IRLE
Institute for Research on Labor and Employment

IRLE WORKING PAPER
#223-10
October 2010

Managing Knowledge Workers in Global Value Chains

Clair Brown and Greg Linden

Cite as: Clair Brown and Greg Linden. (2010). "Managing Knowledge Workers in Global Value Chains." IRLE Working Paper No. 223-10. http://irle.berkeley.edu/workingpapers/223-10.pdf

Managing Knowledge Workers in Global Value Chains

Clair Brown (cbrown@econ.berkeley.edu)
and
Greg Linden (glinden@berkeley.edu)

Center for Work, Technology, and Society, IRLE
University of California at Berkeley

October 20, 2010

Abstract

Global value chains span national and organizational boundaries in a growing number of industries. Knowledge creation and exchange within these diffuse networks is more complex than in the centralized R&D process of the past.

This research, based on extensive fieldwork with engineers and managers in multinational headquarters and subsidiaries in a number of high-tech industries, analyzes alternative modes of managing knowledge workers in this global setting. Strategic human resource management (SHRM), of which formal HR policies are but a small part, is necessary to structure formal and informal network activities, both within and beyond the firm.

We compare two archetypal high-performance SHRM systems and describe how they have evolved in practice. We analyze SHRM for global knowledge flows with offshore subsidiaries, value chain partners, allies, acquisitions, and corporate ventures. We also look at knowledge flows in informal personal networks and via the global circulation of knowledge workers. Finally we review lessons learned about SHRM practices to create and manage knowledge workers in global value chains.

Acknowledgements

The fieldwork that informs this paper and provides most of the examples was undertaken as part of a multi-industry Sloan Foundation study of globalization. Our research focus during that period was semiconductor design. The other industries on which we draw in this paper are electronics contract manufacturing (researched by Tim Sturgeon), personal computers (researched by Jason Dedrick and Kenneth L. Kraemer), and flat panel displays (researched by Stefanie Ann Lenway and Thomas P Murtha). We are grateful to them for sharing their findings, and for their feedback and insights. We gratefully acknowledge funding for our research by the Sloan Foundation, IRLE at UC Berkeley, and ITEC at Doshisha University. In writing this paper, we benefitted from discussions with Melissa Appleyard, Ben Campbell, Hank Chesbrough, Bob Cole, Jim Lincoln, Yoshi Nakata, Gail Pesyna, Michael Reich, Tsuyoshi Tsuru, and Hugh Whittaker.
Any errors are attributable to the authors.

Global value chains that span national and organizational boundaries characterize a growing number of industries. Innovating in these diffuse networks is more complex than in the centralized R&D organization of the past because significant pieces of the development process have been moved offshore and/or outside the company. Unlike the one-way transfers of the past, knowledge must now flow bidirectionally along a firm's value chain.

Knowledge creation and exchange across boundaries is difficult, costly, and time-consuming. When handled badly, it can bust budgets and delay, or even kill, projects.

This article analyzes alternative modes of managing knowledge workers in this global setting. Strategic human resource management (SHRM), of which formal HR policies are but a small part, is necessary to structure formal and informal network activities, both within and beyond the firm. Informal personal networks, including those provided by workers' experiences at universities and at jobs with more than one company, are an important part of the knowledge networks that workers use.

In addition to facilitating the execution of internal projects, SHRM shapes the ability of companies to stay abreast of outside knowledge. In fields where technology changes rapidly and industry boundaries are unstable, firms must be able to locate useful external knowledge, identify new market opportunities, and track potential competitors. This "sensing" capability can be embedded in organizational processes (Teece, 2007: 1322-1323).

A company's SHRM system must be consistent with and reinforce company strategy, but a well-functioning SHRM system cannot compensate for a strategy that does not develop products that meet customer needs. Alternatively, inappropriate SHRM practices can undermine company strategy.

The SHRM system is intertwined with all strategic decisions affecting innovation, such as to what extent and how to protect intellectual property (IP). For example, determinations about the value of proprietary knowledge and how to protect it depend on how long the IP inventors are expected to stay at the company, which is one aspect of SHRM design.

Our analysis draws on examples observed during extensive fieldwork with engineers and managers in the electronics industry, including semiconductor design, contract manufacturing, personal computers, and flat panel displays. This article also draws on the extensive literature about how companies locate, organize and manage their knowledge workers (for example, Baron and Kreps, 1999; Katz, 1997; Brown et al, 1997).

Firms continue to experiment with SHRM. The cases discussed here are not presented as best practices, but rather as examples that contribute to an understanding of how various global SHRM systems function in the real world.

We begin by comparing two archetypal high-performance SHRM systems and then describing how they have evolved in practice. The second section discusses the nature of knowledge and how it is transferred through written material and through personal interactions within the firm, including offshore subsidiaries. The third section explores managing global knowledge flows outside the firms with value chain partners, acquisitions, alliances and informal employee networks. Finally we review lessons learned about SHRM practices to create and manage knowledge workers in global value chains.

1. SHRM System for Knowledge Workers

A complex global value chain requires an analogous global knowledge network that ensures the dissemination of information and knowledge among workers engaged in interrelated activities. As the traditional approach of companies doing their own R&D became unviable for most firms, the integration of a company's internal R&D with external knowledge and the reliance upon innovation throughout the supply chain was increasingly required for global competition (Teece 2002; Iansiti, 1998; Chesbrough, 2003). SHRM systems must facilitate and support the flow of information throughout the global knowledge network, and SHRM systems must provide employees with the required knowledge and the correct incentives in order for the global knowledge networks to function effectively. A company's knowledge network includes both internal (within and across the company units) and external communication (across company borders) flows. A successful global SHRM system in itself adds to the firm's competitive advantage (Harvey, et al., 2002).

The SHRM system for knowledge workers should be structured to support innovation and knowledge flows. In this section we describe two types of high-performance SHRM systems, *high-commitment* and *high-innovation*.

1.1 Two High-Performance SHRM Systems

Two examples of high-performance SHRM systems are representative of many SHRM systems in high-tech companies: high-commitment SHRM (Baron and Kreps, 1999) and high-innovation SHRM (Katz, 1997; Brown, 2006). We focus on four major component parts of the SHRM system: 1) job assignment ("what to do"); 2) skill development and 3) communication flows ("how to do it"); and 4) compensation and promotion ("reward for doing it"). Table 1 summarizes the key characteristics of these two systems[1].

[1] These SHRM systems build upon Brown et al (1997), which compares three types of systems termed SET-Career Ladders (Japan), SET-Post and bid (US), and JAM (US) that are primarily for managing

Table 1: High-Commitment and High-Innovation SHRM Systems

	High Commitment	**High Innovation**
GOALS	Long-term jobs to create required knowledge and foster commitment.	Project-oriented hiring with state-of-art knowledge from mobile talent pool.
Worker Mobility	Seen as a net loss	Seen as cost-effective
KNOWLEDGE		
Characteristics	Experiential, cumulative knowledge important	University and classroom training important
Depreciation of Technology	Slow	Rapid
External Sources	Customers and suppliers; public documents (journals, patents)	Networks of colleagues; conference papers and journal articles
SHRM COMPONENTS		
Job Assignment	Chosen to develop broad skill set, with flexible assignments Contributions to team tasks as well as individual task	Chosen to exploit narrow specialization Work done individually or sequentially within team
Skill Development	Planned by project manager OJT supplemented by formal classroom training	Individual develops knowledge through professional networks and job change Required proprietary knowledge learned on the job
Communication Flows	Open flow internally Gatekeepers for external knowledge Structured flows with suppliers, customers Weak IP protection training	Chinese walls internally Individual use of external networks important Structured flows with suppliers, customers IP protection emphasized
Compensation & Promotion	Performance-based pay to reward ongoing efforts Small differential within cohort Promotions based on future contribution Steep age-earnings profile with low variance	Bonus for project milestones with individual rewards for specific targets Large pay differential based on market opportunities Promotion of those selected to become executives Relatively flat experience-earnings profile with large variance

