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The Internet's Effects on Global Production Networks: Challenges and Opportunities for Managing in Developing Asia

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Abstract

Placing global production networks (GPN) on the Internet poses a fundamental challenge, but also creates new opportunities for managing in Developing Asia. Network flagships can now select best-performing suppliers on a global scale, increasing the pressure on Asian suppliers. But the transition from EDI to the Internet may also provide new opportunities for Asian suppliers, by reducing barriers to network entry, and by enhancing knowledge diffusion.

A conceptual framework is introduced to assess how the Internet reshapes business organization and GPN. That framework is applied to one of the role models of managing in Asia, Taiwan´s Acer Group. The paper highlights a vicious circle that must be broken to reap the benefits of the Internet: Asian firms must reduce a huge efficiency gap between manufacturing and the management of supporting digital information systems (DIS). The *challenge* is to embrace the Internet as flexible infrastructures that support not only information exchange, but also knowledge sharing, creation and utilization. The Internet facilitates this task: it provides new *opportunities* for the outsourcing of mission-critical support services.

(181 words)

Introduction: A New Agenda for Managing in Asia

A progressive liberalization and deregulation of international trade and investment, and the rapid development and diffusion of information and communication technology (IT) have fundamentally changed the global dynamics of competition (Ernst, 2001a**).** Intense price competition needs to be combined with product differentiation, in a situation where continuous price wars erode profit margins. Of critical importance, however, is speed-to-market: getting the right product to the largest volume segment of the market right on time can provide huge profits. Being late can be a disaster, and may even drive a firm out of business. The result has been an increasing uncertainty and volatility, and a destabilization of established market leadership positions (Richardson, 1996; Ernst, 1998).

This growing complexity of competition has changed the determinants of firm organization and growth, as well as the determinants of location. Three interrelated transformations have occurred in the cross-national organization of business. First, global production networks (GPN) have proliferated as a major organizational innovation in global operations (e.g., Ernst, 1997; Ernst, 2002). These networks help global corporations (the "network flagships") to sustain their competitiveness, by providing them with access to specialized suppliers at lower-cost locations that excel in quick and flexible response to the flagships' requirements. Second, GPN have acted as a catalyst for international knowledge diffusion, providing new opportunities for local capability formation in lower-cost locations outside the industrial heartlands of North America, Western Europe and Japan (Ernst, 2001b; Ernst and Kim, 2001). Third, a long-term process of "digital convergence" (e.g., Chandler and Cortada, 2000)**,** enabling the same infrastructure to accommodate manipulation and transmission of voice, video, and data,

has created new opportunities for organizational learning and knowledge exchange across organizational and national boundaries, hence magnifying the first two transformations.

There are widespread expectations that the Internet, the latest incarnation of digital convergence, may further accelerate these transformations (e.g., Department of Commerce, 2000b). By transmitting information in digital format instantly, and at much lower cost than earlier technology generations (like electronic data interchange, EDI), the Internet substantially broadens the scope for collaboration across organizational and national boundaries. A new generation of networking software provides flexible infrastructures that, computer scientists claim, "support not only information exchange, but also knowledge sharing, creation and utilization." (Jørgensen and Krogstie, 2000). The key is the open-ended structure of the Internet, which allows extra networks to be added at any point, creating almost unlimited opportunities for outsourcing and the diffusion of knowledge.

Placing GPN on the Internet will have important - but as yet uncertain - implications for Developing Asia[1], a region that has seen a progressive integration into GPN (Borrus, Ernst, and Haggard, 2000; Ernst and Ravenhill, 1999)[2]. This transformation may strengthen further the dominant position of global network flagships, providing them with new opportunities for effective time management, knowledge outsourcing, and the rationalization of global supply chains. Flagships now have much greater opportunities to select best-performing suppliers on a global scale, increasing the pressures on Asian suppliers. On the other hand, the transition from EDI to the Internet may also provide new opportunities for Asian firms, by reducing barriers to network entry, and by enhancing knowledge diffusion.

There is a huge efficiency gap between Asia's manufacturing systems and the management of supporting digital information systems. The *challenge* is to reduce this gap as quickly as possible by embracing the Internet as a core business function. A vicious circle needs to be broken: a belated transition to digital information systems has prevented the accumulation of knowledge of how to design and implement an appropriate IT organization that reflects the peculiar strengths and weaknesses of diverse Asian management systems. Limited financial and human resources imply that in-house efforts need to be supplemented with outsourcing of IT services. The Internet facilitates this task: it provides opportunities for the outsourcing of mission-critical support services, such as ERP (enterprise resource planning), HRM (human resource management), SCM (supply chain management) and CRM (customer relations management). Furthermore, fierce competition among major producers of Internet software and networking equipment has created a buyers` market - placing Asian firms in a reasonably strong bargaining position. They may also find it easier to recruit specialized IT skills, due to massive retrenchments in the US and Europe.

[1] These issues are addressed in an international policy-oriented research project, coordinated by the East-West Center, on "Placing the Networks on the Internet - Global Production Networks and Local Capability Formation in Developing Asia".

[2] These networks now integrate the region's geographically dispersed, yet concentrated and specialized clusters that feed into triangular trade (Ernst and Guerrieri, 1998).

A conceptual framework is introduced in parts 1 to 3 to assess how the Internet reshapes business organization and GPN. We first highlight expected benefits from Internet-enabled transformations of business organization. In part 2, we argue that the real issue is to analyze how the Internet reshapes the organization of global production networks. In part 3, we assess conflicting claims on how an increased use of the Internet to manage global production networks will affect Asian firms. That framework is then applied to one of the role models of managing in Asia, Taiwan´s Acer Group, to highlight the challenges and opportunities (parts 4 and 5).

1. Expected Benefits - A Taxonomy

Surprisingly, the impact of the Internet on business organization is still a largely neglected research topic. Until recently, important contributions to information management neglect and hardly mention the Internet and the world-wide web[3]. Very little research exists on how the Internet reshapes business strategy and organization, and how this affects industry structure[4]. A simple taxonomy can help to identify expected benefits from Internet-enabled changes of business organization. The Internet transforms economic transactions, by reducing the cost and speed of communication, and by enhancing the scope for knowledge diffusion. Three benefits can be distinguished: marketization, organizational innovations and outsourcing.

