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Global production networks, knowledge diffusion, and local capability formation

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Abstract

This paper develops a conceptual framework that explores the linkage between the evolution of global production networks (GPN), the role of network flagships in transferring knowledge, and the formation of capabilities by local suppliers. GPN are a major innovation in the organization of international business. These networks combine concentrated dispersion of the value chain across the boundaries of the firm and national borders, with a parallel process of integrating hierarchical layers of network participants. The network flagships transfer both explicit and tacit knowledge to local suppliers through formal and informal mechanisms. This is necessary to upgrade the local suppliers' technical and managerial skills, so that they can meet the flagships' specifications. We also examine how GPN can act as mediators in the capability formation of local suppliers.

Keywords: International business strategy; Global production networks; Multinational Corporations; Organizational knowledge; Knowledge diffusion; Capability formation; Local suppliers

1. Introduction

Multinational corporations (MNCs) have been around for a long time (e.g. Wilkins, 1970). Until recently, their international production has focused 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: 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).

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 competitive dynamics, in which MNCs operate. 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; 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; Zander

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and Kogut, 1995); and a shift of market penetration strategies from established to new and unknown markets (e.g. Christensen, 1997).

In response to the increasingly demanding requirements of global competition, three interrelated transformations have occurred in the organization of international economic transactions. First, global production networks (GPN) have proliferated as a major organizational innovation in global operations (e.g. Borrus et al., 2000). Second, these networks 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. 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 (Ernst, 2002c).

The combination of these three transformations has changed dramatically the international geography of production and innovation. We focus on the first two of these transformations. The first transformation signals a new *divide* in industrial organization: a transition is under way from "multinational corporations", with their focus on stand-alone overseas investment projects, to "global network flagships" that integrate their dispersed supply, knowledge and customer bases into global (and regional) production networks (Ernst, 1997, 2002a). There is a growing acceptance in the literature that, to capture the impact of globalization on industrial organization and knowledge diffusion, the focus of research needs to move from the industry and the individual firm to the international dimension of business networks (e.g. Ghoshal and Bartlett, 1990; Rugman and D'Cruz, 2000). Our understanding of these networks is limited. Most studies have focused too narrowly on the perspective of the network flagship ("flagship bias"). We need research that explores as well implications for network suppliers, especially lower-tier suppliers from developing countries.

Equally important is the second transformation: GPN in their operations reportedly disseminate important knowledge to local suppliers in low-cost locations, which could catalyze local capability formation. Knowledge transfer, however, is not automatic. It requires a significant level of absorptive capacity on the part of local suppliers and a complex process to internalize disseminated knowledge. Our understanding of knowledge transfer and local capability formation is limited. International knowledge transfer has been extensively studied, but research has primarily focused on such formal mechanisms as foreign direct investment (FDI) and foreign licensing (FL) (Reddy and Zhao, 1990). These formal mechanisms, however, are only the tip of the iceberg. A larger amount of knowledge is transferred through various informal mechanisms (Westphal et al., 1985; Kim, 1991; Ernst, 2000a). Research on informal knowledge transfer is scarce. The importance of local capabilities in assimilating, adapting, and improving imported technology has long been recognized, but few studies exist on the complex process of local capability formation in developing countries (e.g. Kim, 1997).

GPN transform the production and use of knowledge, with far-reaching implications for an evolutionary theory of economic change. There is a fundamental trend towards an increasing mobility of knowledge, yet little do we know about drivers and implications. A major constraint is a lack of communication between research on GPN, research on international knowledge diffusion, and research on local capability formation. While all three are highly relevant strands of research, their lack of interaction obstructs our understanding of how global networks affect knowledge diffusion and the formation of local capabilities. There is a need to bridge this gap through "appreciative theories", as defined in Nelson's (1995) thought-provoking review of economic growth theory.

This paper develops a conceptual framework that links together the above three areas of research, as a first step towards an appreciative theory. We argue that globalization has culminated in an important organizational innovation: the spread of GPN. These networks combine concentrated dispersion of the value chain across firm and national boundaries, with a parallel process of integration of hierarchical layers of network participants. This has created new opportunities for international knowledge diffusion that lower-tier network suppliers should strive to exploit. To substantiate this argument, we proceed as follows. Section 2 analyzes the three dynamic forces that drive the rapid development of GPN and highlights the

characteristics of the flagship model of GPN. Section 3 explores the categories of knowledge, and the mechanisms of knowledge transfer from flagship companies to local network suppliers. And in Section 4, we discuss how GPN can act as mediators of local capability formation.

