategy for developing the technology portfolio and self-sufficiency of developing countries should include several elements such as identification of indigenous technologies that can be developed at local levels, particularly unfinished prototypes in research laboratories and

[200] H. Hill and Thee Kian Wie, (Eds), Indonesia's Technological Challenge (1998), 13; Y. Okamoto and F. Sjoholm, Technology Development in Indonesia (May 2001); S. Lall, "Technology Policies in Indonesia", in H. Hill and Thee Kian Wie (Eds.), Indonesia's Technological Challenge (1998), 138.
[201] M. Ali, S. Ullah and P. Khan, Managing Innovation and Technology in Developing Countries (2007).

universities; creation of national science and technology initiatives to support and coordinate acquisition of foreign technologies and development of local applications; selective acquisition of advanced technologies from foreign partners; detailed surveys of local consumers to identify their product needs in order to determine the specific technology requirements for local producers; and development of a strong technology-based human resources base, including scientists and managers able to effectively manage technology products.[202]

§70 --Internationalization of research and development in developing countries

Zedtwitz observed that most of the research relating to international R&D strategies and activities has focused on R&D conducted in and by advanced developed countries and suggested several reasons for this including that those countries were responsible for the bulk of R&D conducted on a global basis, their protagonists were more easily accessible and forthcoming and R&D in non-developed countries was relatively insignificant.[203] Zedtwitz pointed to another study that he had done with a colleague that uncovered evidence that European and American firms conducted a significant amount of their R&D activities abroad and he also noted that "R&D has always been considered a domain of firms in technologically advanced and economically developed countries", the ten largest countries in terms of GDP also were the global leaders with respect to technical intensity (except for China and Brazil) and patent applications in the most important markets have been led in number by the largest MNCs headquartered the in advanced countries.[204]

According to Zedtwitz most of the initial research relating to R&D strategies and activities of developing countries concentrated on inbound technology transfer and the capacity of those countries to understand and absorb advanced technologies from

[202] E. Tiagha, "Technology Management and Technology Transfer in Africa", in J. Waiguchu, E. Tiagha and M. Mwaura, Management of Organizations in Africa: A Handbook and Reference (1999), 258-260.

[203] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 2. Zedtwitz noted that "[o]nly a handful of countries outside the advanced economies receive some research attention, among them are Singapore, South Korea, India, and, most recently, China". Id. Informational resources on the topic include J. Couto and J. Vieira, "National Culture and Research and Development Activities", Multinational Business Review, 12(1) (2004), 19; J. Birkinshaw, Entrepreneurship in the Global Firm (2000); U. Holm and T. Pedersen (Eds.), The Emergence and Impact of MNC Centers of Excellence: A Subsidiary Perspective (2000); G. Jones and H. Davis, "Implications of National Culture on the Location of Global R&D", Management International Review, 40(1) (2000), 11; R. Pearce, Global Competition and Technology Basingstoke (1997); J. Birkinshaw and N. Hood, "Multinational Subsidiary Evolution: Capability and Charter Change in Foreign-Owned Subsidiary Companies", The Academy of Management Review, 23(4) (1998), 773; J. Birkinshaw and N. Hood (Eds.) Multinational Corporate Evolution and Subsidiary Development (1998), 268; and J. Birkinshaw and N. Hood, "An Empirical Study of Development Processes in Foreign-Owned Subsidiaries in Canada and Scotland", Management International Review, 37 (1998), 339.

[204] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 2-3 (also citing M. von Zedtwitz and O. Gassmann, "Market versus Technology Drive in R&D Internationalization: Four Different Patterns of Managing Research and Development", Research Policy, 31(4) (2002), 569; and O. Gassmann and M. von Zedtwitz, "New Concepts and Trends in International R&D Organization", Research Policy, 28 (1999), 231).

abroad.[205] As noted above, this situation was understandable given that governments and firms in developing countries devoted relatively little of their scarce resources to R&D. Zedtwitz pointed out that while developing countries had gradually been increasing their investment in science and technology ("S&T") as of the early 2000s their investments ratios of S&T to GDP were still far behind advanced countries.[206] He also reminded that the leading MNCs from developing countries were not involved in activities that technologically-intensive—real estate, oil and exploration and mining and materials—and that the lack of large local market demand for sophisticated and pricey technology goods reduced incentives for private firms in developing countries to focus more of their efforts on R&D.