Marketization

It is argued that the new "digital markets" created by the Internet will increase the "*marketization"* of economic transactions (e.g., Department of Commerce, 2000a). The Internet certainly enables sellers to reach a broader market much more rapidly: a company that has an on-line business potentially has a worldwide market. Equally important is a qualitative improvement in market intelligence: sellers are now in a much better position to track and analyze their customer´s needs and purchasing habits[5]. In turn, the Internet provides buyers with a wider selection of suppliers. It also provides them with a powerful tool for comparing alternative offers, in terms of prices, quality and delivery conditions.

It would be misleading however to expect that the Internet will change relative positions of economic power between buyers and sellers. For instance, earlier expectations that the Internet will shift market power to buyers, especially in business-to-consumer (B2C) markets, have failed to materialize. The same is true for the initial hype that the Internet would bring about a pervasive "disintermediation" of economic relations

[3] An important book like Strategic Planning for Information Systems (Ward and Griffiths, 1996) mentions the Internet just once, but then as a synonym for the information super highway. And the edited volume Global Information Technology and Systems management (Palvia et al, 1996) mentions the Internet briefly three times on its more than 600 pages, but fails to provide an explicit analysis.

[4] Noteworthy exceptions are Nolan (2000), Hagstrøm (2000), Brynjolfsson and Hitt (2000), and Evans and Wurster (2000).

[5] This has raised concerns about invasion of data privacy.

that would drive down prices and would render markets ever more transparent. The basic laws of competitive dynamics continue to matter; they may be modified, but they have not been rescinded.

Organizational innovations

Following Brynjolfsson and Hitt (2000), we argue that the impact of the Internet on economic performance is mediated by a combination of intangible inputs as well as intangible outputs that act as powerful catalysts for organizational innovations. Intangible inputs include, for instance, the development of new software and databases; the adjustment of existing business processes; the recruitment of specialized human resources and their continuous upgrading; and, induced by all of this, the transformation of existing organizational structures and business strategies. Of equal importance are intangible outputs that would not exist without the Internet, like speed of delivery, flexible customization, the transition to a built-to-order (BTO) production model, and improved customer-relations management (CRM).

After a while, these induced organizational changes lead to productivity growth, by reducing the cost of coordination, communications and information processing. Most importantly, these organizational changes enable firms "to increase output quality in the form of new products or in improvements in intangible aspects of existing products like convenience, timeliness, quality and variety." (Brynjolfson and Hitt, 2000, p.4). In short, we are talking about a complex process that involves a set of inter-related ("systemic") changes: by combining the Internet with changes in work practices, strategies, and products and services, a firm transforms its organization as well as its relations with suppliers, partners and customers.

The possible benefits from an Internet-enabled transformation of business organizations are enormous. The Internet provides ample scope for cost reduction across all stages of the production process both for the flagship company and Asian suppliers. Procurement costs can be reduced by means of expanded markets and increased competition through Internet-enabled online procurement systems. Another cost-reducing option is to shift sales and information dissemination to lower-cost channels. By moving customer service and technical support online, for example, Cisco Systems, a leading networking equipment vendor, increased productivity by 200–300 per-cent, resulting in savings of $125 million in customer service costs.

The Internet can also drastically accelerate speed-to-market by reducing the time it takes to transmit, receive, and process routine business communications such as purchase orders, invoices, and shipping notifications. The Internet has greatly expanded the scope for information management: documents and technical drawings can be exchanged in real time, legally recognized signatures can be authenticated, browsers can be used to access the information systems of suppliers and customers, and transactions can be completed much more quickly.

A further advantage can be found in the low cost of expanding a functioning network. While establishing a network requires large upfront fixed investment costs (purchasing equipment, laying new cable, training), the cost of adding an additional user to the network is negligible. The value of the network thus increases with the number of participants ("network externalities").

An especially important benefit is a reduced trade-off between the richness and the reach of information (Evans and Wurster, 2000). Until recently, more complex, detailed, nuanced information could only be shared by a very small number of people; increasing the "reach" of such information sharing requires a reduction in "richness." The Internet provides far greater opportunities to share rich information with a far greater number of people.

Outsourcing

The open-ended structure of the Internet substantially broadens the scope for *outsourcing*. Both network flagships and first-tier suppliers have shifted from *partial* outsourcing, covering the nuts and bolts of manufacturing, to *systemic* outsourcing that includes knowledge-intensive support services. This has intensified the competition among the providers of outsourcing services: competition now focuses on the capacity to provide manufacturing and design services wherever required[6]. What matters is the variety of outsourcing arrangements that the Internet has generated. Our first example concerns the outsourcing of logistics services. FedEx, for example orchestrates the assembly and shipping of laptop computers for Fujitsu; this has enabled Fujitsu to reduce the time consumers have to wait for an order from 10 days to 3 or 4 days. By turning over much of its computerized distribution system to FedEx, Fujitsu has been able to remove the warehousing and inventory costs from its supply chain, cutting inventory 90 percent.

Increasingly however the focus of outsourcing is shifting to knowledge-intensive support services, including most aspects of information management. For instance, Internet service providers (ISP) provide fee-based access to Internet applications and resources for individuals and companies. Web hosting refers to the outsourcing of web site design and maintenance to specialized third party companies that can reap economies of scale and scope. And application service providers (ASP) provide mission-critical applications, such as ERP, HRM, SCM and CRM on a subscription basis.

While the Internet acts as an important enabling technology, there are additional reasons to expect outsourcing pressures to grow: the IT skills shortage[7]; the speed and

[6] Take the electronics industry. For lower-cost outsourcing, network flagships can now choose between alternative locations, established by major contract manufacturers in Asia, Latin America, the former Soviet bloc, and the European periphery. For higher-end outsourcing, flagships can choose between specialized clusters in Nordic countries, the US, France and Germany, as well as Israel, Ireland, and Hungary

[7] During 2000, it was projected that 50% of the 1.6 million IT-related jobs in the US would remain unfilled (Information Technology Association of America, May 10, 2000, at: www.ita.org). Since then, however, the global downturn in the electronics industry has relieved this pressure. Massive retrenchments in the US and Europe may now increase (at least for a while) developing Asia`s

unpredictability of changes in Internet technologies and markets, which makes it risky anyway to sustain large in-house IT workforces; and the high life-cycle costs of purchasing and maintaining networking equipment and Internet applications[8]. Equally important is that intense competition among major producers of Internet software and networking equipment has created a buyers` market, forcing major vendors to rely on outsourcing as an important market penetration strategy.

