

The geography of learning and knowledge acquisition among Asian latecomers

Jessie P.H. Poon*, Jinn-Yuh Hsu** and Suh Jeongwook***

Abstract

This paper examines the geography of technological learning and knowledge acquisition among Taiwanese and Korean firms. Specifically it focuses on the knowledge sourcing experience of Asian manufacturing latecomers in the United States (US). The Asian latecomer model of learning is characterized by a triangular spatial division of knowledge sourcing and technological production that involves the transfer and circulation of knowledge across multiple spatial scales. At the regional level, Korean and Taiwanese firms rely on local learning systems in the form of science parks to create favorable domestic agglomeration economies that are conducive for knowledge accretion. At the trans-regional level, non-core R&D and the manufacturing of technology-driven products are geographically concentrated in China. Lastly, local and trans-regional learning are supplemented by international sourcing of knowledge through the location and investment of R&D facilities in the US. To the extent that extra-local knowledge sourcing in the US is associated with the acquisition of new knowledge forms, such a multiscale spatial strategy is expected to help transform Asian learners from technology latecomer to technology newcomer status.

Keywords: knowledge sourcing, learning, Taiwan, Korea, multiple scales, technology

JEL classifications: O31, O33, N65, L6

Date submitted: 26 April 2005 **Date accepted:** 1 December 2005

1. Introduction

The process of technological diffusion and learning among firms has been a subject of interest among economic geographers in the past decade. Literatures directly resulting from this interest have spawned a number of spatial concepts including notions of the learning region (Florida, 1995), innovation milieu (Camagni, 1995) and system (Lundvall, 1992), technology district (Storper, 1992) and industrial cluster (Britton, 2003; Porter, 1998). Much of this literature has one common goal, that is, to unravel the spatiality of knowledge forms and processes within the context of its (re) production and transmission. While contributing much to the geography of innovation, this

* Department of Geography, University at Buffalo-SUNY, Buffalo, NY 14261, USA.
email <Jesspoon@buffalo.edu>

** Department of Geography, National Taiwan University, Taipei, Taiwan.
email <Jinyuh@ntu.edu.tw>

*** Ministry of Foreign Affairs And Trade, Republic of Korea.

literature overwhelmingly focuses on the regional competences of firms, particularly those of native firms in European and North American regions. Perhaps because of this spatial fixity, explanations of knowledge exchanges, particularly those surrounding tacit knowledge, are biased towards the local context giving the impression that learning and knowledge acquisition is superior with local indigenous insiders.

Such spatial bias neglects a parallel development in international knowledge production and transmission, namely extra-local technological learning and acquisition among foreign firms in knowledge-rich environments, particularly foreign firms from industrializing countries. Unlike early technology comes from North America and Europe, industrializing countries such as Taiwan and South Korea (henceforth Korea) are latecomers to the technological process. The phenomenon of innovation, in the sense of Schumpeterian invention, technical change and diffusion, is much more alien to firms from these countries (Viotti, 2002). The Asian story is one of learning, acquisition, re-innovation and knowledge sourcing than strictly innovating. The question is raised as to what the nature of extra-local learning might be among foreign firms that are not as locally embedded as indigenous firms? This paper seeks to answer this question. We propose that the geography of technological learning and knowledge acquisition among Asian firms requires a multiscale perspective that intertwines local, trans-regional and extra-local international spaces in the organization and coordination of technology and knowledge flows. More specifically, we focus on the process of international learning among these firms through their foreign direct investment in the United States (US). While studies on international research and development (R&D) span a decade of research (Dunning and Lundan, 1998; Cantwell and Odile, 1999), attention is only now turning to the role of multiple geographic scales in knowledge production and its practice. A multiscale process of knowledge acquisition for example has been observed to be at work among European firms (Zeller, 2004), but the level of learning needs to be distinguished: extra-local international learning among European firms appears to be concentrated in the most technology-intensive sectors for example biotechnology (see also Shan and Song, 1997), whereas international learning among Asian firms is underscored by concerns of technological autonomy that potentially liberates them from their subordinate supplier relationships with foreign multinational corporations (MNCs). Korea and Taiwan are vulnerable to such technological dependency because of their embedded role as regional manufacturing suppliers of foreign MNCs (Dicken, 2003). The technological activities of their firms are therefore useful for understanding the geography of learning and knowledge acquisition. In the next section, we detail the process and mechanisms of technological learning and knowledge sourcing among Asian latecomers. The geography of learning is investigated next using survey data that was collected between 2003 and 2004. The paper caps with some implications of the findings.