Zedtwitz estimated that as of the early 2000s the total annual investment in overseas R&D by the leading firms from developing countries, in the aggregate, was quite small in relative terms—roughly equivalent to the R&D budget of a single reasonably-sized technology-intensive MNC.[207] He noted, however, that international R&D by companies from developing countries was becoming increasingly important with the emergence of what Zedtwitz described as "a new class of high-tech companies from developing countries, most notably India and China . . . [that] . . . compete in highly technology-intensive industries, in which customers demand great rates of innovation, and in which timely application of technical know-how is paramount".[208] This was not the first time something like this had happened—recall the rise and dominance of Japanese and Korean firms in the 1970s and 1980s—but Zedtwitz explained that things were different for these new developing country MNCs in that they came from larger home markets that needed to be defended against international competition and had to operate in an environment that featured more accelerated technology change and higher mobility of know-how and labor than in the 1970s.

Zedtwitz provided context for understanding the R&D strategies and activities of firms in developing countries by suggesting a model that included four types of R&D internationalization.[209] The first type, which Zedtwitz noted was the most prevalent form of international R&D, involved cross-border R&D arrangements among advanced countries, mostly within the triad countries of North America, Western Europe, and Japan. The second type was the decision of MNCs from advanced countries to establish

[205] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 3 (citing, e.g., L. Kim, "Stages of Development of Industrial Technology in a Developing Country: A Model", Research Policy, 9 (1980), 254; L. Kim, Imitation to Innovation: The Dynamics of Korea's Technological Learning (1997); and S. Lall, Building Industrial Competitiveness in Developing Countries (1990)).

[206] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 3 (citing, e.g., M. Schaaper, An Emerging Knowledge-Based Economy in China? Indicators from OECD Databases (2004); OECD, Science and Technology in China: Trends and Policy Challenges (2002), 247).

[207] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 6-7.

[208] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 3.

[209] The description of the model in this paragraph is adapted from M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 3-5.

R&D in emerging markets in South-East Asia, China and Eastern Europe to take advantage of improved economic conditions in those markets, set global standards, build global brands and use local R&D efforts to support local sales.[210] The third type in the model included firms in developing countries electing to conduct R&D in advanced countries with the primary objective of "catching up" by acquiring local technology and science. Finally, the fourth type in the model included firms in developing countries that launched R&D initiatives in other developing countries, a phenomenon that Zedtwick suggested would occur to support second generation technology transfer (i.e., when the earlier recipient of a technology transfers a technology on to an even less developed country) or other local business activities.

Zedtwitz argued that the third and fourth types of R&D internationalization in his model denoted novel, and relatively ignored, directions that needed further consideration given that his own research work suggested that international R&D from developing countries had already exceeded 11% of all international R&D as of the mid-2000s.[211] He observed that evidence regarding globalization of R&D activities by companies from developing countries contradicted the long-running narrative that those companies were "too busy absorbing technology transferred from abroad and hardly capable to push technological boundaries themselves".[212] In order to understand what was going on Zedtwitz surveyed strategies of R&D internationalization among Chinese companies and argued, based on his findings, for two propositions: (1) firms from developing countries were more likely to internationalize R&D into advanced countries because of their shortage of domestic technologies, and because of various limitations to serve foreign markets technologically (a strategy described as "innovation capability enhancement"); and (2) firms of developing countries would internationalize R&D into other developing countries opportunistically (i.e., when following local customer requests), a strategy which may ultimately allow them to obtain long-term first-mover advantages in countries that are even less developed (a strategy described as "innovation capability exploitation").[213]