The *high-commitment SHRM system* manages workers in order to elicit high effort and responsibility from loyal engineers who have the knowledge, skills, and judgment required by the company. This approach works well when knowledge is tacit and/or proprietary (specific to the company), as well as cumulative or depreciating slowly, and so much learning is done on the job and experience is valuable. In the high-commitment system, the loss of an engineer who quits is seen as a net asset loss to the company. The company can plan for the skills required over time, since the company is

---

production workers. The two SET systems are high-commitment systems. The analysis presented here in charge of the development of workers' skills and knowledge through job assignments, which determine on-the-job training, combined with some formal classroom training. Since job assignment is the primary way that workers develop skills, project assignments reflect skills being developed as well as skills being used. Engineers can be flexibly deployed across projects, and can be quickly reassigned when needed, since they have been broadly trained and such movements are accepted in order to meet company needs. Engineers tend to go to other engineers on the team or in the division to discuss problems they are solving, and only secondarily turn to scientific journals or public documents. Contact with people outside the company to discuss problems is rare unless it is a specific part of the job assignment (Appleyard et al 2006).

Since the company does not worry about workers quitting, an open flow of information within and across levels of the organization is encouraged. Usually communications external to the company are structured so specific people are in charge of specific information flows (e.g., gatekeepers stay abreast of external knowledge and disseminate relevant knowledge to colleagues; specific team members communicate with specific suppliers or customers on relevant parts of the project). Required company documentation of projects reflects what other teams will need to know down the road, with the assumption that project members will be readily available for consultation. Training of engineers how to protect IP from people outside the company may be weak or nonexistent, since engineers are assumed not to communicate outside the company's official knowledge network, which is well defined.

In addition to effort and project performance, incentives reward loyalty and relationship building within the company and with its partners. Compensation includes performance-based pay to reward ongoing effort, although the differentials among engineers with the same experience are kept small in order to minimize competition among team members and to promote team effort. Promotion is used to signal future contributions; however all workers advance up the ladder (with some variation in speed) as they gain experience. A steep age-earnings profile rewards workers for experience, and the younger workers do not mind the transfer of income to the older workers because all workers eventually receive this transfer, and it reflects the life cycle demands of their families.

The *high-innovation SHRM system* supports rapid innovation through using the mobile talent pool connected to informal global knowledge networks. Engineers are typically hired because their skills and knowledge are required for a specific technology or product being developed. The company wants engineers to remain at least for the tenure of the project. Once hired, the company signals to engineers their future with the company by assignments to follow-up projects, including development of engineers as managers and executives. Engineers can be let go or are encouraged to leave by being put on dead-end projects, such as maintenance of legacy technology. This approach fits well

---

focuses on knowledge workers, and brings the analysis of SHRM systems up to the mid-2000s.

when depreciation of knowledge is rapid and is not cumulative, and so experience is less important than state-of-art knowledge learned at the university or lab. Additional formal classroom training and “need to know” proprietary company knowledge are taught when required on the project (“just-in-time training”). Overall the mobility of engineers is seen as cost effective, since the company can hire required skills and does not have to retrain experienced workers, who usually command higher wages than new graduates.

Engineers are in charge of their career development, and they rely upon their professional associations and their own studying to maintain and expand their skills and knowledge. To the extent possible, engineers carefully choose their jobs (and projects) in order to develop their skills and knowledge over their careers. Graduate degrees, which teach engineers how to evaluate and learn new technologies, are useful in this lifelong re-education process.

Knowledge exchange with colleagues outside the company is an important source of information about new technologies and products being developed as well as about job opportunities. The engineers can use their personal networks to find the knowledge required for solving problems and for evaluating external technologies in order to find appropriate technologies to integrate into their own development work. Since engineers are assumed to be interacting with colleagues from other companies, they are taught what types of information they may share. The flow of information even within the company is restricted in order to protect company IP. When U.S. companies go abroad, particularly to locations with less transparent legal systems, such as China, they often keep core IP close to home because prevention is worth more to the company than enforcement. Documentation of a project is required according to the extent that it is needed by users or future project teams, which may not include many of the same members.

Compensation rewards the individual engineer’s skills and talents. The experience-earnings profile reflects the market opportunities of the engineers. Incentives reward project work, often with bonuses for project milestones, rather than skill development or institution building. Individual effort is rewarded by compensation for specific goals, often related to sales or value to the customer.

Compared to high-commitment SHRM, high-innovation SHRM depends more on the external labor market and less on internal rules for determining pay and promotion. Knowledge workers are evaluated and rewarded for their application of knowledge to specific projects and customer problems. For example at IBM Research, employees are rewarded for their ability to generate solutions to specific customer problems and research managers are rewarded for delivering solutions to business units (Chesbrough, 2003: Ch 5). Companies are more concerned with project performance than with long-term careers for their workers. For workers, mobility replaces lifetime employment; for firms, training is focused on what needs to be done in a specific product or process. To acquire the knowledge required for a new technology or business model, often companies want to hire new graduates rather than retrain their experienced engineers. For example, IBM hired software engineers and systems engineers while laying off semiconductor engineers in the mid-1990s as they changed their business model towards services and no longer had indefinite control of IP as a long-run goal (Chesbrough, 2003, Ch. 5).

Even within a high-tech industry such as semiconductors, the SHRM systems reflect the speed of technological change, as well as how quickly firms are able to restructure their SHRM systems in response to environmental changes. One study using linked employer-employee data from the semiconductor industry shows strong clustering of HRM practices across firms, with relatively high R&D firms much more likely to implement more market-oriented practices, which are high-innovation practices, than relatively low R&D firms, which have more internal labor market or high-commitment practices (Andersson et al, 2008).

1.2 Evolution of SHRM Systems

The high-commitment and high-innovation systems described above are abstract generalizations. In the real world, we observe variants across and within countries, and we observe SHRM systems transforming over time in response to changes in the external environment. In general, large multinational corporations in developed countries tended to use variants of high-commitment SHRM systems during the second half of the 20th century (Jacoby, 1998, 2004). Since at least the mid-1980s, the SHRM systems in high-tech companies have been including more aspects of high-innovation systems, especially in compensation. For a variety of reasons, including differences in the role of unions, in government regulations of company layoffs, and in social norms about what constitutes a successful career, the high-commitment SHRM systems in US high-tech companies transformed into high-innovations systems starting in the mid-1990s, while their counterparts in Japan and the European Union have retained (with minor modifications) high-commitment systems.

U.S. high-tech companies restructured their high-commitment SHRM systems in response to global competition and severe demand cycles in the 1980s and 1990s, which eventually precipitated layoffs and transformed the commitment between the company and workers. Then during the heated labor market in the late 1990s, engineers used job change to improve earnings when fabless and other start-up firms with venture funding drove up earnings for engineers, especially in the Silicon Valley and other high-tech regions. As one Silicon Valley software engineer told us in 1999, “After lunch I don’t answer the phone, since it is head hunters making me big offers, and I don’t want to change jobs right now.”

