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The New Mobility of Knowledge: Digital Information Systems and Global Flagship Networks

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INTRODUCTION

Digital information systems (DIS) are electronic systems that integrate software and hardware to enable communication and collaborative work (Chandler and Cortada, 2000). These systems are not developed in a vacuum. They are a response to transformations in economic institutions and structures that determine industrial dynamics. "Globalization" is a widely used short-hand for those transformations.

How does globalization interact with DIS? To answer that question, we need to open the blackbox of "globalization". We define "globalization" as the integration, across borders, of markets for capital, goods, services, knowledge, and labor. Barriers to integration continue to exist of course in each of these different markets (especially for low-wage labor), so integration is far from perfect. But there is no doubt that a massive integration has taken place across borders that, only a short while ago, seemed to be impenetrable.

This raises the question: Who are the "integrators"? States obviously play an important role in reshaping institutions and regulations. Equally important are private actors, especially large global corporations. Both sets of actors increasingly interact through complex digital formations, as outlined elsewhere in this book. The study of these formations allows us to identify what is "new" about the global economy.

This chapter focuses on digital formations centered in the corporate sector. It explores the link between transformations in international business organization and industry dynamics. The approach that I have chosen focuses on international knowledge diffusion through an extension of firm organization across national boundaries. A central argument is that two inter-related transformations in the organization of international

business may gradually reduce constraints to international knowledge diffusion: the evolution of cross-border forms of corporate networking practices, especially global flagship networks (GFNs), and the increasing use of digital information systems (DIS) to manage these networks. GFNs expand inter-firm linkages across national boundaries, increasing the need for knowledge diffusion, while DIS enhance not only information exchange, but also provide new opportunities for the sharing, and joint utilization and creation of knowledge.

This argument runs counter to a widespread belief, formalized by agglomeration and innovation economists and network sociologists, that knowledge is stickier in space (i.e. less mobile) than markets, finance or production facilities (e.g., Markusen, 1996; Archibugi and Michie, 1996; Breschi and Malerba, 2001). This is said to be true in particular for higher-level, mostly tacit forms of "organizational knowledge" required for learning and innovation. This chapter demonstrates that, in the emerging global network economy, we need to reconsider and amend the "stickiness-of-knowledge" proposition.

We first introduce two conceptual building blocks: a framework that links GFNs, DIS and knowledge diffusion, and a stylized model of forces that drive the development of GFNs. In section 3, we look at the economic structure and peculiar characteristics of the flagship network model that foster the new mobility of knowledge. We explore how two distinctive characteristics of GFN, that are enhanced by DIS, shape the scope for international knowledge diffusion: a rapid yet concentrated dispersion of value chain activities, and, simultaneously, their integration into hierarchical networks. Finally, in section 4, we explore some inherent contradictions of GFNs that reflect the increasingly complex nature of digital formations in the corporate sector. We conclude that the

combined forces of DIS and GFNs are gradually reducing constraints to international knowledge diffusion. But this occurs in complex ways. Knowledge diffusion has created new "cost-and-time-reduction centers" in lower-income regions that thrive on the timely provision of knowledge support services like supply chain management and design services. Yet, the sources of knowledge creation remain concentrated in a few global "centers of excellence" that combine unique capabilities in research, global branding and system integration (**e.g, Pavitt, 2002; Ernst, forthcoming**).

1. CONCEPTUAL FRAMEWORK

Figure 1 (GFNs, DIS and Knowledge Diffusion) describes a simple framework to explore the links between GFNs, DIS and knowledge diffusion

Figure 1 (GFNs, DIS and Knowledge Diffusion)

A GFN integrates a flagships dispersed production, customer and knowledge bases. Covering both intra-firm and inter-firm transactions and forms of coordination, the network links together the flagship´s own subsidiaries, affiliates and joint ventures with its subcontractors, suppliers, service providers, as well as partners in strategic alliances. While equity ownership is not essential, network governance is distinctively asymmetric. The new mobility of knowledge is an "unintended consequence" (Sassen, 2002) of the evolution of these corporate networks. Global corporations (the "network flagships") construct these networks to gain quick access to skills and capabilities at lower-cost overseas locations that complement the flagships' core competencies. Furthermore, flagships need to transfer technical and managerial knowledge to local suppliers. This is

necessary to upgrade the suppliers' technical and managerial skills, so that they can meet the technical specifications of the flagships. Originally this involved primarily operational skills and procedures required for routine manufacturing and services. Over time, knowledge sharing also incorporates higher-level, mostly tacit forms of "organizational knowledge" required for learning and innovation (Ernst and Kim, 2002). The more dispersed and complex these networks, the more demanding their coordination requirements. Knowledge sharing is the necessary glue that keeps these networks growing (Ernst, 2002a). In short, knowledge exchange penetrates new geographic areas, and the contents of knowledge become more complex.