2. Driving forces and characteristics of GPN

2.1. Driving forces

What has driven the shift in industrial organization from "multinational corporations" to "global network flagships" that integrate their dispersed supply, knowledge and customer bases into global (and regional) production networks? To answer this question, we introduce a stylized model of globalization drivers, focusing on three inter-related explanatory variables: institutional change through liberalization, information technology, and competition.

The first driving force is liberalization, which includes four main elements: trade liberalization; liberalization of capital flows; liberalization of 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 (*outsourcing*); and it has reduced the constraints for a geographic dispersion of the value chain (*spatial mobility*).

The second important driver of GPN is the rapid development and diffusion of information and communication technology (IT). These technologies have had a dual impact: they increase the need and create new opportunities for globalization. This argument is based on two propositions. The first proposition is that the *cost* and *risk* of developing IT has been a primary cause for *market* globalization: international markets are required to amortize fully the enormous R&D expenses associated with rapidly evolving process and product information technologies (Kobrin, 1997, p. 149). Of equal importance are the huge expenses for IT-based organizational innovations. (Brynjolfson and Hitt, 2000; Ernst and O'Connor, 1992). As the extent of a company's R&D effort is determined by the nature of its technology and competition rather than its size, this rapid growth of R&D spending requires a corresponding expansion of sales, if profitability is to be maintained. No national market, not even the US market, is large enough to amortize such huge expenses.

The second proposition explains why international production rather than exports have become the main vehicle for international market share expansion. Of critical importance has been the enabling role played by IT: it has substantially increased the mobility, i.e. *dispersion* of firm-specific resources and capabilities across national boundaries; it also provides greater scope for cross-border linkages, i.e. the *integration* of dispersed specialized clusters. This has substantially reduced the friction of time and space, both with regard to markets and production: a firm can now serve distant markets equally well as local producers; it can also now disperse its value chain across national borders in order to select the most cost-effective location.

In addition, IT and related organizational innovations provide effective mechanisms for constructing flexible infrastructures that can link together and coordinate economic transactions at distant locations (Antonelli, 1992; Hagstrøm, 2000). This has important implications for organizational choices and locational strategies of firms. In essence, IT fosters the development of leaner, meaner and more agile production systems that cut across firm boundaries and national borders. The underlying vision is that of a network of firms that enable a global network flagship to respond quickly to changing circumstances, even if much of its value chain has been dispersed.

The third driving force is competition. Together with liberalization, IT 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 growing complexity of competition has changed the determinants of firm organization and growth, as well as the determinants of location. 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 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. Chandler, 1977) of "multinational corporations" to the networked global flagship model (Ernst, 2002c). Until recently, these fundamental changes in the organization of international production have been largely neglected in the literature, both in research on knowledge spill-over through FDI, and in research on the internationalization of corporate R&D.

2.2. *Characteristics of GPN*

The concept of a GPN covers both intra-firm and inter-firm transactions and forms of coordination (Fig. 1): it links together the flagship's own subsidiaries, affiliates and joint ventures with its subcontractors, suppliers, service providers, as well as partners in strategic alliances (e.g. Ernst, 1997; 2002b). These arrangements may, or may not involve ownership of equity stakes. 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 improve the firm's access to resources and capabilities and where they are needed to facilitate the penetration of important growth markets.

The main purpose of these networks is to provide the flagship with quick and low-cost access to resources, capabilities and knowledge that are complementary to its core competencies. In other words, transaction cost savings matter. Yet, the real benefits result from the dissemination, exchange and outsourcing of knowledge and complementary capabilities.

GPN typically combine a breath-taking speed of geographic dispersion with spatial concentration: much of the recent cross-border extension of manufacturing and services has been concentrated on a growing, but still limited number of specialized lower-cost clusters. Apart from the usual suspects in Asia (Korea, Taiwan, Singapore, China, Malaysia, Thailand, and now also India), this includes once peripheral locations in Europe (e.g. Ireland, Central and Eastern Europe and Russia), Brazil, Mexico, and Argentina in Latin America, some Carribbean locations (like Costa Rica), and a few spots elsewhere in the so-called RoW (rest of the world).