Zedtwitz's arguments were similar in many respects to the findings of Zhang, who examined international R&D investment by Chinese companies in Europe and the US using in-depth multi-case studies and identified two R&D strategies that were used by the companies in the survey group.[214] The first strategy was referred to as "technology exploration" and was used in industrialized countries/economies where technology

[210] Zedtwitz cited IBM's establishment of R&D in India, Microsoft's Research lab in China, and Fujitsu's Development Center in Malaysia as examples of Examples of Type 2 R&D internationalization. M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 3.

[211] M. Zedtwitz, International R&D Strategies in Companies from Developing Countries–The Case of China (January 2005), 4.

[212] Id.

[213] Id. at 10-11. Zedtwitz explained that "innovation capability enhancement" came from developing the company's capabilities to understand and conduct cutting-edge technology development by absorbing know-how from advanced countries and "innovation capability exploitation" involved passing on technologies and technical know-how to even lesser developed countries which has been absorbed earlier and refined for use in those countries. Id. at 11.

[214] J. Zhang, International R&D Strategies of Chinese Companies in Developed Countries: Evidence from Europe and the U.S., http://www.phdmanagement.sssup.it/documenti/awarded/zhang_thesis.pdf

capability was relatively stronger than in China and the technology acquired by the Chinese companies could be used to offset their technological weaknesses in their home market. This type of strategy is important to those companies since their home market remains their main sources of business and the technology available in developed countries is essential for those companies to cope with intense and growing domestic competitive pressures. The second strategy, referred to as "ambidextrous" by Zhang, also involved technology exploration but was accompanied by "technology exploitation" which involved Chinese companies adapting their technologies and products to the local market in selected foreign countries. Foreign R&D conducted for the purpose of technology exploitation was generally accompanied by support for sales activities. Zhang noted that Chinese companies used technology exploitation as a means for obtaining short-term economic benefits and leveraging cost advantages; however, those companies also realized that short-term term advantage needed to be paired with technology exploration strategies that allowed the companies to achieve long-term goals of continuous development of their core technologies.

§71 --Knowledge management among SMEs in developing countries

Hussain et al. observed that small- and medium-sized enterprises, or "SMEs", make substantial contributions to national economies and this is certainly the situation in many developing countries where small firms are activities throughout the various industries and markets that have been established in those countries.[215] They also argued that in order for SMEs to remain competitive and generate innovative ideas and technological breakthroughs they must develop an understanding of "knowledge management" ("KM"), which they described as involving "knowledge identification, creation, acquisition, transfer, sharing and exploitation".[216] Hussain et al., along with many others[217], viewed knowledge as a primary source of competitive advantage and set out to study the use of KM in SMEs in developing countries and examine the factors that

---

[215] I. Hussain, S. Si and A. Ahmed, Knowledge Management For SMEs In Developing Countries (citing S. Pavic, S. Koh, M. Simpson and J. Padmore, "Could E-Business Create a Competitive Advantage in UK SMEs?", Benchmarking: An International Journal, 14(3) (2007), 320). Hussain et al. explained that in developing countries "[t]he term SME covers a heterogeneous group of businesses in a developing economy, ranging from a single artisan working in a small shop making handicrafts for a village market to sophisticated engineering firms selling in overseas markets" and that "[g]enerally SMEs in developing countries have not more than 250 employees" (citing E. Fischer and R. Reuber in G. Wignaraja (Ed.), Competitiveness Strategy in Developing Countries: A Manuel for Policy Analysis (2003)).