The use of DIS as a management tool can enhance the scope for knowledge sharing among multiple network participants at distant locations. But these changes will occur only gradually, as a long-term, iterative learning process, based on search and experimentation. The digitization of knowledge implies that it can be delivered as a service and built around open standards. This has fostered the specialization of knowledge creation, giving rise to a process of modularization, very much like earlier modularization processes in hardware manufacturing. As a result, one of the most important recent developments that affect international knowledge diffusion is the rapidly growing trade in intellectual property rights (IPR) (Yau, and Das, 2001).

Under the heading of "e-business", a new generation of networking software provides a greater variety of tools for representing knowledge, including low-cost audio-visual representations (Foray and Steinmueller, 2001). Those programs also provide flexible information systems that support not only information exchange among

dispersed network nodes, but also the sharing, utilization, and creation of knowledge among multiple network participants at remote locations (Jørgensen and Kogstie, 2000). New forms of remote control are emerging for manufacturing processes, quality, supply chains, and customer relations. Equally important are new opportunities for the joint production across distant locations of knowledge support services (e.g., software engineering and development, business process outsourcing, maintenance and support of information systems, as well as skill transfer and training).

While much of this is still at an early stage of "trial-and-error", international business now faces a huge potential for extending knowledge exchange across organizational and national boundaries. But, as Sassen outlines in her contribution, the uncertainties and complexities of operating in global markets means that there are agglomeration economies to be derived from dense spatial concentrations of specialized network suppliers.

2. FORCES DRIVING GLOBAL FLAGSHIP NETWORKS

A defining characteristic of digital formations in the corporate sector is the transition from vertically integrated "multinational corporations" (MNCs), with their focus on stand-alone, equity-controlled overseas investment projects, to "global flagship networks" (GFNs) that integrate their geographically dispersed supply, knowledge and customer bases (Ernst, forthcoming). This contrasts with centuries of economic history where MNCs were the main drivers of international production (e.g., Braudel, 1992; Wilkins, 1970). Typically, the focus of MNCs has been on the penetration of protected markets through tariff-hopping investments, and on the use of assets developed at home to exploit international factor cost differentials, primarily for labor (e.g., Dunning, 1981).

This has given rise to a peculiar pattern of international production: stand-alone offshore production sites in low-cost locations are linked through triangular trade with the major markets in North America and Europe (e.g., Dicken, 1992).

What forces have driven the shift in industrial organization from MNCs to GFNs? To answer this question, we highlight three inter-related explanatory variables: institutional change through liberalization; changes in competition and industrial organization; and information and communications technologies that gave rise to DIS.

2.1 Institutional Change: Liberalization

Liberalization dates back to the early 1970s: it thrived in response to the breakdown of fixed exchange rate regimes and the failure of Keynesianism to cope with pervasive stagflation. To a large degree, it has been initiated by government policies. But there are also other actors that have played an important role: financial institutions; rating agencies; supra-national institutions like bi-lateral or multi-lateral investment treaties and regional integration schemes, like the EU or NAFTA. In some countries with decentralized devolution of political power, regional governments can also play an important role.

Liberalization imposes far-reaching changes on the economic institutions, i.e. the rules of the game that structure economic interactions. These institutions shape the allocation of resources, the rules of competition and firm behavior[1]. Liberalization covers

[1] Liberalization affects all aspects of institutions, but at different speed. North (1996; 12) distinguishes formal rules (statute law, common law, regulations), informal constraints (conventions, norms of behavior, and self-imposed codes of conduct), and the enforcement characteristics of both. While liberalization will first affect formal rules, informal constraints and enforcement mechanisms are more difficult to change. This implies that there is no homogeneous model of liberalization, but many different and often hybrid forms.

four main areas: trade, capital flows, FDI policies, and privatization. While each of these has generated separate debates in the literature, they hang together. Earlier success in trade liberalization has sparked an expansion of trade and FDI, increasing the demand for cross-border capital flows. This has increased the pressure for a liberalization of capital markets, forcing more and more countries to open their capital accounts. In turn this has led to a liberalization of FDI policies, and to privatization tournaments.

The overall effect of liberalization has been a considerable reduction in the cost and risks of international transactions and a massive increase in international liquidity. Global corporations (the network flagships) have been the primary beneficiaries: liberalization provides them with a greater range of choices for market entry between trade, licensing, subcontracting, franchising, etc. (*locational specialization*) than otherwise; it provides better access to external resources and capabilities that a flagship needs to complement its core competencies (*vertical specialization*); and it has reduced the constraints for a geographic dispersion of the value chain (*spatial mobility*).

2.2 Competition and Industrial Organization

As liberalization has been adopted as an almost universal policy doctrine, this has drastically changed the dynamics of competition. Again, we reduce the complexity of these changes and concentrate on two impacts: a broader geographic scope of competition; and a growing complexity of competitive requirements. Competition now cuts across national borders - a firm´s position in one country is no longer independent from its position in other countries (e.g., Porter, 1990). This has two implications. The firm must be present in all major growth markets (*dispersion*). It must also integrate its

activities on a worldwide scale, in order to exploit and coordinate linkages between these different locations (*integration*). Competition also cuts across sector boundaries and market segments: mutual raiding of established market segment fiefdoms has become the norm, making it more difficult for firms to identify market niches and to grow with them.