The degree of dispersion differs across the value chain: it increases, the closer one gets to the final product, while dispersion remains concentrated especially for critical precision components. Concentration of dispersion increases, the more we move toward more complex, capital-intensive precision components: memory devices and displays are sourced primarily from 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 secondary American suppliers, and one recent entrant from Taiwan.

2.2.1. *Flagships*

GPN typically consist of various hierarchical layers that range from network flagships that dominate such networks, down to a variety of usually smaller, local specialized network suppliers. This taxonomy helps to

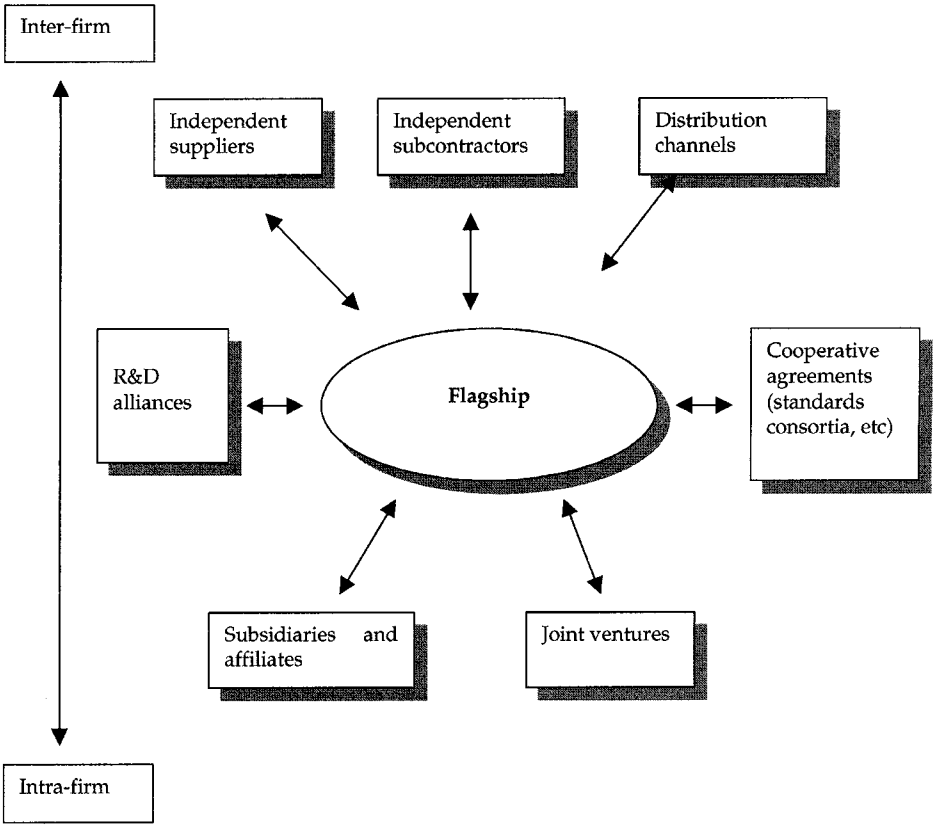


Fig. 1. The nodes of a global production network.

assess the different capacities of these firms to benefit from knowledge diffusion and to upgrade local capability formation.

We distinguish two types of global flagships: (i) "brand leaders" (BL), like Cisco, GE, IBM, Compaq or Dell; and (ii) "contract manufacturers" (CM), like Solectron or Flextronics, that establish their own GPN to provide integrated global supply chain services to the "global brand leaders". Cisco is an interesting example of a "brand leader": its GPN connects the flagship to 32 manufacturing plants worldwide. These suppliers are formally independent, but they go through a lengthy process of certification to ensure that they meet Cisco's demanding requirements. Outsourcing volume manufacturing and related support services enable "brand leaders" to combine cost reduction, product differentiation and time-to-market. Equally important are financial considerations: getting rid of low-margin manufacturing helps the BL to increase shareholder returns.