Let us look at what happened to high-commitment SHRM in semiconductors, where large U.S. firms were known for long-term job ladders that simultaneously encouraged the development of workers’ skills and commitment. Even in the 1980s, when intense global competition from Japan forced U.S. chip companies to be more market-driven and efficient, they downsized mainly through “voluntary early retirement” programs. IBM provides a good example of how downsizing programs evolved over the 1980s into the 1990s. In 1983, IBM offered workers at five locations a voluntary early retirement program in which workers with 25 or more years experience who left IBM could receive two years of pay over four years. IBM offered voluntary retirement programs again in 1986 and 1989.[2] Because of the voluntary nature of these programs for the general workforce, rather than for targeted job titles or divisions, the change in workforce usually was not what the companies would have chosen: the better workers might opt to leave, and the weaker workers, without good job opportunities elsewhere, might stay.

The deep recession in the early 1990s finally pushed IBM, DEC, and Motorola, once known for their employment security, to make layoffs.[3] The new approach to downsizing included voluntary programs for targeted workers. If workers did not accept the termination program, they could become subject to layoff. Workers no longer viewed these programs as voluntary, although the voluntary layoff with severance pay was substantially better than an involuntary layoff without severance pay. In 1991 and 1992, IBM selected workers eligible for voluntary termination, which included a bonus of up to a year's salary. Over 40,000 workers were “transitioned” out. Downsizing continued through 1993, and by 1994 actual layoffs were occurring at IBM.[4]

Similar downsizing occurred throughout the semiconductor industry. DEC, the second largest computer company in the late 1980s with over 100,000 employees, began layoffs in the early 1990s. Over 80,000 workers were laid off worldwide during the 1990s, before Compaq acquired DEC in 1998.[5] Later Compaq was acquired by HP, which announced 14,500 layoffs in 2005.[6]

With the dot.com bust in the early 2000s, massive rounds of layoffs by semiconductor companies occurred again. By the end of 2001, Motorola had laid off over 48,000 workers from its 2000 peak of 150,000 employees.[7] The volatile swings in demand meant that the idea of lifetime employment in the semiconductor industry was a thing of the past, although some selected workers still have excellent job ladders with long careers.

Companies cannot structure their SHRM systems independently of the labor market norms in which they operate, in either their home country or abroad. Within an industry, companies may vary in their retention goals for engineers according to the extent to which their technologies and products rely heavily on internal R&D or on the accumulation of the knowledge embedded over generations of the technology. Although

---

[2] http://www.allianceibm.org/news/jobactions.htm
[3] Some of the observations about specific firms here likely reflect divisions of these large, complex firms beyond their production of semiconductors. We think that the patterns discussed reflect the impact of globalization across high-tech firms.
[4] http://www.allianceibm.org/news/jobactions.htm
[5] http://en.wikipedia.org/wiki/Digital_Equipment_Corporation; http://www.job-hunt.org/about.html
[6] http://www.networkworld.com/topics/layoffs.html
[7] http://www.bizjournals.com/austin/stories/2001/12/17/daily22.html

companies can improve retention rates of engineers through compensation and promotion, they still must contend with the mobility norms reflected in the labor market. In areas with relatively high mobility, such as the Silicon Valley, the costs of retention are higher than in low mobility areas, such as Oregon or Japan. In general companies cannot vary their SHRM systems for knowledge workers within a national labor market, but they can vary how many engineers are selected for career development. For example, in semiconductors TI and Intel have high-innovation systems with well-compensated career ladders for key engineers who stay for their careers, and their retention policies (e.g., promotion decisions) reflect the local labor market. In contrast, Silicon Valley fabless companies usually have high-innovation systems that expect few engineers to stay more than five years (or the life of a project); a select group of founders and early employees, who own stock, provide the required continuity. In computer hardware, Apple also has an SHRM system with retention incentives for selected engineers.

Companies with a high-innovation SHRM system face severe problems during high demand periods, when engineers might leave companies before a project is completed or when too few experienced engineers are available to serve as project managers or as key developers of the next generation technology. In the high-innovation system during peak demand, a disconnect exists between companies wanting to keep workers and workers wanting to accept better job offers; then the positions of companies and workers switch when demand falls (Brown and Campbell, 2003).

Japanese semiconductor companies, including those in multi-product electronics companies, such as Toshiba and NEC, as well as the newly-created stand-alone semiconductor companies such as Renesas and Elpida, continue to use a high-commitment SHRM system that is modified to include more individual performance-based pay in base pay and semi-annual bonuses. The variance of pay for a cohort, i.e., those engineers hired as fresh-outs from the university in a given year, has grown as a result (Tsuru et al, 2005). In the absence of institutions that support a mobile labor market, such as adequate unemployment insurance, portable retirement systems (both private and public), and social acceptance of job hopping, Japanese companies and their workers are locked into a high-commitment system, which works well as long as the required number of engineers is fairly stable or predictable and companies are able to retrain their engineers in leading edge technology.

Even when high-commitment SHRM systems were practiced in both U.S. and Japanese high-tech companies in the early 1990s, they varied in the role of the employees versus managers in taking the initiative in career development. U.S. workers compared to Japanese workers have always been more in charge of their careers within a company, because U.S. workers take the initiative in signing up for outside courses (with tuition paid by the employer) and in bidding for posted job openings within the company, whereas Japanese workers rely upon their supervisors to guide their careers and skill development (Brown et al, 1997: Ch.1).

2. Creating and Managing Global Knowledge Flows within the Firm

Now we turn to look in detail at how companies create and manage the flow of knowledge globally. The process of transferring and using knowledge in a global knowledge network depends upon the characteristics of the knowledge involved and how and by whom it will be used. The documentation of knowledge and the movement and use of people are important and complementary parts of knowledge transfer both within the firm and along the global value chain. First we discuss documentation and under what conditions documentation seems feasible. Then we turn to look in detail at how company SHRM systems manage the global creation and flow of knowledge among people within the firm and along the global value chain.

2.1 Documenting (and Not Documenting) Knowledge

The ability and need to document knowledge depends on the characteristics of knowledge (e.g., tacit or explicit and rate of depreciation) and the experience and location of the users (e.g., experienced or novice, external or internal to company). Although it is true by definition that tacit knowledge goes undocumented, it does not follow that most explicit knowledge, which is formal, systematic knowledge that can be processed and stored electronically, is actually documented. Although some knowledge may be fully documented (codified) or embedded in tools and standards, up-to-date knowledge is often nuanced and tacit, such as knowledge that comes with experience or learning by doing on leading-edge technologies.

The depreciation rate of the technology under consideration affects, and even confuses, the distinction between tacit and explicit or codified knowledge. When depreciation is rapid, as when new technology generations incorporate only a small portion of the earlier generation, knowledge may appear to be tacit because its documentation quickly becomes obsolete and will not be worthwhile for users of future generations to know. When depreciation is slow, as when a technology is cumulative across generations, documentation becomes useful in transferring the knowledge to other users. Expert users, including the developers, of tacit knowledge of slowly-depreciating technology will understand over time how parts of their knowledge can, in fact, be documented.

Table 2 shows the type of documentation that one might expect for the four types of knowledge (tacit and modular, each with fast and slow depreciation) and four types of users (internal users and external users, both experienced and novice). The experienced internal user includes the developers, who would normally provide the documentation.