This has forced firms to engage in complex strategic games to pre-empt a competitor's move. This is especially the case for knowledge-intensive industries like electronics (Ernst, 2002b). 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 location, as well as industrial and firm organization. Take first location decisions. While both market access and cost reductions remain important, it became clear that they have to be reconciled with a number of equally important requirements that encompass: the exploitation of uncertainty through improved operational flexibility (e.g., Kogut, 1985; and Kogut and Kulatilaka, 1994); a compression of speed-to-market through reduced product development and product life cycles (e.g., Flaherty, 1986); learning and the acquisition of specialized external capabilities (e.g., Antonelli, 1992; Kogut and Zander, 1993; Zander and Kogut, 1995; Zanfei, 2000; Dunning, 2000); and a shift of market

penetration strategies from established to new and unknown markets (e.g., Christensen, 1997).

Equally important are changes in industrial organization. No firm, not even a dominant market leader, can generate all the different capabilities internally that are necessary to cope with the requirements of global competition. Competitive success thus critically depends on vertical specialization: a capacity to selectively source specialized capabilities *outside* the firm that can range from simple contract assembly to quite sophisticated design capabilities. This requires a shift from individual to increasingly collective forms of organization, from the multidivisional (M-form) functional hierarchy (e.g., Williamson, 1975 and 1985; Chandler, 1977) of "multinational corporations" to the networked global flagship model.

The electronics industry has become the most important breeding ground for this new industrial organization model. Over the last decades, a massive process of vertical specialization has segmented an erstwhile vertically integrated industry into closely interacting horizontal layers (Grove, 1996). Until the early 1980s, IBM personified "vertical integration": almost all ingredients necessary to design, produce and commercialize computers remained internal to the firm. This was true for semiconductors, hardware, operating systems, application software, and sales & distribution.Above all, "IBM was famous (some would say notorious) for the power of its sales force… (and distribution system)" (Sobel, 1986: 37).

Since the mid-eighties, vertical specialization became the industry's defining characteristic. Most activities that characterized a computer company were now being farmed out to multiple layers of specialized suppliers, giving rise to rapid market

segmentation and an ever finer specialization within each of the above five main value chain stages. This has given rise to the co-existence of complex, globally organized product- specific value chains (e.g., for microprocessors, memories, board assembly, PCs, networking equipment, operating systems, applications software, and sales & distribution). In each of these value chains consists GFNs compete with each other, but may also cooperate (Ernst, 2002a). The number of such networks, and the intensity of competition varies across sectors, reflecting their different stage of development and their idiosyncratic industry structures.

2.3. Information and Communication Technology: Digital Information Systems

The use of DIS to manage these networks has accelerated this process. For the manufacturing of electronics hardware, the use of DIS facilitated geographic dispersion. This is now being mirrored by similar developments for software and electronic design and engineering.

We first need to highlight important transformations in the use of DIS as a management tool. From a machine to automate transaction processing, the focus has shifted to the extraction of value from information resources, and then further to the establishment of Internet-enabled flexible information infrastructures that can support the extraction and exchange of knowledge across firm boundaries and national borders. A combination of technological and economic developments is responsible for this transformation.

On the technology side, the rapid development and diffusion of cheaper and more powerful information and communication technologies (e.g., Sichel. 1997, and Flamm,

1999) has considerably reduced transaction costs. In addition, the move towards more open standards in DIS architecture (UNIX, Linux, and HTML) and protocols (TCP/IP) enabled firms to integrate their existing intranets and extranets[2] on the Internet, which, by reducing cost and by multiplying connectivity, dramatically extended their reach across firm boundaries and national borders.

Compared to earlier generations of DIS, the Internet appears to provide much greater opportunities to share knowledge with a much greater number of people faster, more accurately, and in greater detail, even if they are not permanently co-located (Ernst, 2000b, 2001). The most commonly used technologies today facilitate *asynchronous* interaction, such as e-mail or non-real time database sharing. But as data transfer capacity ("bandwidth") increases, this is creating new opportunities for using technologies that facilitate *synchronous* interaction such as real-time data exchange, video-conferencing, as well as remote control of manufacturing processes, product quality and inventory, maintenance and repair, and even prototyping. This has created new opportunities for extending knowledge exchange across organizational and national boundaries, hence magnifying the scope for vertical specialization. Equally important, wireless Internet-based technologies have increased the mobility of DIS.

On the economic side, vertical specialization, particularly pronounced in the electronics industry, poses increasingly complex information requirements (e.g., Chen, 2002; Macher, Mowery and Simcoe, 2002). As firms now have to deal with constantly changing, large numbers of specialized suppliers, they need flexible and adaptive

[2] An "intranet" is defined as a private network contained within an organization (a firm) that consists of many inter-linked LANs (= local-area networks). Its main purpose is to share company information and computer resources among employees. An "extranet" in turn is a private network that links the flagship via conventional telecommunications networks with preferred suppliers, customers and strategic partners.

information systems to support these diverse linkages. These requirements became ever more demanding, as flagships attempt to integrate their dispersed production, knowledge and customer bases into global and regional networks. DIS now need to provide new means to improve global supply chain management and speed-to-market. DIS also need to provide for effective communication between design and manufacturing, and for the exchange of proprietary knowledge. The semiconductor industry provides examples for both developments (e.g., Macher, Mowery and Simcoe, 2002): vertical specialization gives rise to the separation of design ("fabless design") and manufacturing ("silicon foundry"). This creates very demanding requirements for knowledge exchange between multiple actors at distant locations, say a design house in Silicon Valley and a silicon foundry in Taiwan's Hsinchuh Science Park. Vertical separation of design and production of semiconductor devices in turn has created a vibrant trade in "intellectual property rights" among specialized design firms that create, license and trade "design modules" for use in integrated circuits.