"Contract manufacturers" have rapidly increased in importance since the mid-1990s. This represents an acceleration of a long-standing trend towards vertical specialization that is particularly pronounced in the electronics industry (Ernst, 2002a). During the 1990s, global brand leaders have put up for sale a growing number of their overseas facilities, and in some cases whole chunks of their GPN. BL from North America like HP, Dell, Compaq, Motorola, Intel, IBM, Lucent, Nortel were first in pursuing such divestment strategies. But European BL (e.g., Philips, Ericcson, Siemens and Nokia) and, more recently, Japanese ones (e.g., NEC, Fujitsu, Sony) have followed suit. Outsourcing based on contract manufacturing became the "panacea of the '1990s" (Lakenan et al., 2001, p. 3). CM have aggressively seized this opportunity: through

acquisition and capacity expansion they have developed, within a few years, their own GPN that now complement the networks established by the global brand leaders. This gave rise to an extremely rapid growth of the CM industry. From 1996 to 2000, capital expenditures grew 11-fold (50% CAGR), and revenues increased by almost 400% (81% CAGR).

The flagship is at the heart of a network: it provides strategic and organizational leadership beyond the resources that, from an accounting perspective, lie directly under its management control (Rugman, 1997, p. 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, p. 84). 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.

2.2.2. *Local suppliers*

Greatly simplifying, we distinguish two types of local suppliers: higher-tier "lead suppliers" and lower-tier suppliers. "Higher-tier" suppliers, like for instance Taiwan's Acer group (Ernst, 2000b), play an intermediary role between global flagships and local suppliers. They deal directly with global flagships (both "brand leaders" and "contract manufacturers"); they possess valuable proprietary assets (including technology); and they have developed their own mini-GPN (Chen, in press). With the exception of hard-core R&D and strategic marketing that remain under the control of the network flagship, 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 in a much more precarious position. 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 position is weak; and they are highly vulnerable to abrupt changes in markets and technology, and to financial crises.

3. GPN and knowledge diffusion

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 act as powerful carriers of knowledge. First, 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, 2002a). 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 a GPN are plugged into the flagship's design debates (both on-line and face-to-face) on a regular basis.

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 et al., 1998). Much depends on the types of knowledge involved and the mechanisms that flagships use to disseminate different types of knowledge.

3.1. *The categories of knowledge*

Knowledge may be classified into various categories depending on the purpose of its use. Polanyi's (1962) classified knowledge into explicit and tacit knowledge. Explicit knowledge refers to knowledge that is codified

in formal, systematic language (*encoded* knowledge). It is knowledge that can be combined, stored, retrieved, and transmitted with relative ease and through various mechanisms.

But explicit knowledge is useful only when tacit knowledge enables individuals and organizations to make sense of and utilize it. Tacit knowledge refers to knowledge that is so deeply rooted in the human body and mind that it is hard to codify and communicate. It is knowledge that can only be expressed through action, commitment, and involvement in a specific context and locality. Tacit knowledge is based on experience: people acquire it through observation, imitation, and practice. Its diffusion requires apprentice-type training and face-to-face interaction. It can also be transferred, however, through the movement of human carriers of such knowledge, a fact that much of the literature on industrial districts used to neglect.

Many have attempted to unpackage the blackbox of tacit knowledge (e.g. Sparrow, 1998; Spender, 1996). For our purpose, the following classification, first coined by Collins (1993) and later expanded by Blackler (1995), appear to be most useful. Tacit knowledge may become part of the human body as skills (*embodied* knowledge); part of human being as cognitive capacity (*embrained* knowledge); routinized in organizational practice (*embedded* knowledge); and inculcated in the organization as basic assumptions, beliefs and norms (*encultured* knowledge). Different types of tacit knowledge are associated with different aspects of organizational activities and with different degree of difficulties in transferring it.