2. The Real Issue: Transforming Global Production Networks

Misconceptions

Our next step is to clarify two misconceptions that have dominated management debates in Developing Asia on the impact of the Internet. First, there has been a disproportionate concern with the role of business-to-consumer dotcoms. This is in sharp contrast to the development of the global E-commerce market, where business-to-business (B2B) transactions grow in leaps and bounds, leaving behind B2C transactions.

Second, the established terminology is confusing, and obscures an important aspect of the transformation of business organization. The key word is *e-commerce* which is defined as transactions made over computer networks, such as EDI or the Internet, between unrelated buyers and sellers (e.g., Department of Commerce, 2000a:1). E-commerce implies that the Internet creates new "digital markets" and hence will increase the "marketization" of economic transactions. This neglects a fundamental characteristic of contemporary competitive dynamics: A large share of economic transactions actually takes place *within* GPN, established by large MNEs (the network flagships). The real issue then is to assess the effect of the Internet on the organization of such networks, and to explore how this affects managing in Developing Asia.

Hierarchical Global Production Networks

GPN integrate the dispersed supply and customer bases of the network flagship, i.e. its subsidiaries, affiliates and joint ventures, its suppliers and subcontractors, its distribution channels and value-added resellers, as well as its R&D alliances and cooperative agreements, such as standards consortia[9]. This may, or may not, involve ownership of equity stakes. These networks do not necessarily give rise to less hierarchical forms of firm organization (as predicted for instance in Bartlett and Ghoshal, 1989; Nohria and Eccles, 1992). Network participants differ in their position within such networks, and hence face very different challenges. We use a taxonomy that distinguishes various hierarchical layers of participants that range from *flagship companies* that dominate such networks, down to a variety of usually smaller, local network participants (Ernst, 2000b). The flagship is at the heart of a network: it provides strategic and

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access to IT skills.

[8] While intense competition reduces unit prices of Internet software and networking equipment, the frantic pace of technological change in both areas has drastically cut product-life cycles. For each generation, this has increased the life cycle costs of purchase and maintenance.

[9] For details, see e.g., Ernst, 1994, 1997a, 1997b, 2001b, and Ernst and Ravenhill, 1999. For empirical case studies on diverse GPN, see Borrus, Ernst and Haggard (eds.), 2000.

organizational leadership beyond the resources that, from an accounting perspective, lie directly under its management control (Rugman, 1997: 182).

A global flagship breaks down the value chain into a variety of discrete functions and locates them wherever they can be carried out most effectively, where they improve the firm's access to resources and capabilities, and where they are needed to facilitate the penetration of important growth markets. This reflects increasing pressures to exploit complementarities that result from the *systemic* nature of knowledge (Antonelli, 1998). The strategy of the flagship thus directly affects the growth, the strategic direction and network position of lower-end participants, like specialized suppliers and subcontractors from Developing Asia. The latter, in turn, " have no reciprocal influence over the flagship strategy" (Rugman and D´Cruz, 2000, p.84)[10]. The flagship derives its strength from its control over critical resources and capabilities that facilitate innovation (e.g., Lazonick, 2000), and from its capacity to coordinate transactions and knowledge exchange between the different network nodes. Both are the sources of its superior capacity for generating profits.

Increasing vertical specialization is the fundamental driver of this flagship model of industrial organization (Ernst, 2001a). Flagships retain in-house activities in which they have a particular strategic advantage; they outsource those in which they do not. It is important to emphasize the diversity of such outsourcing patterns (Mowery and Macher, 2001; Ernst, 1997b). Some flagships focus on design, product development and marketing, outsourcing volume manufacturing and related support services. Other flagships outsource as well a variety of high-end, knowledge-intensive support services. This includes for instance trial production (prototyping and ramping-up), tooling and equipment, benchmarking of productivity, testing, process adaptation, product customization and supply chain coordination. It may also include design and product development.

The result is that an increasing share of the value-added becomes dispersed across the boundaries of the firm as well as across national borders. Even if these activities do not involve formal R&D, they may still require a substantial exchange of knowledge. Hence, under certain conditions, global production networks may enhance the diffusion of knowledge across firm boundaries and national borders and, arguably, improve the opportunities for managing in developing Asia.

Carriers of Knowledge Diffusion

[10] With Rugman`s flagship model, we share the emphasis on the hierarchical nature of these networks. However, there are important differences. Rugman and D`Cruz (2000) focus on localized networks within a region; they also include "non-business infrastructure" as "network partners". We do not share their assumption that a combination of transaction cost and resource-based theory is sufficient to explain such forms of business organization.

Let us recapitulate the fundamental rationale of GPN: they help flagships to sustain their competitiveness, by providing them with access to specialized suppliers at lower-cost locations that excel in quick and flexible response to the flagships` requirements. The flagships can exert considerable pressure on local suppliers, especially in small developing countries: they can discipline suppliers by threatening to drop them from the networks whenever they fail to provide the required services at low price and world class quality.

At the same time, GPN also may act as powerful carriers of knowledge. Two effects can be distinguished: First, GPN can act as a conduit for knowledge diffusion for state-of-the-art management approaches as well as product and process technologies, including the required tacit knowledge. At the same time, the requirements of network flagships can also provide both pressures and incentives to catalyze knowledge creation and capability development within firms and industrial districts in small economies.

Flagships need to transfer technical and managerial knowledge to the local suppliers. This is necessary to upgrade the suppliers` technical and managerial skills, so that they can meet the technical specifications of the flagships. Second, once a network supplier successfully upgrades its capabilities, this creates an incentive for flagships to transfer more sophisticated knowledge, including engineering, product and process development. This reflects the increasingly demanding competitive requirements that we referred to earlier. In the electronics industry for instance, product-life-cycles have been cut to six months, and sometimes less (Ernst, 2001a). Overseas production thus frequently occurs soon after the launching of new products. This is only possible if flagships share key design information more freely with overseas affiliates and suppliers. Speed-to-market requires that engineers across the different nodes of an GPN are plugged into the flagship´s design debates (both on-line and face-to-face) on a regular basis.

In short, GPN expose local suppliers to the flagship`s management practices and technological knowledge. International technology transfer has been extensively studied, but research has primarily focused on such formal mechanisms as foreign direct investment and foreign licensing. These formal mechanisms, however, are only the tip of the iceberg. A larger amount of technical knowledge is transferred through various informal mechanisms that involve a substantial amount of tacit knowledge (e.g., Westphal, Kim and dahlman, 1985; Wong, 1991; Kim, 1997; Ernst, Ganiatsos and Mytelka, 1998; Saxenian, 2001; Ernst, 2000). This includes early supplier involvement in product design and prototype development; access to proprietary technical and marketing information on end users` requirements and on competitors' products; informal sharing of technical information and ideas between the flagship and different network nodes; and knowledge exchange through informal, transnational peer group networks[11].