In addition, far-reaching changes in work organization have fundamentally increased the requirements for information management and for the exchange of knowledge (e.g., Ciborra et al, 2000). The transition from Fordist "mass production" to "mass customization" requires a capacity to constantly adapt products or services to changing customer requirements, "sensing and responding" to individual customer needs in real time (Bradley and Nolan, 1998). This necessitates dynamic, interactive information systems, and a capacity to rapidly adjust the organization of firms and corporate networks to disruptive changes in markets and technology. Third, real-time resource allocation, performance monitoring and accounting became necessary, due to

the short-term pressures of the financial system (quarterly reports) and due to the shortening life cycles of products and technologies. Fourth, to cope with ever more demanding competitive requirements, firms have to continuously adapt their organization and strategy, hence the demand for flexible DIS.

Following Brynjolfsson and Hitt (2000), we argue that the impact of DIS on economic performance is mediated by a combination of intangible inputs as well as intangible outputs that act as powerful catalysts for organizational innovation[3]. After a while, these induced organizational changes may lead to productivity growth, by reducing the cost of coordination, communications and information processing. Most importantly, these organizational changes may 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 (Milgrom and Roberts, 1990): by combining DIS 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.

Once we adapt such a framework, it becomes clear that firms that participate in GFNs can reap substantial benefits from using DIS as a management tool. There is ample scope for cost reduction across all stages of the production process, both for the flagship company and local suppliers. Procurement costs can be reduced by means of expanded

[3] Intangible inputs include, for instance, the development of new software and databases; the adjustment of existing business processes; and the recruitment of specialized human resources and their continuous upgrading. Of equal importance are intangible outputs that would not exist without DIS, like speed of delivery, the flexibility of response to abrupt changes in demand and technology, and organizational innovations, like "just-in-time" (JIT), "mass customization", the built-to-order (BTO) production model, integrated supply chain management (SCM), and customer-relations management (CRM).

markets and increased competition through Internet-enabled online procurement systems. Another cost-reducing option is to shift sales and information dissemination to lower-cost on-line channels.

The transition to Internet-based information systems can 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. There is much greater scope for knowledge 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 an Internet-based information system. While establishing a network backbone requires large up-front 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"). In addition, the Internet and related organizational innovations provide effective mechanisms for constructing flexible infrastructures that can link together and coordinate knowledge exchange between distant locations **(**Hagstrøm, 2000; Pedersen et al, 1999; Antonelli, 1992).

This has important implications for organizational choices and locational strategies of firms. In essence, Internet-enabled DIS foster the development of leaner, meaner and more agile production systems that cut across firm boundaries and national borders. The underlying vision is that of *networks of networks* that enable a global network flagship to respond quickly to changing circumstances, even if much of its value

chain has been dispersed. DIS, especially the open-ended structure of the Internet, substantially broadens the scope for vertical specialization. It allows global flagships to shift from *partial* outsourcing, covering the nuts and bolts of manufacturing, to *systemic* outsourcing that includes knowledge-intensive support services, such software production, electronic design services, business process outsourcing, maintenance and repair of in formation systems, as well as skill transfer and training (Ernst, 2002c)

3. THE FLAGSHIP NETWORK MODEL

3.1. Theoretical Foundations

Until recently, these fundamental changes in the organization of international production have been largely neglected in the literature, both in research on knowledge spill-overs through FDI, and in research on the internationalization of corporate R&D. This is now beginning to change. There is a growing acceptance in the literature that, to capture the impact of globalization on industrial organization and upgrading, the focus of our analysis needs to shift away from the industry and the individual firm to the international dimension of business networks (e.g., Bartlett and Ghoshal, 1989; Gereffi and Korzeniewicz, 1994; Ernst, 1997; Rugman and D´Cruz, 2000; Birkinshaw and Hagstrøm, 2000; Borrus, Ernst and Haggard, 2000; Pavitt, 2002; Ernst and Ozawa, 2002). Flagship-driven corporate networks are of course only one of diverse complex digital formations that are currently reshaping the international economy (see contributions by **Sassen, Garcia, Latham**, in this volume).

Our model of GFNs emphasizes three essential characteristics: i) *scope*: GFNs encompass all stages of the value chain, not just production; ii) *asymmetry*: flagships

dominate control over network resources and decision-making; and iii) *knowledge diffusion*: the sharing of knowledge is the necessary glue that keeps these networks growing.