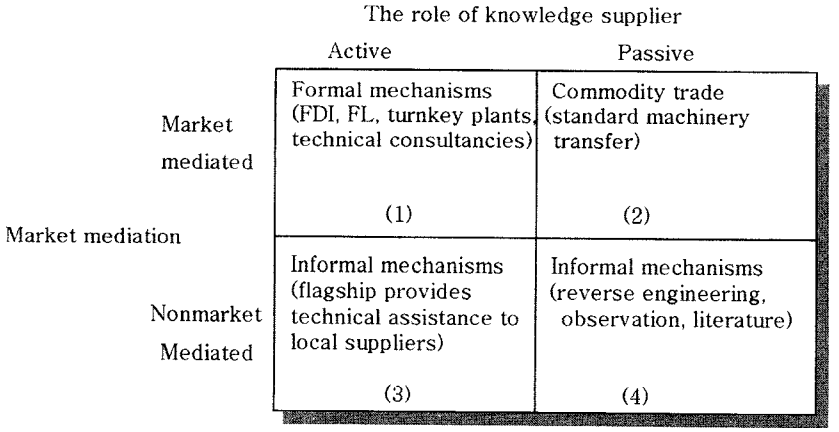
3.2. Knowledge transfer mechanisms

Flagships transfer knowledge across borders through various mechanisms. First, the transfer may be mediated through the market, involving a formal contract for terms and conditions between the knowledge supplier and the knowledge buyer with payment involved. Knowledge may also be transferred informally without any payment involved. Second, the flagship may play an active role, exercising significant control over the way in which knowledge is disseminated to and used by the local supplier. Alternatively, the flagship may play a passive role, having almost nothing to do with the way the local supplier takes advantage of available knowledge that is either embodied in or disembodied from the physical items. These two dimensions—market-mediation and the role of flagships—offer a useful two-by-two matrix, as shown in Fig. 2, to identify different mechanisms of knowledge transfer through GPN (Kim, 1991).

First, network flagships use largely formal mechanisms such as FDI, FL, technical consultancies, etc. in quadrant 1 to transfer knowledge to local suppliers, if the latter are subsidiaries or joint venture partners. For instance, when such flagships as Intel, Motorola, Texas Instruments, and Fairchild decided to outsource assembly operations of their semiconductor devices, they took the mechanisms of FDI, FL, and technical consultancies to establish their subsidiaries in the Philippines (Antonio, 2001) and other countries in Southeast Asia. They insisted on majority ownership in the subsidiaries, licensed and transferred a complete production system.

Second, independent local suppliers rely heavily on standard machinery in quadrant 2 to improve their productivity in production operations. Machinery is a major source of process innovation for their users (Abernathy and Townsend, 1975). Flagships are not necessarily the suppliers of the machinery, but they can play an important indirect role, by forcing independent local suppliers to purchase more sophisticated equipment to improve their production capabilities. For instance, Mando, one of the major auto components suppliers from Korea, purchased a series of robots to automate their production processes. Each of the robots embodied state-of-the-art production knowledge. The equipment suppliers, however, had little influence over the way Mando employees assimilate knowledge by using these robots.

Third, a more direct way for flagships to transfer knowledge to independent local suppliers are informal mechanisms in quadrant 3, largely through the original equipment manufacturing (OEM) arrangements. As in the quadrant 1, flagships actively transfer knowledge in the form of blue prints, technical specifications, and technical assistance, mostly free of charge, to independent local suppliers to ensure that products and services produced by the latter meet the former's technical specifications. For instance, Boeing outsources some parts of fuselage from independent local suppliers in Japan, Taiwan, and Korea. In doing so, Boeing actively provides the local suppliers with



Source: Adapted from Kim, 1997, page 101.

Fig. 2. Knowledge transfer mechanisms.

technical literature, product specifications, and technical assistance to help them meet its specifications.

Fourth, independent local suppliers can also rely on knowledge transfer mechanisms in quadrant 4. Like in quadrant 2, flagships exert little direct influence over the way independent local suppliers use such mechanisms as reverse engineering, observations, and human mobility to expedite upgrading their capabilities. In Korea, for instance, the Small Industry Promotion Corporation and industry-related SME associations frequently organizes observation tour of foreign firms as a way to acquire new knowledge. Human mobility in quadrant 4 includes not only the repatriation of top-rated engineers trained abroad (Saxenian, in press) but also the active use of experienced foreign engineers who are hired for short periods as so-called "moonlighters".

To what degree do the flagships use the knowledge transfer mechanisms? The shift from MNCs to global network flagships has expanded both the mechanisms and the volume of knowledge transfer. MNCs relied heavily on the mechanisms in quadrant 1 of Fig. 2 in setting up their plants either for the penetration of protected markets or for exploiting differential factor costs. In contrast, flagships transfer knowledge not only through mechanisms in quadrant 1 but also through mechanisms in quadrant 3. Flagships also tend to transfer more knowledge to local suppliers than vertically integrated MNCs. These transfers are necessary to enable local suppliers to provide the flagship with competitive products and services, in line with the changing requirements of markets and technology.