Table 2 Technology Documentation by Knowledge and User Type

Type of Knowledge		Internal User		External User	
		Expert (Developer)	**Novice**	**Experienced**	**Novice**
Modular	**Slow Depreciating**	Key specs	Detailed (self-sufficient)	Overview with key specs	Detailed (self-sufficient)
	Fast Depreciating	Key specs with notes on changes	Detailed specs, with notes on changes	Key specs with notes on changes	Not worth doing
Tacit	**Slow Depreciating**	Summary notes	Summary notes plus OJT	Need to know basis	Not worth doing
	Fast Depreciating	Not worth doing	Not worth doing	Not worth doing	Not worth doing

Even when knowledge can be codified, often it is not documented for others to use because documentation is time consuming, and therefore costly. Detailed documentation sufficient for novice users, both internal and external, to learn the technology requires that the depreciation rate is slow enough that a new user will use the new technology long enough to warrant the cost of both the documentation and the learning period. In contrast, fast depreciating modular knowledge will not be documented in sufficient detail for a novice external user, but some documentation of key specifications with notes on the changes made will be provided for experienced users and for teaching novice internal users, who are working with the experienced developers.

Tacit knowledge with fast depreciation will not be documented, since the users know they will have to continually update their knowledge through experience as the technology changes, and novice users require on-the-job training to learn the technology. When tacit knowledge has slow depreciation, then a summary of the technology that facilitates on-the-job training for novice internal users is useful. This documentation will be made available to experienced external users, who presumably have permission to use the technology (i.e. users of the technology that are in the firm’s global knowledge network) as the documentation becomes available and revised.

Company requirements for documentation vary, and reflect the need for use of knowledge by workers both within the development group and in other parts of the company, as well as the number of potential users in other companies. In one software company we interviewed, documentation was deemed critical within a project team because the technology was cumulative across generations and because the thirty-person project had subteams that needed to know what the other subteams were doing. The engineers were required to provide online documentation on a weekly basis before they could continue their development work[8].

Ensuring that required documentation is done can be difficult, because engineers tend to put off documenting their work. In one fabless semiconductor company, the problem of engineers' resistance to documentation was solved by a junior engineer being assigned to a lead engineer and documenting what was done as part of the learning process.

Company policies on documentation may be slow to adjust to changes in technology depreciation. A company that faces an increasing rate of technology depreciation may cling to poorly adapted documentation requirements through several cycles before the unnecessary overhead cost is noticed and corrected.

2.2 Using SHRM to Manage Internal Knowledge Flows

Companies invest in offshore activities for several different reasons, which can affect the way the firm's global knowledge flows are managed. The three primary reasons for locating a value chain activity globally are access to location-specific resources including engineering talent; cost reduction; and local market development and access (Ferdows, 1997; Brown and Linden, 2006). These motivations often co-exist in a single location. For example, a company may move chip design to China in order to take advantage of engineering talent that is low cost and knowledgeable about customized solutions for the Chinese telecommunication systems as well as to gain government approval for market access.

Because these motivations often overlap in practice, it is useful to classify individual sites in a firm's internal global network in terms of the role the sites play in developing skills and knowledge. Sites that are located primarily for cost reduction in manufacturing or for local market access can be classified as low competence, and sites that are located primarily to draw upon engineering talent in product or market development can be classified as high competence (Ferdows, 1997). These two types of sites play very different roles in the company's global knowledge network and require different types of management.

A low competence site, used to lower costs and improve production capacity, produces as directed for local or export markets, and performs technical support for the local markets. Their role in the knowledge network is usually confined to collection of locally-based data, such as about customers or rivals, which are passed along to the home office.

A high competence site, used to access technical talent and knowledge, plays an important role in the company's knowledge network. These sites undertake sophisticated activities such as design or marketing and become interdependent with the company's

[8] Brown, Personal communication in the Silicon Valley, July 2006.

primary innovation centers. Knowledge workers at these sites must have the ability to develop technologies, products, or services that can be used in local markets or even in global markets.

Companies must adapt their domestic high-commitment or high-innovation SHRM systems to local norms, laws, and economic conditions when they open operations abroad. Often this occurs through a learning process. For example, in fieldwork in Japan in the early 1990s, we observed two U.S. high-tech companies trying to use a job posting system, based on the high-innovation system in place at their U.S. sites, to transfer employees to new jobs in their Japanese subsidiaries. However Japanese workers, accustomed to a high-commitment system, trusted and depended upon their supervisors to plan their job path and skill development. Eventually one company quit using the job posting system, and the other company involved the supervisors in having employees respond to the posted openings.

By the same token, when Japanese companies operate in the U.S. they must modify their high-commitment SHRM system to cope with the mobile labor market. In particular, they must train workers in IP protection and improve their internal systems for safeguarding IP. In addition, they must be more flexible in hiring experienced workers and in allowing more variance in individual pay.

An important step in establishing a foreign development subsidiary is hiring the managing director, who must hire and supervise the project managers. This group is critical for the success of the subsidiary because they lead the projects and need to be able to work together. In practice, the top local managers are often foreign nationals with experience at the parent company so that they understand both the company's culture and the local culture, know how to communicate with the home office (and possibly other locations in the firm's global knowledge network), and have experienced the full flow of a project (Harvey, et al., 2002).

We observed this practice of transferring top managers and, in many cases, project managers to their home country in order to transfer technology and start up major new projects during our fieldwork at U.S. semiconductor subsidiaries in India. Most of the team members were engineers educated in India.

After management, the next challenge in setting up a foreign subsidiary is the recruitment of engineers. Competition for top engineering talent is intense in every high-tech region we have studied in the U.S., Japan, China, and India. The hiring process used at home is of no help in foreign labor markets, where the foreign companies often have lower status than comparable domestic companies. Hiring often involves developing relationships at local universities, which may include second-tier institutions, and learning how to screen students to judge their talent and education. In India, one well-known company hiring chip design engineers on a top campus administers a test with unusual and challenging problems to 30 or 40 students, interviews 10 or 12 of these, and hires the top three.[9]

Alternatively, companies may partner with or buy foreign companies in order to gain access to engineering talent. For example, one of the primary motivations for California-based semiconductor equipment supplier Applied Materials' 1993 joint venture (fully acquired by Applied in 1999) with Japan's Komatsu, was to help them gain access to substantial numbers of entry-level university graduates in Japan, in order to quickly build a customer service organization in the display industry. In India, U.S-based chip companies have acquired a number of compatible design services firms to rapidly increase development operations in a fiercely competitive labor market. For example, in 2004 Qualcomm acquired Spike Technologies with 150 engineers in Bangalore.[10]

The addition of a relatively low-cost overseas engineering subsidiary can generate morale and transition problems at home, especially if employees at home are to be fired after training their offshore replacements. The employees know it's coming, but they don't want to quit and lose unemployment benefits. Although this morale problem can be offset to some extent by compensation and severance packages, the potential problems arising from a half-hearted transfer of knowledge cannot be overlooked.

In addition, even in cases where the domestic team will continue to work with the offshore team, the domestic experts may feel they are showing the offshore team how to do the project and correcting their mistakes without receiving credit. We heard this complaint from a semiconductor group in the U.S. about their contributions to an Indian project team, who acknowledged the importance of the input from the U.S. engineers.