[11] Of course, knowledge transfer is not a sufficient condition for effective knowledge diffusion. Diffusion is completed only when transferred knowledge is internalized and translated into the capability of the local suppliers (e.g., Kim, 1997, and Ernst, Mytelka and Ganiatsos, 1998). Much depends on the motivations, resources and capabilities of local suppliers (Ernst and Kim, 2001). These issues are at the center of current industrial policy debates, and hence are beyond the scope of this article.

Typically, the flagships` outsourcing requirements have become more demanding. Cisco for instance selects suppliers according to three criteria: a solid financial standing; high ratings on a quarterly scoreboard measuring performance in delivery, quality etc.; and speed of response. The latter is of critical importance: suppliers are expected to respond within hours with a price, a delivery time, and a record on their recent performance on reliability and product quality. This implies that local suppliers can only upgrade or perish. To stay on the GPN, local suppliers must develop their capabilities through internalizing transferred knowledge. The only way for suppliers to survive the intense pressures imposed by the flagships, is to upgrade from a position of simple contract manufacturers (so-called "box shifters") to providers of integrated, knowledge-intensive support service packages.

At the same time, network participation can also provide an incentive for local suppliers to invest in their knowledge base and capabilities. This requires however that the flagship reduces the perceived risk of such investments through a longer-term commitment; that network participation provides the supplier with a stable source of income to finance the investment; and that the network offers access to superior market and technology information that may reduce the risks involved in the investment decision. Of course not all networks meet these fairly demanding requirements[12].

3. Impact of the Internet - Assessing Conflicting Claims

In short, under certain circumstances, GPN may provide a combination of new opportunities, pressures and incentives for local suppliers to upgrade their capabilities. How will an increased use of the Internet to manage global production networks affect Asian firms? What new opportunities does this create for managing in Developing Asia, especially for local capability formation? And what forces constrain the capacity of Asian firms to reap such benefits? Both pessimistic and optimistic scenarios are possible[13].

Pessimistic Scenario

A pessimistic scenario emphasizes potential negative implications for Developing Asia. First, access to Internet-based technologies and organizational innovations is highly unequal (OECD, 2000, chapter 3; Ernst and Jiacheng, 2000). Outside the industrial heartlands of the U.S., Japan and Europe, fundamental constraints exist to *access* (spread and capacity of information infrastructure), *connectivity* (variety of linkages) and *receptivity* (capacity to receive and absorb information). In Asia, for instance, there is only one direct Internet link between two Asian cities, Tokyo and Seoul. More than 99%

[12] It is now well established that nationality of ownership of network flagships, home country institutions and product mix (specialization) explain why GPN differ in their governance structures, and hence in the incentives they provide for upgrading investment by local suppliers (Ernst and Ravenhill, 1999; Borrus, Ernst and Haggard, 2000, chapter1).

[13] The East-West Center project, mentioned above, assesses these conflicting scenarios, based on structured interviews with global network flagships, Asian suppliers and Internet service providers.

of the international Internet traffic in Asia is routed through the US. This will slow down access of Asian firms to broad bandwidth, which is essential for reaping productivity benefits. It constrains the region´s capacity to adjust the evolving Internet architecture to the specific needs and capabilities of its firms and public sectors. It will also make it more difficult to develop a strong regional pool of hardware and software companies that provide Internet infrastructure equipment.

Thus far Japan has failed to act as the region's engine for the rapid spread of Internet-based changes in business organization. This is primarily due to Japan's weak economy, but there are also important structural constraints at work. The Japanese system is resistant to change, and this is amplified by its sluggish political system, high Internet-access charges, and its lack of a standardized payment system. There are however expectations that this will change, as Japan moves ahead with ambitious plans to develop powerful broadband technologies.

Japan is scheduled to be the first country to introduce 3G mobile telecommunications during 2001. This aggressive schedule reflects the interest of the leading Japanese hardware producers who need unified global standards to reap economies of scale. However, Japan´s previous experience with its aggressive promotion of so-called HDTV (= high-definition TV) standard for analogue systems indicates the substantial risks involved: a premature bet on a standard that fails to succeed could very well produce a negative lock-in effect. It is also an open question whether NTT-DoCoMo's leadership in wireless Internet ("i-mode") will change this picture, or whether this is a costly impasse that distracts scarce resources away from catching-up with the US lead in placing GPN on the Internet[14].

Even within developing Asia itself substantial disparities are now emerging. Most notably, Korea's e-business market is projected to be 2.5 times the size of China's by 2005, and larger than the combined markets of Singapore, the rest of Southeast Asia, India, and Hong Kong. This reflects Korea's higher stage of development, its broader knowledge base, and its more robust national information infrastructure.

In some ways the Internet may actually increase inequality by further concentrating power in the upper strata of business networks. Network flagships and first-tier suppliers are under increasing pressure to reduce the high costs of network coordination that result from multiple sourcing, duplication of tasks, and excess capacity. In addition, suppliers are now confronted with much more demanding requirements in terms of performance, efficiency, and speed. All of this may be disastrous for lower-tier suppliers who lack the financial muscle and technology to respond to these pressures. The Internet may also increase network entry barriers: it facilitates a shift from partial outsourcing, which covers the nuts and bolts of manufacturing, to systemic outsourcing, which includes knowledge-intensive support services and calls for capabilities that lower-tier network participants may not possess. We may therefore see an erosion of the

[14] Note that NTT-DoCoMo failed to keep its originally planned introduction date for 3G technology in April 2001.

broad base of the network pyramids—many of the smaller, lower-tier suppliers of developing Asia may be pushed out of business.

Optimistic Scenario

Alternatively, there are strong considerations that argue for a more optimistic view. Placing global production networks on the Internet creates new entry opportunities for smaller players, providing them with powerful channels for knowledge outsourcing and capability development. Electronic data interchange (EDI), the predecessor of Internet-enabled e-business, was a useful tool but was too expensive for smaller firms. In the United States, while 95 percent of Fortune 500 companies used EDI extensively, only 2 percent of firms overall could afford to do so. The Internet is likely to reduce such barriers by reducing the costs of communication.