A focus on international knowledge diffusion through an extension of firm organization across national boundaries distinguishes our concept of GFN from network theories developed by sociologists, economic geographers and innovation theorists that focus on localized, mostly inter-personal networks (e.g., Powell and Smith-Doerr, 1994). The central problem of these theories is that industries now operate in a global rather than a localized setting (Ernst, Guerrieri et al, 2001). Important complementarities exist however with work on global commodity chains (GCC) (e.g., Gereffi and Korzeniewicz, 1994). A primary concern of the GCC literature has been to explore how different value chain stages in an industry (i.e. textiles) are dispersed across borders, and how the position of a particular location in such GCC affects its development potential through access to economic rents (e.g., Gereffi and Kaplinsky, 2001; Henderson, Dicken et al, 2001)[4]. Strong complementarities also exist with research on computer-based flexible information infrastructures that frequently uses the terms "extended enterprise" or "virtual enterprise", where the first stands for more durable network arrangements, while the latter for very short-term ones (e.g., Pedersen, 1999; Jørgensen and Krogstie, 2000; and various issues of the electronic journal virtual-organization.net).

As for the dynamics of network evolution, our approach complements the transaction cost approach to networks and vertical disintegration that centers on the

[4] Unfortunately, no one has as yet come up with a convincing and robust set of indicators. How should academic researchers, even with the best possible funding, be able to measure distribution of rents across borders, when global flagships like Enron and telecom majors excel in the development of sophisticated off-balance-sheet financial techniques and transfer pricing?

presumed efficiency gains from these organizational choices (e.g., Williamson, 1985 and 1997; Milgrom and Roberts, 1990). The latter approach however skips some of the more provocative chapters in the economic history of the modern corporation. Chandler's vibrant histories (e.g., 1962 and 1990) show that the quest for profits and market power via increased throughput and speed of coordination were more important in explaining hierarchy than the traditional emphasis on transaction costs. This implies that the analysis of the determinants of institutional form must move beyond a narrow focus on transaction costs to the broader competitive environment in which firms operate. It is time to bring back into the analysis market structure and competitive dynamics, as well as the role played by knowledge and innovation. Like hierarchies, GFN not only promise to improve efficiency, but can permit flagships to sustain quasi-monopoly positions, generate market power through specialization, and raise entry barriers; they also enhance the network flagships´ capacity for innovation (Ernst, 1997b; Borrus, Ernst, Haggard, 2000: chapter1)

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3.2. Network Characteristics

GFNs differ from MNCs in three important ways that need to be taken into account in the study of knowledge diffusion (Ernst, forthcoming). First, these networks cover both intra-firm and inter-firm transactions and forms of coordination: a GFN links together the flagship´s own subsidiaries, affiliates and joint ventures with its subcontractors, suppliers, service providers, as well as partners in strategic alliances. A network flagship like IBM or Intel breaks down the value chain into a variety of discrete functions and locates them wherever they can be carried out most effectively, where they

can improve the flagship's access to resources and capabilities, and where they are needed to facilitate the penetration of important growth markets.

Second, GFNs differ from MNCs in that a great variety of governance structures is possible. These networks range from loose linkages that are formed to implement a particular project and that are dissolved after the project is finished, so-called "virtual enterprises" (e.g., Pedersen et al, 1999: 16)), to highly formalized networks, "extended enterprises", with clearly defined rules, common business processes and shared information infrastructures. What matters is that formalized networks do not require common ownership: these arrangements may, or may not involve control of equity stakes.

Third, "vertical specialization" ("outsourcing" in business parlance) is the main driver of these networks (Ernst, 2002b). GFNs help flagships to gain quick access to skills and capabilities at lower-cost overseas locations that complement the flagships' core competencies. As the flagship integrates geographically dispersed production, customer and knowledge bases into GPNs, this may well produce transaction cost savings. Yet, the real benefits result from the dissemination, exchange and outsourcing of knowledge and complementary capabilities.

Increasingly, the focus of outsourcing is shifting from assembly-type manufacturing to knowledge-intensive support services, like supply chain management, engineering services, and new product introduction. Outsourcing may also include design and product development. This indicates that GFNs also differ from traditional forms of subcontracting: much denser interaction between design and production and other stages of the value chain require substantially more intense exchange of information and

knowledge. Network flagships increasingly rely on the skills and knowledge of specialized suppliers to enhance their core competencies.

Two distinctive characteristics of GFN that are enhanced by DIS shape the scope for international knowledge diffusion: a rapid yet concentrated dispersion of value chain activities, and, simultaneously, their integration into hierarchical networks.

3.3. Concentrated Dispersion

GFNs typically combine a rapid geographic dispersion with spatial concentration on a growing but still limited number of specialized clusters. To simplify, we distinguish two types of clusters (Ernst, 2002d): "centers of excellence" that combine unique resources, such as R&D and precision mechanical engineering, and "cost and time reduction centers" that thrive on the timely provision of lower-cost services[5]. Different clusters face different constraints to knowledge diffusion, depending on their specialization, and on the product composition of GFNs. The dispersion of clusters differs across the value chain: it increases, the closer one gets to the final product, while dispersion remains concentrated especially for high-precision and design-intensive components.