2. Knowledge production and learning among Asian firms

A recurrent theme in the economic geography of innovation and knowledge is that ‘the enduring competitive advantages in a global economy lie increasingly in local things—knowledge, relationships and motivations—that distant rivals cannot replicate’ (Porter, 1998, p. 78). The notion that a local scale of geography optimizes the creation and transmission of knowledge and innovation and thereby the potential for technological learning stems from the presumption that the viscosity of knowledge exchanges,

particularly tacit knowledge, is high, so that spatial proximity enhances knowledge production, recombination and utilization among firms and between knowledge agents. There is no shortage of literature in economic geography on the negative relationship between knowledge flows and distance, and recent reviews include Malmberg and Maskell (2002), Gertler (2003) and Bathelt *et al.* (2004). One concomitant effect of this interest on the role of proximity in facilitating knowledge exchanges is that a rich though relatively empirically thin literature has emerged on relatively self-contained and socially embedded relationships within a region that are thought to hasten and intensify innovations among native firm residents, and articulated through spatial regimes such as the innovation milieu, learning region or industrial cluster.

Three themes are particularly pertinent to the research in this paper from this literature. First, information sharing increases when social bonds proliferate as this encourages a firm to adopt more cooperative forms of behavior as the basis for exchange. This in turn contains the inclination of firms to act opportunistically through the reduction of uncertainties. Social bonds intensify trust-based, cooperative transactions and to the extent that knowledge in technology involves some form of proprietary information, the willingness to communicate and relay some of this information is increased between two cooperative rather than uncooperative parties. In this case, the transmission of knowledge is greater when firms interact considerably with one another, and the latter is enhanced if firms are located close to one another. Relational proximity that facilitates interaction-based learning between customers, suppliers and distributors, constitutes the main mechanism of learning here (Gertler, 1995; Dyer, 1996; MacPherson, 2002; Britton, 2003).

Second, firms do not interact and learn in a spatial vacuum. Hence local knowledge assemblers are necessarily institutionally and socially constitutive, and institutional thickness promotes the fermentation of innovative activity (Amin, 1999). Institutional knowledge assemblers include universities, research institutes and laboratories, financial institutions or venture capital (Keeble *et al.*, 1999) and legal firms, agencies or organizations that help protect proprietary knowledge and that thicken skilled labor markets (Cohen and Fields, 1999). Areas or regions with a thicker institutional infrastructure are said to be better incubators for new knowledge formation (Cooke *et al.*, 1997). More recently, Gertler (2003) has argued that national institutions also matter in that they determine the market rules and framework within a country driving innovations and knowledge creation at the regional level. Gertler's point that national rather than regional institutions matter more may be illustrated in national regulatory frameworks governing genetic manipulation or research using embryos which have strong implications for knowledge production in applied biotechnology research in the US and Europe.

Third, criticism is mounting on the tendency of the economic geography literature to assume a 'tacit = local versus codified = global' binary of knowledge forms (Bathelt *et al.*, 2004, p. 32). The tacit-codified binary may be traced to Nelson and Winter's (1982) attempt to explain knowledge forms in terms of two ways of 'knowing'. In spatial terms, the more objective codified knowledge is said to rely on mental representations that allow information processing and exchanges such that its material manifests—publications, engineering drawings, industry certification and blueprints—enjoy a greater efficiency in spatial transmission because they are less idiosyncratic in terms of time and location. The more phenomenological nature of tacit knowledge, on the other hand, confers a spatial quality of stickiness since tacitness in

the Polanyi (1967) sense is physically embodied in people and relationally embedded in communities of practice. Such a binary way of explaining knowledge forms and their spatial outcomes however has become increasingly dissatisfactory (Bunnell and Coe, 2001). Nonaka *et al.* (2000) have argued that not all codified knowledge is much more readily transmitted and learned. A highly customized machine for instance requires simultaneous conversions between explicit and tacit knowledge. A recent study of Swedish transnational firms (TNCs) further suggests that the less articulable or more tacit the knowledge, the greater the transfer of knowledge among Swedish MNCs despite the higher level of complexity in more tacit forms of knowledge as compared to codified knowledge (Nobel, 1999). This greater transfer of knowledge may be explained by fear of firms of the appropriation of knowledge by their competitors through codified forms. By keeping the transfer of knowledge in more tacit forms, they seek to minimize knowledge leakage. While tacit knowledge can be distanced (between TNCs and foreign units) the preferred mode of transmission among TNCs may also be relational and organizational proximity that resists or reduces the potential conversion of proprietary knowledge to a public good.

In other words, knowledge has become increasingly intertwined so that it is becoming difficult to privilege its forms and production in terms of a single spatial scale (Bunnell and Coe, 2001). Acquisition of codified and tacit knowledge is more a multiscale than uni-scale process rendering its spatial articulation both a local as well as distanced process (Allen, 2002). Amin and Cohendet (2004) have usefully moved the tacit-codified discussion and its spatial counterpart, the local-global binary, away from a dualistic distinction to a more dynamic framework where tacit and codified knowledge serve as both inputs to, and outputs of, each other. Scale transcendence in the practice of learning is particularly useful in explaining the Asian experience.