Reduced access costs will enable smaller firms in developing Asia to participate in Internet-enabled global production networks while outsourcing most aspects of their information management. There are service providers that offer fee-based access to Internet resources for individuals and companies. Web-site design and maintenance can be outsourced to specialized third-party companies that can reap economies of scale and scope, while application-service providers offer, on a subscription basis, important applications such as enterprise resource planning and the management of human resources, supply chains, and customer relations.

The opportunity to outsource can make a critical difference, since most Asian suppliers to global production networks have little knowledge concerning information management. Many do not possess the necessary technology and have been handicapped by the financial crisis. They lack the financial resources, the human resources, and the knowledge to develop the necessary critical services in-house. For example, the cost of building and maintaining an e-commerce website averages between $500,000 and $2.5 mil-lion per year (plus expenditures for training), well beyond the means of small and medium-sized enterprises. Outsourcing such services can thus provide the missing link to reaping the benefits of network participation, especially for lower-tier suppliers in developing Asia.

Another important argument for the optimistic scenario considers the impact of the Internet on the diffusion of knowledge. The Internet not only provides rapid and lower-cost access to information; it can also reduce the friction of time and space for the exchange of knowledge, far surpassing earlier generations of information technology. In principle, closer and smoother interactions can be established between distant industrial sites that are connected within global production networks. In this way, the Internet may enhance the potential for learning and innovation among participants by introducing inter-active and real-time transactions or other forms of communication that connect participants—buyers, sellers, designers, production managers, and so on—instantaneously, creating virtual teams that can engage in interactive learning across great distances. With the transition from EDI to the Internet, all network participants can now

interact with each and every other participant. For each of these different interactions, it is possible to customize information appropriately.

Vastly improved search capabilities for information and knowledge are now at the disposal of even small firms. This implies that the latter can now move beyond the status of possible recipients, and can actively search for and shape information and specialized knowledge. Global network flagships are no longer alone in their quest for worldwide knowledge sourcing. For developing Asia, the Internet provides a historic opportunity to benefit from enhanced international knowledge diffusion.

4. Challenges - The Case of Taiwan´s Acer Group

A Belated Transition to Digital Information Systems

Acer exemplifies an important puzzle that confronts Developing Asia´s electronics industry. While being a major producer of electronics equipment and components, especially related to computing, the company was late to understand the critical importance of information technology as a tool to enhance its operational efficiency. During the 1990s, Acer was highly successful in establishing a low-cost and flexible approach to the development of its GPN[15]. Based on informal, social peer group linkages, Acer´s decentralized "Client-Server" model provided considerable flexibility to respond quickly to changes in markets and technology (Ernst, 2000).

However, this model now has reached its limits, not only with regard to cost efficiency, but, more importantly, with regard to speed-to-market and flexibility. The catalyst has been the emergence of the "built-to-order" model in the PC industry, pioneered by Dell and others, that now requires a capacity to combine price leadership, quality and customer services with product differentiation and speed-to-market. Severe price wars, and especially the emergence of low-cost PCs, put enormous pressure on second-tier PC brands: Acer was literally pushed out of the US market and was overtaken by Compaq in former strongholds like Mexico. Serious problems also emerged with service and support, which are critical in the consumer markets that Acer had targeted with its PC models. Acer faces a fundamental challenge: Based on Internet-enabled "virtual integration", the BTO-model is far superior to Acer`s model that had tried to combine a broad product portfolio[16] and vertical integration with a decentralized management structure based on informal relations.

The Impact of Globalization

[15] From humble origins, Acer has grown within less than two decades into a global network flagship that employs more than 32,000 people in 120 enterprises in 37 countries, supporting dealers and distributors in over 100 countries.

[16] Acer´s extremely broad product portfolio covers not only PCs and peripherals, but also semiconductors, electronic components, software, Internet services, publishing, multimedia content, distribution, and real estate development.

Probably the greatest challenge to the Acer model came from the rapid geographic dispersion of Acer´s production networks to overseas locations, primarily in Southeast Asia and China. Out of Acer´s 21 manufacturing sites, six are large volume manufacturing sites located overseas: two in China, and one each in the Philippines, Malaysia, Mexico and Wales. Equally important are Acer`s 19 overseas final assembly and configuration centers that are much more geographically dispersed to major markets. Adding further complexity, Acer needs to integrate its networks into the GPN of major OEM customers, like IBM (its largest customer).

The coordination of such "networks of networks" requires highly efficient communication. Yet, Acer`s external communication with vendors, distributors, OEM customers and suppliers continues to rely on informal information systems, based on personal contacts through meetings, phone calls, and faxes. Within Taiwan, this system worked reasonably well, due to the dense supply network in the Taipei-Hsinchu cluster. Once manufacturing moved overseas however, these informal networks could not be transplanted. There was no alternative but to develop more structured information systems that facilitate information exchange and knowledge diffusion and that help to improve coordination

It was only since 1998 that Acer has started to address these problems. Management attempted to reduce it product portfolio for OBM products. Simultaneously, the company was reorganized along five major product lines in order to improve coordination among Acer´s many business units. These moves were accompanied, at long last, by substantial investments in formalized, IT-based information networks that were meant to address major weaknesses in inventory control and supply chain management.

The Evolution of Acer`s IT Organization

In line with its decentralized business model, Acer`s IT organization was characterized by high fragmentation: each business began to build its own information systems with functions appropriate to its own needs, but without much concern for the requirements of other units, or the whole group. The resultant patchwork of decentralized IT systems accentuated the problems that had been created earlier by informal, personalized information systems. Top management lacked information on what individual business units were doing. Nor was its possible to exchange on-line information between units. This increased inventory and stifled quick response to emerging problems. It also prevented an effective monitoring of financial performance and obstructed strategic marketing. Fragmentation of IT systems also prevented the sharing of IT resources across business units, and hence increased the cost of developing these systems.

Since 1998, Acer has undertaken various initiatives to introduce Internet-based information systems to its PC business. These initiatives have focused on three areas: customer relations, supply chain management, and the rationalization of Acer´s GPN. Given the sorry state of customer relations, especially in the US, this business function

required immediate action[17]. Supply-chain-management (SCM) has been a second important weakness, where Acer was lagging behind best practice, especially with regard to inventory and speed-to-market. Acer has decided to implement i2 SCM software worldwide[18]. Implementing this system may even require more time than for customer relations management (CRM)[19].