Let us look at some indicators in the electronics industry, a pace setter of the flagship network model (Ernst, 2002b). On one end of the spectrum is final PC assembly that is widely dispersed to major growth markets in the US, Europe and Asia. Dispersion is still quite extended for standard, commodity-type components, but less so than for final assembly. For instance, flagships can source keyboards, computer mouse devices and

[5] "Cost & time reduction centers" include the usual suspects in Asia (Korea, Taiwan, China, Malaysia, Thailand, and now also India for software engineering and web services),but also exist in once peripheral locations in Europe (e.g., Ireland, Central and Eastern Europe and Russia), in Brazil, and Mexico in Latin

power switch supplies from many different sources, both in Asia, Mexico and the European periphery, with Taiwanese firms playing an important role as intermediate supply chain coordinators. The same is true for printed circuit boards. Concentration of dispersion increases, the more we move toward more complex, capital-intensive precision components: memory devices and displays are sourced primarily from "centers of excellence" in Japan, Korea, Taiwan and Singapore; and hard disk drives from a Singapore-centered triangle of locations in Southeast Asia. Finally, dispersion becomes most concentrated for high-precision, design-intensive components that pose the most demanding requirements on the mix of capabilities that a firm and its cluster needs to master: microprocessors for instance are sourced from a few globally dispersed affiliates of Intel, two American suppliers, and one recent entrant from Taiwan[6].

In other words, geography continues to matter, even when DIS and high-velocity transportation are used. Rapid cross-border dispersion thus coexists with agglomeration. GFNs extend national clusters across national borders. This implies three things: First, some stages of the value chain are internationally dispersed, while others remain concentrated. Second, the internationally dispersed activities typically congregate in a limited number of overseas clusters. And third, agglomeration economies continue to matter, hence the path-dependent nature of development trajectories for individual specialized clusters. In short, the new mobility of knowledge remains constrained in space: while cross-border exchange of knowledge has penetrated new geographic areas, it remains limited to a finite number of specialized clusters.

America, in some Caribbean locations (like Costa Rica), and in a few spots elsewhere in the socalled RoW (= rest of the world).

[6] Ernst, 2002e provides a systematic analysis of the diversity of cluster dispersion, using examples from the semiconductor and the hard drive industries.

3.4. Integration: Hierarchical Networks

A GFN integrates diverse network participants who differ in their access to and in their position within such networks, and hence face very different opportunities and challenges. These networks do not necessarily give rise to less hierarchical forms of firm organization (as predicted for instance in Bartlett and Ghoshal, 1989, and in Nohria and Eccles, 1993).GFNs typically consist of various hierarchical layers, ranging from network flagships that dominate such networks, due to their capacity for system integration (Pavitt, 2002), down to a variety of usually smaller, local specialized network suppliers.

Flagships

The flagship is at the heart of the network: it provides strategic and organizational leadership beyond the resources that, from an accounting perspective, lie directly under its management control (Rugman, 1997: 182). The strategy of the flagship company thus directly affects the growth, the strategic direction and network position of lower-end participants, like specialized suppliers and subcontractors. The latter, in turn, " have no reciprocal influence over the flagship strategy" (Rugman and D´Cruz, 2000, 84)[7]. The flagship derives its strength from its control over critical resources and capabilities that facilitate innovation, and from its capacity to coordinate transactions and knowledge exchange between the different network nodes.

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 (Ernst,1997). 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.

To move this model a bit closer to reality, we distinguish two types of global flagships: i) Original equipment manufacturers (OEM) that derive their market power from selling global brands, regardless of whether design and production is done in-house or outsourced; and ii) "contract manufacturers" (CM) that establish their own GFN to provide integrated manufacturing and global supply chain services (often including design) to the OEM.

Local Suppliers

Local suppliers differ substantially in their capacity to benefit from the new mobility of knowledge. Greatly simplifying, we distinguish two types of local suppliers: higher-tier and lower-tier suppliers. "Higher-tier" suppliers, like for instance Taiwan´s Acer group (Ernst, 2000a), play an intermediary role between global flagships and local suppliers. They deal directly with global flagships (both OEMs and CMs); they possess valuable proprietary assets (including technology); and they have sufficient resources to upgrade their absorptive capacities. Some of these higher-tier suppliers have even

[7] 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".

developed their own mini-GFN (Chen, 2002). With the exception of hard-core R&D and strategic marketing that remain under the control of the OEM, the lead supplier must be able to shoulder all steps in the value chain. It must even take on the coordination functions necessary for global supply chain management**.**

"Lower-tier" suppliers are the weakest link in the GFNs. Their main competitive advantages are low cost and speed, and flexibility of delivery. They are typically used as "price breakers" and "capacity buffers", and can be dropped at short notice. This second group of local suppliers rarely deals directly with the global flagships; they interact primarily with local higher-tier suppliers. Lower-tier suppliers normally lack proprietary assets; their financial resources are inadequate to invest in training and R&D; and they are highly vulnerable to abrupt changes in markets and technology, and to financial crises.