Over time, the successful integration of a subsidiary in the firm's global knowledge network requires trust. Trust and understanding must be established not only between the managers of the subsidiary and the home office, but also among specific development teams at various sites whose activities are interdependent. As an IBM executive put it: "If you don't have that trust, then you put measurement systems… that can drive bad behaviors, and that distance these teams."[11]

The high-profile acquisition of IBM's PC division by Lenovo, a Chinese firm, yielded examples of these cross-cultural challenges. In a 2006 interview, the American described some of the cultural problems that surface "every day": "In the U.S. and Europe, we have highly opinionated executives who like to make their voices heard. The China team tends to listen more and express themselves more thoughtfully. The Americans and Europeans need to know that if a Chinese colleague is nodding silently, it

---

[9] Interview, Bangalore, Nov.2005.
[10] Spencer Chin, "Qualcomm acquires Spike Technologies to bolster 3G capability," EE Times, September 30, 2004.
[11] IBM's Senior Fellow James A. Kahle. in audiocast "How dispersed design teams can succeed," posted September 18, 2006 at http://www.edn.com/article/CA6372953.html?ref=nbsa&text=kahle

doesn't mean they're agreeing. We also have a program in place to teach our China team better confrontational management skills."[12]

Trust and understanding must be built up over time, possibly by starting a new subsidiary's development team on relatively simple confidence-building projects such as simple support tasks. Over time the manager of a subsidiary assigned a supporting role will advocate for more ambitious projects to demonstrate the possibility of a more interdependent position in the firm's global knowledge network. These are two of the scenarios in which a site will develop its competence over time and evolve from low competence to high competence. We observed this in design centers in Bangalore, where a low-cost engineering pool for the parent company gradually, either by home-office plan or local management advocacy, takes responsibility for development of specific products for global markets.

During a globally-dispersed project, the glue between sites is communication. The use of email, videoconferencing, and other electronic means of communication facilitates the creation of trust and the exchange of knowledge via collaboration. The more tacit the knowledge involved, the greater the need for frequent communication during innovation projects (Subramaniam and Venkatraman, 2001).

Despite the ease of communication by electronic channels, the actual movement of engineers back and forth is also very common, because the frank discussion and brain-storming critical to team-based development projects is less likely to occur by e-mail or phone. Face-to-face meetings are also helpful for building trust. For the subsidiary as a whole, trust with the parent group may be enhanced by mutual transfers of personnel lasting from months to years. Japanese firms often bring key foreign personnel to work in Japan for a month or so. These exchanges are not related to a specific task or product, but to the acculturation of foreigners.

Travel also occurs as part of regular projects. In one chip company with a relatively new Indian subsidiary, we interviewed an expert from the US who traveled to India for three or four major milestone reviews over a seven-month design project. As the project moved to the prototype phase, two or three engineers from the Indian team traveled to the US to help with testing, which was a centralized function.[13]

In the flat panel display equipment industry, before setting up a new tool at customer sites, one equipment supplier brought the two top engineers from its Japan, Korea, Taiwan, and U.S. affiliates for two months of hands-on training at its California headquarters. At U.S. PC companies with Asian development operations, engineers are also brought to the U.S. for short periods, although it is even more common for a U.S. engineer to travel for training to Taiwan or China. Outbound travel can also be involved in disseminating knowledge, as when an engineer travels from headquarters to give seminars at offshore subsidiaries about a new design tool or technique.

---

[12] Jane Spencer, "Lenovo CEO Has Global Ambitions," wsj.com, November 17, 2006.
[13] Interview in Bangalore, November 2005.

As these examples make clear, travel is a necessary part of global development projects. Although it is burdensome for the company and especially for individuals, it often falls to top engineers and managers to make the trips because of their leading-edge knowledge.

Global innovation adds other complexities for engineers and managers. Task assignments must be more carefully detailed for offshore teams than for locally-based engineers. When work is divided across many time zones, team members, and especially the leaders, must be prepared to communicate frequently at odd hours, which can take a heavy personal toll. These various costs and challenges must be recognized as part of the work routines, and team members who meet them must be properly rewarded.

3. Global Knowledge Flows Outside the Firm

Now we look at managing the flow of knowledge between the firm and value chain partners, allies, and start-ups, including acquisitions.

3.1 Value Chain Partners

Innovation processes increasingly extend beyond the boundaries of the firm to value chain partners and allies, and better knowledge integration with development partners leads to better innovation performance in terms of profits and market share (Lin and Chen, 2006). However a firm's SHRM is able to control only one side of any collaboration, even when specific aspects of the SHRM system, such as job assignments and communication flows, have been negotiated as part of the partnership. The firm's employees are covered by the firm's SHRM system, and these practices must be flexible enough to be compatible with the other firm's culture and practices, especially those that control communication flows, performance evaluation in joint projects, and control of intellectual property.

Similarly to innovation with foreign subsidiaries, knowledge flows in global value chains usually require travel to permit face-to-face interactions to complement communication by email and videoconferencing with real-time interactive document manipulation. These trips are time-consuming, exhausting, and add expense to the project budget.

In the software contracting industry, some projects require extensive face-to-face interaction, with as many as one onsite worker for every two offshore (Hira, 2004). Nevertheless, with advances in telecommunications, the ability of offshore application developers to work remotely has advanced steadily over time (Dossani and Kenney, 2004). However the need for face-to-face interaction will likely never go away. According to the CIO of a U.S. company engaged in manufacturing and IT consulting with offices in India, "...any significant project related to development must be accompanied by onsite interaction. This is true whether it is outsourced in Chicago or Chennai. Phone conversations are fine for straightforward conversions or any other pure labor endeavor. When it comes to development work, you must understand the standards and local nuances of the client. ... This interaction can take place over several weeks and then move back offshore. However, we have found that the communications will deteriorate over time if there is not periodic face-to-face interaction."[14]

Even in linkages with a high level of modularity in the handoff, companies typically exchange engineers. For product-level projects, the most common situation is for developed country engineers to spend time at the facilities of affiliates and offshore suppliers. While two-week visits during product launch phase are typical, some companies send engineers to "live" on the production lines of their contractors. The need for this type of exchange changes over time as the linkage matures. When the output of an existing line is relocated offshore, engineers are sent to help contractors adopt the existing process. When new processes are developed offshore from the beginning, engineers are dispatched less to teach and more to ensure that all aspects of the production line are performing satisfactorily.

In the flat panel display industry, AKT, a leading equipment supplier, hosts process teams from its customers for a one-to two-week visit at its Santa Clara facility to work on experiments with AKT engineers as part of the preparation by the customer's Asian factory to introduce new-generation production lines. In the case of outsourced semiconductor manufacturing, vertically integrated customers that rely on foundries (contract manufacturers) for buffer capacity need to transfer their internally-developed fabrication process for each product. Since the larger customers typically have multiple products and processes running at large foundries such as TSMC and UMC, these customers have a more or less permanent staff of engineers at the foundry site.

PC vendors and their Taiwanese contract designer-manufacturers (known in the industry as ODMs) have formal face-to-face meetings four or five times over each eight-to twelve-month product development cycle. Usually one meeting occurs during design, and the others occur at the end of each stage of development. However, there may be many other, less formal face-to-face meetings between individual designers or engineers to work out specific issues. As put by one ODM, "there is somebody (from the PC maker) here about every two weeks throughout the design and development process. Sometimes it is product managers, sometimes industrial designers and other times electrical, mechanical or software engineers. The engineers usually stay a week and work closely with our engineers. Engineers also come to Taiwan or China to see production once it gets rolling. They want to be sure things are going OK and they want to see how things are being done in detail."

The need for face-to-face meetings is critical in the early phase of a long-term collaboration. Technology transfer, for example, requires intense interaction. When the Japanese LCD producer Mitsubishi was initially assisting a Taiwanese company,

---

[14] Craig Hergenroether, CIO of Barry-Wehmiller Companies, in Norman Matloff, "Offshoring: What Can Go Wrong?" IT Pro, July /August 2005.

Chunghwa Picture Tubes, to initiate production under license in 1997, it brought many engineers and fab operators to Japan for training.