4. Local capability formation

Local suppliers can only effectively absorb knowledge disseminated by global network flagships, if they have developed their own capabilities. Knowledge internalization and capability building require individual and organizational learning. Individuals are the primary actors in learning and knowledge creation (Hedberg, 1981). They constitute local capabilities that may be combined at the organizational level. Organizational learning, however, is not the simple sum of individual learning. Only effective organizations can translate individual learning and capabilities into organizational learning and capabilities.

4.1. Concepts

Firms create knowledge primarily through the dynamic process of conversion between explicit and tacit knowledge (Nonaka, 1991). Tacit-to-tacit conversion (called *socialization*) takes place when tacit knowledge of one individual is shared with others through training, whereas explicit-to-explicit conversion (*combination*) takes place when an individual or a group combines discrete pieces of explicit knowledge into a new whole. Tacit-to-explicit conversion

(*externalization*) occurs when an individual or a group is able to articulate the foundations of individual tacit knowledge. Finally, explicit-to-tacit conversion (*internalization*) takes place when new explicit knowledge is shared throughout the firm and other members begin to use it to broaden, extend, and reframe their own tacit knowledge. Such conversion tends to become faster in speed and larger in scale in a spiral process, as more actors in and around the firms become involved in knowledge conversion (Nonaka and Takeuchi, 1995). For effective knowledge conversion to lead to productive learning, two important elements are required: an existing knowledge base or competence (most of it tacit knowledge), and the intensity of effort or commitment. Cohen and Lavinthal (1990) call this "absorptive capacity". How fast and successfully the local suppliers internalize and translate transferred knowledge into their own capability through learning will be largely determined by their absorptive capacity and their ability to upgrade it continuously.

Tacit knowledge enables the individual as well as the organization to use both explicit and tacit knowledge available elsewhere and to create new knowledge through various knowledge conversion activities in production and R&D. The intensity of effort, on the other hand, determines the speed of knowledge conversion. It represents the amount of emotional, intellectual, and physical energy that members of an organization invest in acquiring and converting knowledge. Exposure of individuals and firms to relevant external knowledge is insufficient, unless they make a conscious effort to internalize and use it. Hence, considerable time and effort must be directed to learning (Kim, 1998). Of the two, the intensity of effort or commitment is more important than the knowledge base, as the former creates the latter, but not vice versa (Ullrich, 1998).

4.2. GPN as mediators of local capability formation

Let us first look at explicit knowledge. Flagships typically provide the local suppliers with *encoded* knowledge, such as machinery that embodies new knowledge, blueprints, production and quality control manuals, product and service specifications, and training handouts. This is done to assist the suppliers in building capabilities that are necessary to produce products and services with the expected quality and price. Personnel at the local suppliers read and try to assimilate the transferred explicit knowledge into their tacit knowledge (*internalization* in Fig. 3). In most cases, the acquisition of explicit knowledge alone is not sufficient for the local suppliers to assimilate and use it in production, as the translation of explicit knowledge into actual operations requires a significant amount of tacit knowledge. Thus, to augment the explicit knowledge, network flagships typically invite engineers and managers of the local suppliers to its best-practice plants, so that they can observe how actual production systems work and to receive a systematic training.

This can help to translate knowledge gained from the literature into actual operations (*internalization*). It also enables local engineers to internalize how the flagships' organization and production systems are managed (*internalization* of *embedded* knowledge), and to absorb tacit knowledge directly transferred from foreign engineers through training (*socialization*). Once they return home, however, these engineers confront various unforeseen problems in their attempts to translate what they have learned at the flagships into the operational systems that exist at home. For this reason, the flagships also send their own engineers (*embodied* and *embrained* knowledge) to help local engineers debug problems in engineering and manufacturing systems (*socialization*).

Take the case of subsidiaries or joint ventures in quadrant 1 of Fig. 2. When Sony established Hwashin Electronics Company in Korea as a joint venture to outsource its consumer electronics products, it supplied not only machinery and equipment for the mass-production system of its joint venture partner. Sony also provided blue prints of products, product specifications, and production and quality control manuals (*encoded* knowledge). In addition, the flagship invited a number of Korean engineers, technicians, and managers to undergo training at Sony's plant in Japan on production, organization, and human resource management (HRM), transferring *embedded* and *encultured* knowledge. Sony also dispatched a number of engineers and technicians to Korea to help Korean engineers debug problems encountered in operating and maintaining the production system and controlling the quality of products to ensure that Hwashin meet the technical specifications of Sony's