4. CONTRADITIONS

It is important to emphasize that nothing guarantees the uninterrupted growth of digital formations in the corporate sector. As with other such formations, inherent contradictions may well cause the pendulum to swing in the opposite direction. In this last section, we highlight problems in the efficiency of coordinating GFNs, focusing on recent developments in the electronics industry. In essence, these contradictions reflect a growing tension between increasingly complex interactions between multi-tier networks of networks and limited organizational capabilities to cope with the resulting coordination requirements.

4.1. Networks of Networks: Outsourcing based on Contract Manufacturing

The "New Economy" boom in the US has accelerated a long-standing trend toward vertical specialization. Especially in the electronics industry, outsourcing based on contract manufacturing became the "panacea of the '90s"(Lakenan et al ,2001: p3), a "New American Model of Industrial Organization" (Sturgeon, 2002). Two inter-related transformations need to be distinguished: supply contracts and M&A. Global brand leaders like Dell, the "original equipment manufacturers" (OEMs) increasingly subcontract manufacturing and related services to US-based global "contract manufacturers" (CMs), like Flextronics. Equally important however is that the very same CMs have acquired existing facilities of OEMs, as the latter are divesting internal manufacturing capacity, seeking to allocate capital to other activities that are expected to generate higher profit margins, such as sales and marketing, and product development.

This has created increasingly complex, multi-tier "networks of networks" that juxtapose global ties among the two large global players (the OEMs and CMs), as well as intense regional ties with smaller firms (the local network suppliers). A focus on complex, multi-tier "networks of networks" distinguishes our analysis from Sturgeon's modular production network model (2002). That model focuses on two actors only: global OEMs and CMs, most of them of American origin. OEMs and CMs are perceived to interact in a virtuous circle where each of them can only win. In that model, nothing can stop continuous outsourcing through contract manufacturing: "turn-key suppliers and lead firms co-evolve in a recursive cycle of outsourcing and increasing supply-base capability and scale, which makes the prospects for additional outsourcing more attractive" (Sturgeon, 2002, p.6).

4.2. Limitations to the US-Style CM Model

In contrast, our analysis emphasizes serious limitations to the US model of contract manufacturing, forcing both OEMs and CMs to adjust and rationalize the organization of their networks. That model was based on the assumption of uninterrupted demand growth. In reality however, demand and supply only rarely match. This simple truth was all but forgotten during the heydays of the "New Economy".

Industry observers highlight seven important limitations[8]: First, global contract manufacturing is a highly volatile industry. While powerful forces push for outsourcing, this process is by no means irreversible. Major OEMs retain substantial internal manufacturing operations; they are continuously evaluating the merits of manufacturing products or providing services internally versus the advantages of outsourcing. Second, global CMs are now in a much weaker bargaining position than OEMs, whose number has been reduced by the current downturn and who are now much more demanding. In principle, important long-term customer contracts permit quarterly or other periodic adjustment to pricing based on decreases or increases in component prices. In reality however CMs "typically bear the risk of component price increases that occur between any such re-pricings or, if such re-pricing is not permitted, during the balance of the term of the particular customer contract (Jabil, 10K report 2001, p.49).

A third important limitation of the US CM model represents trade-offs between specialization advantages and rapid inorganic growth through M&A. In economic theory, vertical specialization is supposed to increase efficiency, i.e. to reduce the wastage of scarce resources. It is not clear whether the recent rapid growth of CM has produced this result. The excessive growth and diversification that we have seen during the "New

Economy" boom may well truncate the specialization and efficiency advantages of the CM model. The leading CMs have aggressively used M&A to pursue in parallel four objectives that do not easily match: rapid growth; a broadening of the portfolio of services that they can provide; a diversification into new product markets (especially telecom equipment); as well as an expansion of their own production networks, establishing a global presence at record speed. Yet, this forced pace of global expansion may well create an increasingly cumbersome organization that could undermine the supposedly primary advantage of the CM model: a capacity for rapid scaling-up and scaling-down, in line with the requirements of the OEMs.

Fourth, the rapid expansion of GFNs is subject to extreme risks and uncertainty. This reflects the much greater volatility of international operations compared to domestic ones. Managing GFNs thus requires major efforts, in terms of management time and resources, which of course conflicts with the need to keep overheads at very low levels.

Take the assessment of the risks involved in its international operations by a major US global contract manufacturer (Jabil). In its 10K report for 2001 (p.50), the company emphasizes the following risks: "difficulties in staffing and managing foreign operations; political and economic instability; unexpected changes in regulatory requirements and laws; longer customer payment cycles and difficulty collecting accounts, receivable export duties, import controls and trade barriers (including quotas); government restrictions on the transfer of funds to us from our operations outside the United States; burdens of complying with a wide variety of foreign laws and labor practices; fluctuations in currency exchange rates, which could affect local payroll, utility

[8] This section is based on email correspondence with Bill Lakenan, lead author of a recent study by Booz-

and other expenses; inability to utilize net operating losses incurred by our foreign operations to reduce our US income taxes; …(and, especially in lower-cost locations) …" currency volatility, negative growth, high inflation, limited availability of foreign exchange".