Similarly, when a PC vendor starts work with a new ODM partner, both companies spend considerable time "educating" one another. One PC maker uses visitors from headquarters to the design center in Taipei to convey management culture, engineering practices, or technical matters to the ODM. Training is in Taipei, but new people in Taipei have to build relations with partners in the U.S., e.g., people working in the same skill area. There is a mentoring system, with weekly conference calls on skills. They also bring people from the U.S. to Taipei for training forums, which are often intense 3-hour meetings on a specific issue.

Cultural differences can loom even larger with value chain partners than with subsidiaries because the partner is outside the company's sphere of command and control. For example, in the personal computer (PC) industry, the management practices of U.S. vendors with respect to their Taiwanese subcontractors are modified to account for different organizational cultures. In interviews, a vendor described Taiwanese companies as wanting to maintain harmony, avoid conflict, and look for alignment quickly, whereas Americans encouraged debate, conflict, and negotiation. Communication styles also differed according to this U.S. vendor: "Americans hit the key point and then explain the details, whereas Taiwanese build the story and then get to the main point. We have to ask them, 'What's your one page slide?' We have started to use templates to get them to go through our process. We also have classes on conflict management and communication."

Similarly Japanese workers, who solve problems together as teams, are aware of company-generated knowledge, but they are slow to put that knowledge into action. Team members work together, collect and analyze data, and then develop a consensus on what action to take. Team leaders and supervisors tend to keep strict control of the problems that teams work on and of team process, which may hinder innovation and problem-solving. U.S. workers are better at taking individual action, but less aware of internal knowledge sources. In the fast-changing semiconductor industry, problems may be solved more quickly through learning by doing than through careful planning or consulting company documents. The competitive atmosphere within U.S. firms leads to engineers being less willing to work with team members and share credit with others. This focus on individual effort and knowledge comes at the expense of maintaining an active communication channel of knowledge within firms (Campbell, 2003). This difference in how teams function can make a joint development team operate ineffectively, as we saw in one US-Japanese software case. Only after the team continually missed its timetable and workers from each company expressed discontent in the contributions of the other company's engineers, did the partner companies finally take action to help the engineers work better as a team.

Over time the need for monitoring and training is reduced as the two firms and their people get to know each other. To quote one manager, "If you build a relationship, the person at the ODM will do ten iterations to try to fix a problem and will have a solution the next day. If not, they'll try one thing and if it doesn't work, will wait for the next instructions."

Intellectual property control is a central challenge with value chain partners, and the problem can be particularly thorny seen from the point of view of the supplier. Dis-integration of the value chain is predicated in part on the provision of generic capabilities to a range of customers, some of whom may be direct competitors. Suppliers learn a lot about their customers during joint development activities, and for the most part customers accept that suppliers with good reputations can be trusted.

In the situation when design and development are outsourced or done jointly with contractors, as in the PC industry, the supplier may gain valuable general knowledge from a PC maker, such as how to solve a heat problem or increase battery life. PC makers recognize that in many instances, this knowledge might be used by the contractor in future work with other PC makers. Contractors have their own knowledge to protect from a brand-name PC firm that works with different contractors for different models. One Taiwanese contractor indicated that they have their own tests and processes that they do not share with PC vendors because it is proprietary. They share the results so the vendor sees the advantage, but not the actual processes or test equipment.

When it comes to individual employees of the supplier, customer firms may be unwilling to rely on trust. For example, in the flat display panel industry, many equipment companies have dedicated teams that work only with a single customer. This approach can present a problem for career development of key employees when particularly powerful customers resist promotions of individuals to positions of greater responsibility involving multiple clients. In one case, a high-performing engineer from Company A worked closely with Client B for two years. Company A wanted to promote her to a position that would put her in contact with Clients C, D, and E, but Client B objected because of IP risk. At this point, the employee will most likely leave because the alternative is for Company A to put the employee in a holding job until Client B forgets about her or the sensitive knowledge becomes obsolete. In this type of situation, companies must be prepared to have a key employee leave, or else promote her to a job that does not directly use specific customer knowledge.

3.2 Acquisitions

The internalization of external technology through acquisition raises a unique set of SHRM issues because the acquired company, with its own SHRM system and values, must be integrated into the new parent company. Intel and Cisco are prominent examples of companies that acquired companies with new technologies to speed their time to market or reduce development costs. Acquisition potentially gives the acquiring company instant knowledge and full control of the new technology, provided the parent company can successfully utilize the acquired employees who developed and implemented the technology. Retaining the engineering team in an acquisition is critical to successfully using the acquired technology in product or process innovations. In a failed example, STMicroelectronics acquired the DSL modem chip business from Alcatel, but lost the engineering team to a start-up. STM then exited the business.[15]

A firm's incumbent engineering staff may be uneasy about the acquired technology because of the "not invented here" bias. Cisco faced this problem with its first acquisition in 1993 (Mayer and Kenney, 2004). Cisco learned from its mistakes and became one of the most successful technology acquirers. With a typical product life-cycle of 18 months, the company figured it only has 6 months to develop a new product. Many products cannot be developed in this timeframe, and Cisco looked to young companies as the source for new technology.

Once Cisco has decided to acquire a company, it implements a standardized integration process that developed over several years as the pace of its acquisitions accelerated (Mayer and Kenney, 2004). A primary reason Cisco acquires a company is to improve its time to market with the new technology, and Cisco set up SHRM practices so that the key employees of the acquisition are the people who take the product to market. "Golden handcuffs" for these new employees typically consist of two-year noncompete agreements and the granting of Cisco stock options that vest over time (usually five years).

For the acquired employees, Cisco's HR department has procedures to ensure rapid assimilation. A typical acquired company has 60 to 100 employees, and each new hire is assigned a "buddy" of equal status and with a similar job. A special integration team explains and models Cisco's values and norms to the new employees, and the HR manager lays out clear expectations. An analysis of 38 Cisco acquisitions found that annual post-acquisition turnover of engineering staff was below 15% (Mayer and Kenney, 2004: 316).

The Cisco SHRM system into which the acquired engineers are integrated fosters high innovation. Managers are expected to meet their performance goals, and they can be fired for inadequate business results. They can also be fired if they don't recruit and develop a great team of people. Employee bonuses are tied to specific customer satisfaction goals. Promotion and compensation are tied to performance, but employees are encouraged to take risks and try something new (as long as they don't make the same mistake twice). Company policy is to have managers get rid of lower performing employees by terminating the bottom 5% of employees each year.[16] Post-acquisition management is often further complicated by the cross-border, cross-culture issues discussed above, when the acquired company is retained as a new foreign subsidiary. In

---

[15] "Heard on the Beat: ST exits from DSL chip market," Silicon Strategies, February 4, 2005.
[16] Harvard Business School (2000).

high-tech industries, such acquisitions are as likely to involve engineering or research teams in advanced economies as the low-cost engineers mentioned earlier.

3.3 Alliances and Consortia

Knowledge relationships with comparable, as opposed to suppliers or customers, add the additional challenge of managing learning from a competitor or potential competitor. Two common forms of knowledge collaboration with equal partners are the alliance, in which each partner separately makes a defined contribution, and consortia, where partners cooperate at a single site.

Although alliances have a set of clearly-defined formal goals, alliances often have the implicit goal of learning from the partner. Managing, and controlling learning in an alliance can be tricky because learning occurs through experience as well as through formal learning activities. Taiwan's flat panel display industry provides an example of unintended rapid accumulation of knowledge within an alliance of unequals. Japanese display producers started to develop second sources in Taiwan in response to competition from Korea. Although the Japanese companies attempted to place limitations on the transfer of know-how, the Taiwanese licensees worked hard to become independent in their knowledge and surprised the Japanese by growing the Taiwanese industry far more rapidly than the Japanese had anticipated or desired.