Because Schumpeterian innovation is 'the privilege of industrialized countries' (Viotti, 2002, p. 657), innovation among industrializing Asian countries is more accurately described by a process of learning including the absorption and improvement of innovation from industrialized countries. Asian learning is based on a model of reverse product cycle (Abernathy and Utterback, 1977; Hobday *et al.*, 2004). Under the product cycle model that is widely used to describe the technological trajectory of industrialized countries, the initial phase of the innovation cycle is characterized by product innovation driven by new demand in more sophisticated and rapidly changing developed markets. As firms evolve and mature, product innovation gives way to process innovation where the focus of innovations is on improving the efficiency of the product including its cost, quality, and, technical or equipment system. This technological trajectory is however reversed in the case of Asian firms. In the first stage, innovation is characterized by incremental processes that are largely a result of supplier-dominated technological relationships with their MNC customers in the US, Europe or Japan. Such incremental process innovation includes original equipment (OEM) or original design (ODM) manufacturing where firms serve as contract manufacturers with technology that is largely supplied by the MNCs. In the case of ODM, firms can execute their own designs. As the level of innovation accelerates the firm's production factors and relations undergo transformations which in turn encourage the firm to free itself from its subordinate supplier relationship through more autonomous innovation. During this phase, the firm begins to engage more in product innovation than simply improving the efficiency of existing products.

The literature informs that codified knowledge acquisition that is embodied in material forms such as manuals, reverse engineering, and in performative forms (Thrift, 2000) like seminars or trade shows, constitute relatively spatially convenient instruments of knowledge acquisition. This is because they are generally more accessible; they also lend themselves more easily to commoditization (Amin and Cohendet, 2004). However, simply learning codified rules of swimming does not imply the successful practice of swimming. Nor do learning codified mathematical formulae necessarily result in an ability to solve mathematical problems. Indeed for Searle (1983, p. 150), a swimmer becomes better not because she/he internalizes the rules better, but because 'Practice makes perfect'. That is to say, the internalization of knowledge is facilitated by repeated experience so that knowledge is cumulative. Thus Nightingale (2003, p. 177) writes 'the important concept is not that some knowledge is codifiable, but that some knowledge is tacit'. In learning how to swim, codified and tacit knowledge are complementary than substituting.

Under the reverse product cycle model, increased technological progress and autonomy are accomplished through external specialist providers who have mastered significant capabilities as well as technological knowledge and experience. This includes consultants or skilled personnel with significant R&D knowledge recruited from US universities, research institutes or extra-local firms. More recently, firms are also turning to international networks for crucial sources of knowledge. Asian firms deploy a multi-scalar triangular spatial strategy: exploiting local innovation systems of knowledge spillovers through the establishment of science and technology parks, turning regionally to China for skilled but cheap personnel by recruiting Chinese engineers and scientists, and sourcing for knowledge globally by directly investing in facilities and operations in the US, particularly around regions of active innovation and knowledge buzz (Storper and Venables, 2004). That firms are operating through and across spatial scales to acquire knowledge implies that the notion of 'being there' needs to be reconceptualized as more than a function of proximity. Both Currah and Wrigley (2004) as well as Zeller (2004) have provided several ways of thinking about proximity, including organizational, technological and virtual proximities. Under organizational proximity, the spatial organization of communication patterns in a firm need not be physical but functional or psychological. In the case of the latter, it is the shared tacit understanding that matters more, hence the efficiency of its transmission is less constrained by physical distance if relational proximity is present (Gertler, 2003). Shared tacit consent in turn implies that technological and virtual proximities (e.g. the Internet, teleconferencing) could help overcome geographical barriers in the acquisition of knowledge that is distanced.

In sum the geography of technological learning points to the emergence of spatial architectures that support simultaneous proximate and distanced exchange infrastructures which in turn, facilitate the simultaneous circulation as well as integration of knowledge forms both tacit and codified. Such a model demands a more complex spatial strategy that resists the privileging of a spatial scale, collapsing home and host, indigenous and foreign, local and global sources, and the spaces in-between. In this paper, the primary empirical focus of the paper is on sourcing by Asian firms of global knowledge in the US that helps in the upgrading and augmentation of their home-based knowledge. The global dimension of technology sourcing has been the least studied of Asian firms' spatial strategies. Rather, technological learning and acquisition has focused on local knowledge transfers between foreign MNCs and indigenous firms (Mathews and Cho, 2000; Hobday *et al.*, 2004; Yeung and Li, 2000). As will be

described in a later section, much of the US investments of the firms are concentrated around regions of relatively thick innovations.