Establishing Internet-Enabled Production Networks

The next and most difficult step will be to extend the Internet to the rationalization of Acer´s GPN, but this will be a long and challenging process. This reflects the messy state of Acer´s GPN: there is not one network, but a patchwork of networks run by different business units, with very little interaction and sharing of network resources. In order to get the process of streamlining started, Acer has begun working with major OEM clients (especially IBM) to develop close EDI and Internet-based linkages.

As for the other side of the coin, Acer`s links with its suppliers, apparently not much has happened thus far. Unifying these multi-tier networks into one global SCM system is a truly mind-boggling challenge: some of these networks are overwhelmed, while others are underused, and the composition of these networks keeps constantly changing, especially at the lower-tier levels. There has been some talk of studying how to develop a community network with suppliers. However, catching-up based on purely in-house efforts is no longer a realistic option (see below).

Implementation

To implement this strategy, Acer has gone through yet another round of organizational restructuring, and established the Acer Digital Services Group (ADSG). One of its tasks is to invest in and develop Internet-related businesses and to coordinate Acer´s operational Internet systems[20]. It will be difficult to implement the IT-related

[17] The first step was to establish an integrated worldwide customer database, based on Siebel 99 CRM software. Asia is used as the initial testing-ground: Acer relies on Andersen Consulting to model its service business, look at future customer service needs and implement Siebel 99. In a second step, experience gained in Asia is then supposed to feed into the revamping of customer relations in the US, where Acer is working with a small specialized consultancy to upgrade its existing CRM software. Implementation proceeds step by step by region, centered on regional data centers (one or two in Asia, one in the US, and one in Europe) and three regional call centers (North America, Asia, Europe) that can offer customers 24-hour service. The challenge of course will be to transform these regional subsystems into a unified global system built on standardized procedures. (Dedrick, Kraemer and Tsai, 1999)

[18] Dallas-based i2 Technologies, founded by Sanjiv Sidhu, is the world leader in an area of supply chain optimization known as advanced planning and scheduling (APS). The company is a pioneer, since the early 1990s, in preaching the benefits of using clever algorithms to plan and optimize corporate supply chains.

[19] The first step was to implement factor planning software in Acer`s US and European plants. This is supposed to be followed by the implementation of i2 software in Acer´s main manufacturing plants and purchasing offices in Taiwan.

[20] It remains unclear however what are its specific objectives, and whether this new group has enough power to push through an effective transformation of Acer`s information organization.

initiatives that we have described before, due to Acer' s highly decentralized organization. Acer also has little experience in managing IT-based information systems. An equally important constraining factor is a Babylonian mixture of hardware platforms and software programs, which makes it difficult to inter-connect the existing disparate systems so that they can effectively communicate and share information.

Another complicating factor is Acer´s policy to "run Acer on Acer", i.e. to use as much as possible its own PCs and its Altos servers. In principle, this is a good idea, as it can strengthen Acer`s capacity to design and manage Internet-based information systems. Yet, it has substantial disadvantages in terms of cost and time required. This is arguably a major drawback in an industry that suffers from intense price competition and where speed-to-market for new products is of critical importance. There is a vicious circle involved. Acer`s earlier success with decentralized organization and informal, personalized information systems delayed the transition to IT-based information systems. This in turn prevented the accumulation of knowledge, through trial-and-error, of how to design and implement an appropriate IT organization that can address the peculiar strengths and weaknesses of this company. Limited resources prevented an attempt to address these problems in a big leap forward. Acer was unlikely to succeed where even major industry players like Compaq had stumbled.

5. What Acer´s Experience Tells Us About Opportunities

Outsourcing of IT Services & Strategic Partnering

This arguably explains why, over the last few months, Acer has aggressively pursued outsourcing of IT services and a number of strategic alliances to catch up rapidly and at reasonable cost. Let us look at four examples that illustrate what are realistic opportunities as well as some potential drawbacks[21].

Entry into the Market for Internet-Based Business Management Solutions

A first step has been to establish a joint venture with an industry leader, Computer Associates, to develop software that will enable Taiwanese companies, including SMEs, to conduct financial management over the Internet. This enables Acer to collect feedback information on customer requirements, and to use this as a base for improving Acer`s own information management. CA wants to penetrate a potential new growth market for its business management application software ACCPAC that is well established in the US market. For Acer, this venture has three interesting features: First, Acer`s contribution will be to provide localization services, marketing, sales and logistics. Its main task is to adapt ACCPAC to incorporate Chinese language, as well as Taiwan´s peculiar financial practices, laws and regulations. Based on access to the program´s source code, this provides Acer with invaluable information on the design of Internet-based business management solutions.

[21] The following is based on press releases at acer.com, and phone interviews.

Second, KPMG Taiwan plans to use the joint venture`s solutions to assist Taiwanese SMEs to establish and manage such systems. This in turn will provide Acer with feedback on what is needed to manage and maintain Internet-based management systems. Third, the joint venture´s general manager will be a prominent industry executive with more than 10 years´ experience with leading companies such as Sun Microsystems and Bell Labs. This is likely to facilitate the diffusion of complementary tacit knowledge to Acer´s management.

Marrying OEM with Contract Manufacturing: Acer`s Alliance with Solectron

Another way to learn quickly the tricks and pitfalls involved in Internet-based SCM, is to link up with one of the leading electronic contract manufacturers. The latter firms provide outsourcing services on a fee basis across the value chain, that extend well beyond the nuts and bolts of manufacturing. In the process, these companies have developed best-practice IT-based global supply chain management systems.

In October 1999, Acer announced an alliance with Solectron, based in Milpitas/Ca, the world`s largest electronics manufacturing services company, to jointly provide Internet-enabled computer design, manufacturing and service solutions for desktop PCs, servers and workstations[22]. The immediate objective of this alliance is to accelerate speed-to-market for both companies, and to combine Acer`s manufacturing prowess with Solectron`s superior capacity for global supply chain management. This will provide Acer with low-cost access to critical tacit knowledge about how to run an Internet-based global production network (Solectron`s key competitive advantage).

Acer`s Joint Venture with GE Information Services

A third possible approach is to enter the market for Internet-based information systems for GPN ("e-commerce services" in industry parlance), by linking up with one of the major global players as an Asian junior partner. In December 1999, Acer announced a joint venture with GE Information Services, one of the leading global providers of interned-based e-commerce services[23]. The business plan foresees the venture to become the largest service center for business-to-business e-commerce in Asia by 2002. Initially, the following mission-critical services are provided for Internet-based SCM: buyer-seller matching, appropriate Internet transaction environment, and end-to-end supply chain systems. The venture will also establish a "center of excellence" to service Internet business users from Developing Asia.