[216] I. Hussain, S. Si and A. Ahmed, Knowledge Management For SMEs In Developing Countries. See also W. Boh, "Mechanisms for Sharing Knowledge in Project-Based Organizations", Information and Organization, 17 (2007), 27 (KM is a systematic process for acquiring, organizing, sustaining, applying, sharing and renewing both the tacit and explicit knowledge of employees to enhance organizational performance and create value) and R. Pillania, "Current Status of Storage and Access of Knowledge in Indian Industry", Journal of Information and Knowledge Management, 5(1) (2006), 37 (defining KM as "a systematic, organized, explicit and deliberate ongoing process of creating, disseminating, applying, renewing and updating the knowledge for achieving organizational objectives"). Further discussion of "knowledge management" can be found elsewhere in this Part.

[217] See, e.g., D. MacKinnon, A. Cumbers and K. Chapman, "Learning, Innovation and Regional Development: A Critical Appraisal of Recent Debates", Progress in Human Geography, 26(3) (2002), 293; and G. Patriotta, Organizational Knowledge in the Making - How Firms Create, Use, and Institutionalise Knowledge (2003).

influence the adoption of KM by SMEs in those countries. They concluded that, in general, SMEs, in developing countries have either not realized the importance of KM to the potential success of their businesses or been reluctant to take sound principles of KM into their strategic thinking and daily routines.[218]

Hussain et al. described a number of challenges that SMEs in developing countries might face in implementing and maintaining KM tools and practices starting with the obvious issue of a lack of core resources such as land, labor and capital. In addition, Hussain et al. noted that "[m]any SME owner-managers lack even fundamental concepts about KM and are unaware about underlying benefits of KM" and that "[c]ultural barriers such as distrust, lack of recognition and communication, knowledge is power mindsets, retrenchment concerns and so forth act as demotivators with regard to effective knowledge sharing and utilization of 'what we know'".[219] Other challenges include difficulties developing KM competencies, visionary leadership and a "sharing" organizational culture and acquiring the managerial expertise necessary to understand and deploy sophisticated KM strategies, tools and procedures. However, Hussain et al. optimistically cited several potential advantages that SMEs might have with respect to implementing KM practices including their flat structures and short decision making processes which should, in theory, facilitate shorter and faster information flow that can improve communication; more flexible organizational cultures that would be more adaptable to change; relative freedom from potentially stifling bureaucratic practices and formal systems that might slow progress; and a higher incidence of innovativeness that can nurture a continuous improvement culture.[220] Hussain et al. concluded by recommending that SMEs in developing countries rely on "personalization" strategies for KM based on managing knowledge through human communication with a focus on "dialogue between individuals, not knowledge objects in a database".[221]

[218] I. Hussain, S. Si and A. Ahmed, Knowledge Management For SMEs In Developing Countries (citing R. McAdam and R. Reid, "SME and Large Organization Perceptions of Knowledge Management: Comparisons and Contrasts", Journal of Knowledge Management, 5(3) (2001), 231; and M. Nunes, F. Annansingh and B. Eaglestone, "Knowledge Management Issues in Knowledge-Intensive SMEs", Journal of Documentation, 62(1) (2006), 101.

[219] I. Hussain, S. Si and A. Ahmed, Knowledge Management For SMEs In Developing Countries (citing G. Von Krogh, "Care in Knowledge Creation", California Management Review, 40(3) (1998), 133; and M. Handzic and H. Hasan, The Search for an Integrated KM Framework (2003), 3).

[220] I. Hussain, S. Si and A. Ahmed, Knowledge Management For SMEs In Developing Countries.

[221] Id. For further discussion of "personalization" strategies see, e.g., M. Cerdan, C. Lopez-Nicolas and R. Sabater-Sa´nchez, "Knowledge Management Strategy Diagnosis from KM Instruments Use", Journal of Knowledge Management, 11(2) (2007), 60; M. Greiner, T. Hmann and H. Krcmar, "A Strategy for Knowledge Management", Journal of Knowledge Management, 11(6) (2007), 3; and S. Zanjani, S. Mehdi and M. Mandana, "Organizational Dimensions as Determinant Factors of KM Approaches in SMEs", in Proceedings of World Academy of Science, Engineering and Technology (2008), 35.