In most alliances, however, learning from the partner is not part of the explicit agreement, and it requires explicit mechanisms to communicate lessons and to put them into practice. Analyzing an international sample of eleven companies from a range of industries including aerospace, chemicals, semiconductors, and pharmaceuticals, Gary Hamel (1991, p.87) found that "asymmetries in learning within the alliance may result in a shift in relative competitive position". Firms were most likely to acquire skills from their alliance partners when they intended to do so from the outset. Moreover, learning was most successful when there was an explicit mechanism in place for recording individual learning, integrating lessons from multiple individuals, and transferring the lessons to all units in the company capable of benefiting from it.

Another setting in which companies collaborate with competitors is research consortia, which were given relaxed antitrust treatment by the National Cooperative Research Act (NCRA) of 1984. Some consortia conduct research in members' separate labs, and others bring engineers together in a central facility. Centrally-operated consortia raise issues of technology transfer, assignee selection, and integration of results. A well-known example of a research consortium is SEMATECH, which the U.S. semiconductor industry founded in 1987 with government backing and which has since become fully industry-financed and open to non-U.S. companies. In its early years, SEMATECH had trouble attracting high-quality assignees because it was little known and viewed as a career-interrupting move. Furthermore, member companies had not put mechanisms in place to absorb the knowledge developed during the assignees' two- to three-year tenure.

Gibson and Rogers (1994) report that, as of 1992, nearly 20 percent of the 289 assignees who finished at SEMATECH were no longer at their original companies within a year of finishing their assignment. They describe how one member company addressed the problem by implementing deferred bonuses for returnees who stayed two years. Other member companies offered better integration of SEMATECH sojourns into employee career ladders, and an assignment to SEMATECH is now viewed as career-enhancing. Technology transfer has been improved by bringing assignees back to their originating company for seminars and other briefings of fellow employees.

Often alliances present incentive problems because senior managers are only marginally involved, and middle managers' responsibilities for any given alliance are secondary to their internal responsibilities (Doz and Hamel, 1998). This does not need to be the case. Alliances in the formative years of the flat panel display industry were extremely important to the companies that entered them, and consequently received a great deal of senior management attention and involvement. The management teams were very carefully structured, selected, and given clear responsibilities as well as authority for implementation.

3.4 The Invisible Global Knowledge Networks

In addition to its formal global structure, a company's knowledge network encompasses an informal global knowledge community provided by workers' contacts at their former universities and at former employers. These university and professional networks, which often include social activities, form the basis for an engineer's personal network and are an important extension of a firm's formal knowledge network, especially in the United States. Awareness of these is critical to ensure that knowledge through these channels is managed effectively by high-tech companies.

Saxenian (2006) describes the network of engineers among the U.S. and Asian countries (Taiwan, China, and India) and how the foreign-born engineers' connections in the U.S. and at home have helped them contribute to the development of technology and start-ups in both in the U.S. and their homeland. She sees the brain circulation as a vital factor in the development of emerging companies in the U.S. and Taiwan and increasingly in China and India.

The mobility of high-tech engineers among companies coupled with the large proportion of foreign-born engineers in the U.S. has led to the current situation where many engineers depend more on their professional associations and social networks than on their employers for staying abreast of new technologies and for career development, including information about job opportunities. For example, in the Silicon Valley, engineers often belong to a local professional association that has an ethnic identity, such as the Chinese American Semiconductor Professionals Association, North American Taiwanese Engineers Association, and Silicon Valley Indian Professionals Association. Many engineers also belong to non-ethnically-based professional associations. The

Institute of Electrical and Electronics Engineers (IEEE) lists 39 societies for specific specialties, such as the Solid-States Circuit Society for chip designers. In addition, engineers are often active in alumni associations, such as at Stanford, UC Berkeley, MIT, or National Taiwan University.

The social and professional networking of engineers can be useful in several ways: hiring workers, acquiring knowledge, or assessing external technology. For example, when setting up operations in a new location or when starting a new company, once key engineers are hired, they can aid in identifying other engineers with the desired expertise.

In solving specific problems, engineers can use their networks to the extent that this can be done without disclosing proprietary information. For example, an engineer may call up a colleague to ask questions about a paper the colleague presented at a conference or published in a journal. This direct approach can save the engineer a great deal of time in applying information that is publicly available but that still requires some experience in understanding how to replicate it. Training in the appropriate boundaries for these external communications is, as discussed above, an important dimension of a company's SHRM system.

Previous jobs and professional conferences are other potentially important sources for engineers' knowledge about new technologies and their potential applications. Although an engineer with specific skills may be hired by an employer for a specific project, often the value of the engineer includes his/her broader knowledge of technology and how it might be integrated in the project. The possibility of using external knowledge in a project must be made clear to the project team, whose members need to be rewarded for identifying relevant external technology as well as for creating new technology.

A survey of semiconductor R&D engineers in the U.S., Japan, and Korea that asked about sources of technical information used in solving problems suggests that U.S. engineers are more inclined to use the invisible knowledge network. All three groups of engineers reported the same top three sources of knowledge: their colleagues within the company, followed by journals and then by conference presentations. After these three sources, answers differed by nationality. U.S. engineers relied on external private contacts (face-to-face meetings, telephone calls, and visits) and consortium membership for technical information about other semiconductor companies, while Japanese and Korean engineers relied on external public sources (popular press, journals, conferences, and public newsletters). U.S. engineers were more likely to learn useful technical information from customers, and Japanese and Korean engineers were more likely to rely upon journals and patents. When solving problems, U.S. engineers approached someone outside the company sooner in the process, while Korean engineers used journals sooner in the process and Japanese engineers went to their supervisor sooner. Statistical analysis of the survey indicated that engineers who operate in a more externally-oriented system are more likely to solve problems faster (Appleyard et al 2006; Brown 2006).

4. Conclusions and Lessons Learned

As this chapter has indicated, companies are still learning through experience about how to structure and manage global knowledge networks, which most corporations understand are a vital part of competitive advantage. The global knowledge networks observed in this project were often not well integrated into company SHRM systems and did not work as well as expected given their importance to company performance. Based upon our fieldwork at high-tech U.S. companies, which utilized some variant of high-innovation SHRM, we offer some guidelines for the management of global knowledge networks in high-tech companies with rapid technological change.

A key factor in building an effective high-innovation SHRM system is to develop practices that encourage workers to tap into external sources of knowledge and utilize their individual networks while respecting the intellectual property of their employer. The SHRM system should measure and reward appropriate employee interactions with the internal and external resources of the global knowledge network.

Managing projects with members dispersed over broad geographic distances has the following basic requirements:

- a shared set of product goals, such as product specifications, with specific task assignments and responsibilities for each subgroup;
- an agreed-upon procedure for making changes to the goals and responsibilities;
- a process for problem solving across subgroups;
- regular meetings, either video or telephone;
- specific milestones for each subgroup and frequent discussion of the progress being made toward them;
- understanding of the interdependencies among the tasks to be completed by each subgroup;
- discussion of the subgroup dynamics, such as each subgroup’s evaluation of the work and of the contribution being made by the other subgroups.

A high-innovation SHRM system must ensure that engineers on all teams are well-integrated into a project with strong guidance by the project leader, and everyone understands their specific tasks, how they fit together, and how problems will be addressed. Team incentives should encourage members to help each other when needed, and personal incentives should target individual goals so that members perform at their peak and exploit all possible knowledge channels. Managers need to identify the engineers who are essential for developing the technology or providing the leadership for the next generation of product development, and provide incentives in terms of promotion and compensation to retain them (Brown and Campbell, 2003).