[22] It is planned to extend this cooperation in the future to encompass laptops, a variety of emerging Internet appliances for wireless Internet applications, as well as for Internet-enabled built-to-order products where customers are able to customize the final configuration.

[23] As part of General Electric, GEIS has developed information systems for one of the world`s largest GPN: more than 100,000 participating firms in over 100 countries, with 293,000 employees. This has enabled GEIS to become a leading supplier of Internet-enabled SCM software.

For GEIS, the link with Acer provides a low-cost access to the Asian market, in cooperation with a leading Asian company with a well-established brand image. From Acer´s perspective, teaming up with GEIS is a low-cost approach to learning key features of Internet-based SCM. Acquiring this knowledge should help to improve the efficiency of Acer`s GPNs. This may also enable the company to enter this market as a quasi OEM supplier of certain components of such information systems, both hardware and software. This would have fascinating implications: companies from Developing Asia that successfully used the OEM route for knowledge outsourcing in manufacturing (Ernst, 2000a) may now well be able to replicate this approach for Internet-based information systems.

Outsourcing of Internet Services for the Acer Global Network

Finally, Acer announced in January 2000 that it will outsource the design, implementation and management of Internet services for its GPNs to AT&T Solutions, a leading supplier of such services.

The objective is to transform Acer´s six disparate GPNs that run on different legacy software programs into an integrated, global Internet-enabled information system. It is expected that this will improve the communication flow between GPN participants, such as diverse Acer groups, clients, suppliers and dealers, and hence reduce transaction costs and time-to-market, as well as exposure to glitches in quality and CRM[24]. Called "Acer Global Network", this unified Internet-enabled GPN will cover altogether 58 locations worldwide.

Outsourcing is only partial: Acer retains a finger in the pie, in order to increase the scope for learning. The Acer Global Network is managed by a task force jointly established by AT&T, Acer and Pagic, a joint venture of ADSG (Acer Digital Services Group) and Taiwan Cellular Corp., Taiwan`s largest private telecom company. Pagic is well qualified for knowledge outsourcing from this arrangement: it has assembled a workforce specialized in the development of value-added networking services, designed to accommodate the different business models of clients, providing an integrated Internet solution. Acer expects "…to learn the management skills from AT&T whilst building a stable global networking system." (Simon Lin, President of Acer Inc., the most important of Acer`s groups). For an Asian company, to achieve such a relatively symmetrical outsourcing relationship requires that it has valuable proprietary assets. In Acer´s case these are its reputation for flexible volume manufacturing at low-cost and high quality, as

[24] In the words of Stan Shih, Acer's co-founder and chairman: "I am confident that with their (i.e., AT&T´s) outstanding expertise we can significantly improve Acer´s global logistics and service quality." (Press release, acer.com, January 13, 2000).

well as its network of suppliers in Asia that can deliver whatever is needed at short notice.

Conclusions

This paper argues that placing global production networks on the Internet can act as a powerful catalyst for upgrading business organization and management in Developing Asia. This requires however that Asian firms overcome their reluctance to embrace the Internet as a core business function, and that they invest in IT as a strategic management system. The challenge is not primarily a financial one - access to funding may not be a major problem, as networking equipment vendors and Internet software companies are eager to penetrate the region`s emerging markets. The real challenge is to rethink established ways of managing that for much of the last three decades have worked well. The Internet provides a historic opportunity for the region to catch up in the development of structured digital information systems. It provides almost unlimited opportunities for the outsourcing of mission-critical support services. At the same time, fierce competition within the Internet industry has created a buyers` market - placing Asian firms in a reasonably strong bargaining position.

The real issue is how the Internet reshapes the organization of GPN and what this implies for the position of Asian network participants. While important constraints continue to exist in Developing Asia to access, connectivity and receptivity, the Internet can substantially reduce the barriers to enter GPN, especially for smaller Asian specialized suppliers. However, lower-tier suppliers without proprietary assets will suffer. Most importantly, the Internet is likely to improve substantially opportunities for international knowledge diffusion, which could provide a considerable boost to local capability formation. Yet again, this will work only for higher-tier suppliers that possess specialized capabilities.

Using this framework, we have taken a closer look at one of the role models of managing in Asia, Taiwan´s Acer Group. Its experience provides important lessons on the challenges and opportunities that the Internet raises for Asian firms. First, IT and globalization pose a challenge to idiosyncratic forms of Asian management. Acer´s attempt to run a global, multi-divisional and vertically integrated corporation with a highly decentralized management system, based on informal social information networks has turned out to be unsustainable. Not only did it fail to provide the drastic cost reductions required by pervasive price wars in the PC industry. Worse, it left Acer vulnerable in areas that were supposed to be its natural strengths: speed of response to changing markets, quality and customer relations management.

Second, it is important to understand the competitive dynamics that shape decisions on how to use the Internet. In the computer industry, the catalyst has been the emergence of the “built-to-order” model, pioneered by Dell and others. Based on Internet-enabled “virtual integration”, the BTO-model is far superior to Acer`s model that had tried to combine a broad product portfolio and vertical integration with a decentralized management structure based on informal relations. Third, a failure to develop an effective

digital information system resulted in poor coordination among the company´s many business units, a situation exacerbated by the informal, decentralized management system. This left Acer with little alternative but to move away from an outdated business model. A transition was necessary from a decentralized Client-Server model to a system that combines increasing outsourcing and strategic partnering with highly centralized forms of management control. Embracing the Internet as a key business function has facilitated this transition.

REFERENCES

Antonelli, C. (1998). The Microdynamics of Technological Change, Routledge, London.

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

Borrus, M., D. Ernst and S. Haggard (eds.) (2000). International Production Networks in Asia: Rivalry or Riches?, Routledge, London.

Brynjolfson, E. and L.M. Hitt, 2000, "Beyond Computation: Information Technology, Organizational Transformations and Business Performance", manuscript, Sloan School of Management, MIT, July.

Chandler, A. D. and J.W. Cortada, 2000, " The Information Age: Continuities and Differences", chapter 9 in: Chandler, A. D. and J.W. Cortada (eds.), A Nation Transformed by Information, Oxford University Press, Oxford and New York.

Dedrick, J., K.L. Kraemer and T. Tsai. "Acer: An IT Company Learning to Use Information Technology to Compete", working paper, Center for Research on Information Technology and Organizations, University of California, Irvine, October.

Department of Commerce (2000a). "The Electronic Commerce landscape: Technology and Business Converging", chapter D, in: U.S. Industry and Trade Outlook 2000, Washington, D.C.