Fifth, rapid growth, based on the use of stock as a currency for mergers and acquisitions (M&A) is extremely risky, and contains the seed of future problems. It stretches the already limited financial resources of CMs, which typically have to cope with very low margins. The downturn of the global electronics industry has further increased these financial pressures on leading US-based CMs[9]. This of course raises the question whether this will lead to off-balance sheet financing techniques to hide accumulated debt.

Sixth, in contrast to the original expectation that outsourcing based on contract manufacturing may improve inventory and capacity planning, global brand leaders in the electronics industry, that rely heavily on outsourcing, have experienced very serious periodic mismatches between supply and demand. When a product unexpectedly becomes a hit, outsourcing provides these OEMs only with a limited capacity for scaling-up. During a recession, on the other hand, OEMs cannot abruptly reduce orders that they had previously placed with CMs[10].

Allen & Hamilton on global contract manufacturing (Lakenan et al, 2001); recent 10K reports of the leading US global CMs; and author's interviews at affiliates of global CMs in Malaysia.

[9] Ironically, these pressures are particularly severe for those CMs, like Solectron, that have aggressively diversified beyond the PC sector into telecommunications and networking equipment, the high-growth sectors of the "New Economy" boom.

[10] Take Cisco. During the peak of the "New Economy" boom, from 1999 to 2000, demand for its products grew by 50%. Reliance on CMs produced severe component shortages and a massive backlog in customer orders. When demand fell abruptly, starting from the fall of 2000, Cisco found itself saddled with excess capacity of $ 2.25bn that it had put in place to meet expected demand growth. Excess capacity of this magnitude is deadly in time-sensitive industries like electronics.

Lastly, there seems to be a conflict of interests between OEMs, who are looking for flexibility, and CMs, who are looking for predictability and scale. For instance, OEMs focus on early market penetration and rapid growth of market share to sustain comfortable margins. OEMs thus need flexibility in outsourcing arrangements that allows them to divert resources at short notice to a given product as it becomes a hit. This sharply contrasts with the situation of CMs: with razor-thin margins, they need to focus ruthlessly on cost cutting. CMs need predictability: "they want to make commitments in advance to reap benefits like big-lot purchases and decreased overtime." (Lakenan et al , 2001, p.10).

These conflicting interests complicate the coordination of CM-based outsourcing arrangements. They also require substantial fundamental changes in the organization of both OEMs and CMs, as well as an alignment of incentives through contract terms and agreements. If such alignment does not occur, it may well be that the new mobility of knowledge will face new constraints. The irony is that, the more dispersed and digitized these global networks, the more difficult it becomes to coordinate them.

In short, effective outsourcing requires that both flagships and CMs acknowledge their conflicting interests. Further, with complexity comes uncertainty. In industries with rapidly shifting technologies and markets, OEMs have no way to predict with any accuracy the specifications of what they will need, in terms of capacity, design features and configuration, and in terms of the specific mix of performance requirements. In the electronics industry, all of these variables can change quite drastically and at short notice. Such high uncertainty has important implications for the reorganization of CM-based outsourcing arrangements. Flexibility now becomes the key to success. Proceeding by

conjecture ("stochastically") takes over from a deterministic approach. Flagships need adjustable networks to "satisfy a range of possible demand profiles with a portfolio of customizable capacity." They "need access to - and the ability to turn off - big chunks of production more quickly than ever contemplated in order to capture profitability."(Lakenan et al, 2001, pages 11, 12).

CONCLUSIONS

The chapter demonstrates that digital formations in the corporate sector are shaped by the evolution of cross-border forms of corporate networking practices, especially global flagship networks (GFNs), and the increasing use of digital information systems (DIS) to manage these networks. These two inter-related transformations in the organization of international business are gradually reducing constraints to international knowledge diffusion. GFNs expand inter-firm linkages across national boundaries, increasing the need for knowledge diffusion, while DIS enhance not only information exchange, but also provide new opportunities for the sharing, and joint utilization and creation of knowledge. In the emerging global network economy, we thus need to reconsider and amend the "stickiness-of-knowledge" proposition.

The approach that I have chosen focuses on international knowledge diffusion through an extension of firm organization across national boundaries. We explore how two distinctive characteristics of GFNs, that are enhanced by DIS, shape the scope for international knowledge diffusion: a rapid yet concentrated dispersion of value chain activities, and, simultaneously, their integration into hierarchical networks. We demonstrate that the new mobility of knowledge is an unintended consequence of the evolution of global flagship networks. The more dispersed and complex these networks,

the more demanding their coordination requirements. Hence, knowledge sharing is the necessary glue that keeps these networks growing.

But this occurs in complex ways. Knowledge diffusion has created new "cost-and-time-reduction centers" in lower-income regions that thrive on the timely provision of knowledge support services like supply chain management and design services. Yet, the sources of knowledge creation remain concentrated in a few global "centers of excellence" that combine unique capabilities in research, global branding and system integration. While reducing the constraints to knowledge diffusion can enhance global development, the critical issue remains the unequal distribution of the sources of knowledge creation.

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