In practice, the management issues extend beyond these fundamentals. Repeatedly our respondents told us that interpersonal collaborations across locations could be stressful because of differences in language, culture and time zones. Participants in an alliance or partnership were often unsure what they could or couldn’t talk about with their opposite numbers. As one respondent said, "There are no firewalls in people's heads."

The choices made by companies in locating and managing their global activities and partnerships will continue to evolve and be shaped by a variety of forces, including strategic issues, internal capabilities, global competition, and local labor markets. The competitive pressures to develop new products, contain costs, and enter new markets mean that a firm’s ability to manage knowledge across firm and national boundaries will continue to be a driver in determining competitive advantage.

References

Andersson, Fredrik, Clair Brown, Benjamin Campbell, Hyowook Chiang, and Yooki Park. (2008). “The Effect of HRM Practices and R&D Investment on Worker Productivity” in Stefan Bender, Fredrik Andersson, Julia Lane, Kathyrn Shaw and Till von Wachter (eds), *The Analysis of Firms and Employees: Quantitative and Qualitative Approaches.* Chicago, IL: University of Chicago Press.

Appleyard, Melissa, Clair Brown, and Linda Sattler, 2006, “An International Investigation of Problem-Solving Performance in the Semiconductor Industry”, Journal of Product Innovation Management. 23: 147-167.

Baron, James, and David Kreps, 1999, Strategic Human Resources, Wiley

Brown, Clair, 2006. “Managing Creativity and Control of Knowledge Workers”. Hugh Whittaker and Bob Cole (eds). Oxford, England: Oxford University Press, pp. 145-165.

__________ and Benjamin Campbell, 2003. “Connect with Your Workforce”. Center for Work, Technology, and Society (IIR) Working Paper, UC Berkeley. Version for MOT Classroom Use. Distributed by Ministry for Science and Education, Japan, for national use in MBA courses.

__________ and Greg Linden, 2006. “Offshoring in the Semiconductor Industry: A Historical Perspective”, Susan M. Collins and Lael Brainard, eds. Brookings Trade Forum 2005: Offshoring White Collar Work. Washington, DC: Brookings Institution Press, pp. 279-333.

__________ and Greg Linden, 2006. “Semiconductor Engineers in a Global Economy.” Paper presented at the National Academy of Engineering, Workshop on the Offshoring of Engineering: Facts, Myths, Unknowns, and Implications, October 24-25, 2006, Washington, DC.

__________, Yoshifumi Nakata, Michael Reich, and Lloyd Ulman. Work and Pay in the United States and Japan. New York: Oxford University Press. 1997

Campbell, Benjamin. “Japanese and U.S. Semiconductor Firms: Bridging the Knowing-Doing Gap on the Shopfloor”. Working Paper, Center for Work, Technology, and Society, UC Berkeley. Version for MOT Classroom Use distributed by Ministry for Science and Education, Japan, for use in MBA courses. 2003.

Chesbrough, Henry. 2003. Open Innovation, Harvard Business School Press.

Dossani, Rafiq, and Martin Kenney. 2004. “Offshoring: Determinants of the location and value of services.” Unpublished manuscript prepared for Sloan Workshop Series in Industry Studies, Stanford University, August 13, 2004.

Doz, Yves L. and Gary Hamel. Alliance Advantage: The Art of Creating Value through Partnering. Harvard Business School Press, 1998.

Eppinger, Steven D, 2001. "Innovation at the Speed of Information", Harvard Business Review, 79(1): 149-158, January.

Ferdows, Kasra 1997. “Making the Most of Foreign Factories,” Harvard Business Review, March-April, pp.73-88.

Gereffi, Gary, John Humphrey, and Timothy Sturgeon (2005). “The Governance of Global Value Chains”, Review of International Political Economy.

Gibson, David V. and Everett M.Rogers. 1994. R&D Collaboration on Trial. Boston: Harvard Business School Press.

Hamel, Gary. 1991. “Competition for Competence and Inter-Partner Learning Within International Strategic Alliances.” Strategic Management Journal, v.12, special issue (Summer): 83-103.

Harvard Business School, “Cisco Systems: Are You Ready?” Harvard Business School Case 9-901-002, 2000

Harvey, Michael, Cheri Speier, and Milorad M. Novicevic, 2002. “The Evolution of Strategic Human Resource Systems and Their Application in a Foreign Subsidiary Context.” Asia Pacific Journal of Human Resources, 40(3): 284-305.

Hira, Ron. 2004. “U.S. Immigration Regulations and India’s Information Technology Industry,” Technological Forecasting and Social Change, 71(8): 837-854.

Iansiti, Marco. 1998. Technology Integration. Boston: Harvard Business School Press.
Jacoby, Sanford M. (2004) Employing Bureaucracy: Managers, Unions, and the Transformation of Work in the 20th Century (Revised Edition) Lawrence Erlbaum Associates

Jacoby, Sanford M. (1998) Modern Manors. Princeton University Press

Katz, Ralph (ed). The Human Side of Managing Technological Innovation New York: Oxford University Press, 1997

Katz, Ralph and Tushman, Michael L. (1997). “A Study of the Influence of Technical Gatekeeping on Project Performance and Career Outcomes in an R&D Facility”, in Ralph Katz, ed. The Human Side of Managing Technological Innovation, New York: Oxford University Press, 331-346.

Lin, Bou-Wen, and Chung-Jen Chen, 2006. "Fostering Product Innovation In Industry Networks: The Mediating Role Of Knowledge Integration." International Journal of Human Resource Management, 17(1) : 155-173.

Linden, Greg, and Deepak Somaya. 2003. "System-on-a-Chip Integration in the Semiconductor Industry: Industry Structure and Firm Strategies," Industrial and Corporate Change, 12(3): 545-576.

Mayer, David, and Martin Kenney, 2004. "Economic Action Does Not Take Place In A Vacuum: Understanding Cisco's Acquisition And Development Strategy." Industry and Innovation, 11(4): 299–325.

Murtha, Thomas P., Stefanie Ann Lenway, and Jeffrey A. Hart, 2001, Managing New Industry Creation: Global Knowledge Formation and Entrepreneurship in High-Technology. Stanford, CA: Stanford University Press.

Pfeffer, Jeffrey and Robert Sutton, "Knowing 'What' to Do Is Not Enough", California Management Review Fall 1999

Saxenian, AnnaLee. The New Argonauts: Regional Advantage in a Global Economy. Cambridge: Harvard University Press, 2006

Subramaniam, Mohan, and N. Venkatraman, 2001. "Determinants Of Transnational New Product Development Capability: Testing The Influence Of Transferring And Deploying Tacit Overseas Knowledge." Strategic Management Journal, 22(4): 359–378.

Teece, David J. Managing Intellectual Capital: Organizational, Strategic, and Policy Dimensions (Clarendon Lectures in Management Studies) Oxford University Press. 2002

Teece, David J. "Explicating Dynamic Capabilities: The Nature And Microfoundations of (Sustainable) Enterprise Performance." Strategic Management Journal, 28(13): 1319–1350 (2007).

Tsuru, Tsuyoshi, Masahiro Abe, and Katsuyuki Kubo. "Pay Structures and the Transformation of Japanese Firms: An Empirical Analysis of Performance and Pay Using Personnel Data" (in Japanese). The Economic Review, Vol. 54, No. 3, pp. 264-285.

Tushman, Michael and Philip Anderson (eds.), Managing Strategic Innovation and Change, Oxford U. Press, 1997

________ and Charles O'Reilly III, Winning through Innovation, Harvard Business School Press, 1997