Department of Commerce (2000b). Digital Economy 2000, third annual review, Washington, D.C.

Ernst, D. (2002), "Digital Information Systems and Global Flagship Networks - A New Divide in Industrial Organization", in: Industry and Innovation, Vol. 9,No.2 (August), special issue "Global Production Networks, Information Technology and Local Capabilities", guest editors: D. Ernst and Linsu Kim.

Ernst, D. (2001a). "The Economics of Electronics Industry: Competitive Dynamics and Industrial Organization", in: The International Encyclopedia of Business and Management (IEBM), editors: Malcolm Warner and William Lazonick, International Thomson Business Press, London.

Ernst, D (2001b). (forthcoming). "Global Production Networks and the Changing Geography of Innovation Systems. Implications for Developing Countries", special issue of the Journal of the Economics of Innovation and New Technologies , on "Integrating Policy Perspectives in Research on Technology and Economic Growth", edited by Anthony Bartzokas and Morris Teubal.

Ernst, D. (2000). "Inter-Organizational Knowledge Outsourcing. What Permits Small Taiwanese Firms to Compete in the Computer Industry?", in: Asia Pacific Journal of Management (John Wiley), special issue on "Knowledge Management in Asia", August.

Ernst, D. (1997a). "Partners in the China Circle? The Asian Production Networks of Japanese Electronics Firms", in: Barry Naughton (ed.), The China Circle, The Brookings Institution Press, Washington, D.C.

Ernst, D. (1997b).From Partial to Systemic Globalization. International Production Networks in the Electronics Industry, report prepared for the Sloan Foundation project on the Globalization in the Data Storage Industry, The Data Storage Industry Globalization Project Report 97-02, Graduate School of International Relations and Pacific Studies, University of California at San Diego (94 pages).

Ernst, D. (1994). "Network Transactions, Market Structure and Technological Diffusion - Implications for South-South Cooperation", in: L. Mytelka (ed.), South-South Cooperation in a Global Perspective, OECD, Paris.

Ernst, D. (1983). The Global Race in Microelectronics, with a foreword by David Noble, Massachusetts Institute of Technology (MIT), Campus Publishers, Frankfurt and New York, 290 pages.

Ernst, D. and Linsu Kim, 2001, "Global Production Networks, Knowledge Diffusion and Local Capability Formation. A Conceptual Framework", East West Center Working Paper: Economic Series # 19, April.

Ernst, D. and He Jiacheng, "The Future of E-Commerce in China", AsiaPacific Issues, No.46, East-West Center, Honolulu, October.

Ernst, D. and J. Ravenhill (1999). "Globalization, Convergence, and the Transformation of International Production Networks in Electronics in East Asia", Business & Politics, Vol I#1.

Ernst, Dieter and Paolo Guerrieri (1998). "International Production Networks and Changing Trade Patterns in East Asia. The Case of the Electronics Industry", Oxford Development Studies, Vol.26, No.2, June.

Evans, P. and T.S. Wurster (2000). Blown to Bits. How the New Economics of Information Transforms Strategy, Harvard Business School Press.

Fransman, Martin (1997). "Convergence, the Internet, Multimedia and the Implications for Japanese and Asian Tiger Companies and National Systems", paper presented at international symposium on "Innovation and Competitiveness in NIEs", STEPI, Seoul, May.

Fruin, W.M. (1997). Knowledge Works. Managing Intellectual Capital at Toshiba, Oxford University Press, New York and Oxford.

Hagstrøm, P. (2000), "New Wine in Old Bottles: Information Technology Evolution in Firm Strategy and Structure", in: Birkinshaw, J. and P. Hagstrøm, eds., The Flexible Firm. Capability Management in Network Organizations, Oxford University Press, Oxford etc.

Jørgensen, H.D. and J. Krogstie, 2000, "Active Models for Dynamic Networked Organisations", Working Paper # , Institute of Computer & Information Sciences, Norwegian University of Science and Technology, available from hdj.jok@ informatics.sintef.no.

Kim, Linsu (1997), *Imitation to Innovation: The Dynamics of Korea's Technological Learning,* Boston: Harvard Business School Press.

Lazonick, W. (2000), Understanding Innovative Enterprise: Toward the Integration of Economic Theory and Business History, manuscript, University of Masachusetss Lowell and The European Institute of Business Administration (INSEAD), Fontainebleau, May.

Nohria, N. and R.G. Eccles (1992), Networks and Organizations: Structure, Form,

and Action, Harvard Business School Press, Boston, Mass.

Nolan, R.L. (2000), "Information Technology Management since 1960", in: Chandler, A. D. and J.W. Cortada (eds.), A Nation Transformed by Information, Oxford University Press, Oxford and New York.

OECD, 2000, OECD Information Technology Outlook: ICTs, E-Commerce and the Information Economy, Paris.

Palvia, P.C. et al, eds (1996), Global Information Technology and Systems Management. Key issues and Trends, Ivy League Publishing, Nashua, MH.

Richardson, G.B., 1996, " Competition, Innovation and Increasing Returns", DRUID Working Paper #96-10, Department of Business Studies, Aalborg University, July.

Rugman, A. M. (1997), "Canada," Chapter 6 in J. H. Dunning (ed.) *Governments, Globalization and International Business,* London: Oxford University Press.

Rugman, A.M. and J. R. D´Cruz, 2000, Multinationals as Flagship Firms. Regional Business Networks, Oxford University Press, Oxford and New York.

Saxenian, A., 2002, "The Silicon Valley Connection: Transnational Networks and Regional Development in Taiwan, China and India", in: Industry and Innovation, Vol. 9,No.2 (August), special issue "Global Production Networks, Information Technology and Local Capabilities", guest editors: D. Ernst and Linsu Kim.

Teece, D. (1986). "Profiting from Technological Innovation", Research Policy, 15/6: 285-306.

Ward, J. and P. Griffiths (1996), Strategic Planning for Information Systems, 2nd edn., Chichester: Wiley.

Westphal, Larry, Linsu Kim, and Carl Dahlman (1985), "Reflections on the Republic of Korea's Acquisition of Technological Capability," in Nathan Rosenberg and Claudio Frischtak (eds.) *International Technology Transfer: Concepts, Measures, and Comparisons,* New York: Praeger, 167-221.

Wong Poh Kam, 1991, Technological Development through Subcontracting Linkages, Asia Productivity Organization, Tokyo.