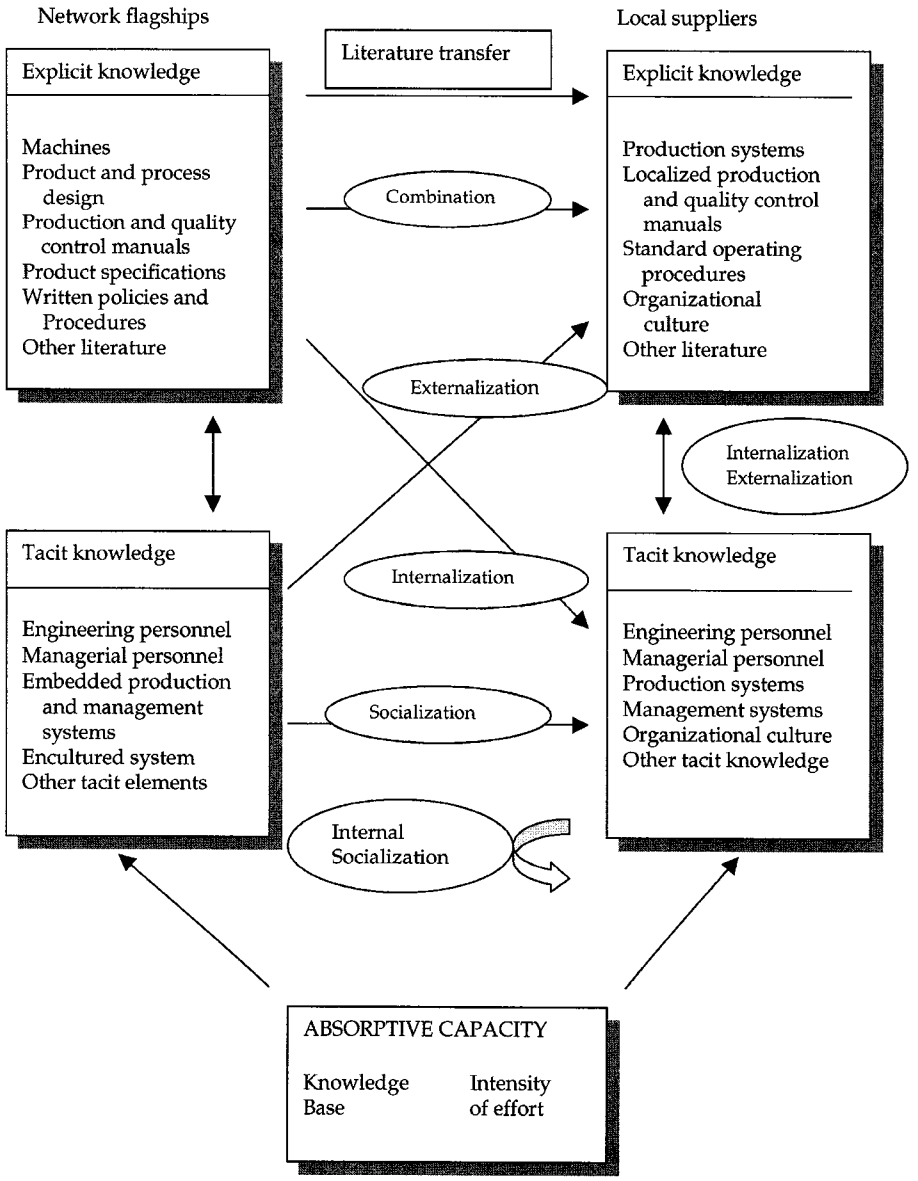


Fig. 3. The process of local capability formation.

products (*embodied* and *embrained* knowledge). Sony had done these knowledge transfer activities formally as part of its FDI and FL to Hwashin.

In the case of independent local suppliers in quadrant 3 of Fig. 2, when General Electric decided to outsource its microwave ovens from Samsung under the OEM arrangements, it sent its engineers to Samsung to explain its technical specifications (*encoded* knowledge) and taught Samsung engineers master the engineering details of the product (*embrained* knowledge), (Magaziner and Patinkin, 1989). GE had done all these knowledge transfer activities free of charge to ensure that Samsung's products meet GEs technical specifications.

Second, local suppliers may attempt to translate such explicit knowledge as production and quality

control manuals, HRM handbooks, and other literature transferred from flagships into their own production and quality control manuals and HRM handbooks, which may be more compatible with local institutions and business behavior. Then a *combination* takes place from a set of explicit knowledge to a new set of explicit knowledge at the local suppliers. In this process, *externalization* of knowledge also takes place from tacit knowledge of local engineers and managers to explicit knowledge in the form a new set of manuals and handbooks. For instance, when Volvo took over the ownership of Samsung's heavy machinery division after the Asian crisis to turn it into its Asian supplier, Volvo introduced its own management systems, which reflects both Volvo's requirements and those shaped by local institutions. In developing a new set of manuals and handbooks, the ground was laid for *internalization*, *combination* and *externalization*.

Third, the link with GPN also induces knowledge conversions within local suppliers. The key is the diffusion of locialized and internalized knowledge accumulated by a limited number of engineers and managers of the local suppliers through training provided by the network flagship. This knowledge needs to be diffused within local suppliers through spiral processes of *socialization*, as more actors in and around the firms get involved in knowledge conversion activities. *Externalization* and *internalization* take place internally, as actors convert from/to explicit to/from tacit knowledge within the local supplying firms, gradually developing *embedded* knowledge. For instance, Samsung Electronics recently sent a group of HRM specialists to GE to learn the latter HRM system. Upon return, these specialists have conducted a series of seminars for HRM specialists in the firm to share the knowledge, leading to the development of new HRM policy and procedures and to the gradual formation of new embedded knowledge.

Fourth, the effectiveness and speed of knowledge conversion process will be determined not so much by quantity and quality of the knowledge transferred by the flagships as by the absorptive capacity of the local suppliers. This holds true regardless of the knowledge transfer mechanisms. Tacit knowledge plays a central role in this process. This is true even for the conversion from explicit knowledge to explicit knowledge. Once again, this highlights how important it is for local suppliers to develop a rich tacit knowledge base. The strength of the domestic knowledge base determines the level of sophistication of the converted knowledge, while the intensity of effort accelerates the speed of the conversion processes. In turn, spiral processes of knowledge conversion determine the level of the company's internal knowledge base. Leading local suppliers thus invest heavily in recruiting the cream of the crop from universities; they also develop intensive training programs to upgrade the existing knowledge base.

5. Conclusions

Liberalization, digital convergence, and intensifying global competition have produced a major organizational innovation: a transition from "multinational corporations" that exploit labor cost differentials in different countries to "global network flagships" that integrate their dispersed supply, knowledge, and customer bases into global (or regional) production networks. The paper demonstrates that these networks have boosted international knowledge diffusion, providing new opportunities for capability formation by local suppliers in developing countries. Under pressure from flagships, local suppliers have a strong incentive to internalize transferred knowledge through various forms of knowledge conversion. The baseline, however, is the absorptive capacity of the local suppliers: it determines the effectiveness of capability formation.

There is nothing automatic about these processes. Local suppliers need to take an active approach to maximize their benefits from network participation. Flagships place business orders and transfer valuable knowledge to local suppliers with only one objective in mind: to strengthen the competitiveness of their GPN. In response to intensifying global competition, the flagships' outsourcing requirements have become more demanding. Typically, suppliers are selected by 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 constantly upgrade their absorptive capacity. Local suppliers, therefore, must tap, develop, and retain highly skilled human resources. Adequate incentives are required to sustain a high intensity of effort. Ruthless global competition implies that typically only a limited number of higher-tier local suppliers is strong enough to cope with these challenges. But it is unclear what will happen to the great majority of local firms that are outside this charmed circle of higher-tier suppliers.

In short, participation in GPN is no substitute for domestic upgrading efforts. Without the latter, network integration of some "higher-tier" suppliers may well increase the divide between firms and districts that have and those that do not have access to the information and knowledge that is necessary to reap the benefits of network participation. Many people are understandably concerned that this may lead to a decline in economic growth and welfare. This paper demonstrates that there is cause for cautious optimism: network participation may provide new opportunities for effective knowledge diffusion to local firms and industrial districts in developing countries, *provided* appropriate policies and support institutions are in place that enable local suppliers to exploit the opportunities and pressures that result from network participation. The nature of these policies and institutions will be the subject of a separate article.

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