3. The geography of learning and knowledge acquisition

3.1. Transcending scale

The previous section suggests that the complexities of technological learning and knowledge transfer and acquisition are more appropriately captured by multiple and simultaneous scales of analysis. In this section, we discuss how the Asian multi-scalar spatial model of learning relies on a fluid circulation of knowledge both within and across local, trans-regional and international spaces. Specifically, scale transcendence is realized through a triangular pattern of practice of knowledge acquisition and production. Within the domestic contexts of Korea and Taiwan, the state actively deploys the advantages of geographical proximity by encouraging relational proximity through institutional learning and knowledge transfers in the form of science and technology parks. The state sets up special committees to review, regulate and even monitor knowledge upgrading among firms in these parks. Regulatory measures were undertaken to minimize land speculation and to encourage knowledge spillovers between firms (Hsu, 2004).

In Korea, national science and technology policies promote government research institutes (GRIs) over university R&D because Korean universities are traditionally oriented towards undergraduate teaching (Kim, 1997). The more successful Daedeok Science Park (DSP) in Korea was created in 1978. Coordination between the country's Ministry of Science and Technology, and Ministry of Education and Ministry of Construction ensured that the DSP, built some 120 miles south of Seoul, became relatively well-endowed with research institutes; indeed the number of research institutes in Korea is nearly three times those in Taiwan.¹ As of 2002, there were nearly 30 publicly funded and 29 private research institutes, and 130 venture businesses in the science park. Despite criticisms that DSP was forced upon private industries with the result that there is little local knowledge spillovers (Castells and Hall, 1994), some evidence is emerging that the park has become relatively successful in forging institutional learning over time: more than 1000 applications in international patents were filed in 2002 among the park's public and private research institutes (Park, 2004), and over 100 local firm spin-offs have occurred (Shin, 2001). Consistent with the literature on local innovation system, one advantage of geographical proximity is associated with institutional and inter-organizational interactions (Amin, 1999). Institutional-motivated learning in turn contributes to knowledge thickness over time. An example of this may be illustrated through Korean firms' gradual mastery of the CDMA (code division multiple access) knowledge and technology in 1995.² Until the mid-1990s, Korea's telecommunication industry was importing and licensing this important technology from the US company Qualcomm. This included relatively successful chaebols like

1 Korea has a total of 50 public research institutes and some 10 427 private research institutes (Korea Industrial Technology Association or KOITA) in the country. Taiwan has fewer than 20 public research institutes and the number of private research institutes is not known.

2 CDMA is part of an ultra high frequency wireless telephone system that allows many signals to be transmitted through a single channel.

Samsung and LG Electronics which are major players in the manufacturing of cellular phones on the international market. The CDMA technology was mastered by one of DSP's research institutes, namely the Korean Electronic and Telecommunication Research Institute, and subsequently transferred to the industry.

In Taiwan's case, the state established the Hsinchu Science-based Industrial Park (HSIP) which is supported by the Electronic Research Service Organization (ERSO), a public lab, and which is also the research arm of the government. Most of the key high-technology firms today are spin-offs from ERSO. The HSIP and its neighboring corridor to Taipei is home to Taiwan's most rapidly growing microelectronics industries such as the integrated circuit and personal computer (PC) industries. In contrast to their Korean counterparts, these firms, mostly small and medium sized (SMEs), collectively build up a vertically disintegrated industrial system. Local companies dominate the international market for a large and growing range of computer-related products, from notebook computers to optical scanners, keyboards and power supplies. In addition, Taiwan's state-of-the-art semiconductor foundries account for two-thirds of global output.

Because of their small size, many of Taiwan's high-tech firms are disadvantaged in terms of internal resources both financially and technologically, and this forces them to rely on external partners for their manufacturing processes. Under these circumstances, a more refined model of regional learning is necessary in order to understand Taiwan's decentralized high technology industrial system. The Taiwanese firms have to be open to their customers, suppliers and partners in order to discuss and negotiate the possible paths of product development. They benefit by learning from external resources, in addition to the internal resources through the coupling of R&D, production and design functions. Hence, on the one hand, Taiwan's case appears to confirm the regional innovation literature's conclusion on the merits of vertically disintegrated inter-firm transactions that are largely collaborative to build technological assets. On the other hand, HSIP is not as locally self-contained compared to Korea's DSP because a significant dimension of knowledge flows in the region is that they are associated with international knowledge sources, more specifically, from knowledge networks in the Silicon Valley (Hsu, 2004).

HSIP's global links with the Silicon Valley are articulated in several ways: Taiwanese companies recruit overseas engineers, they set up listening posts in Silicon Valley to tap into the knowledge networks there, or they attract successful overseas returnees to start up their own businesses. All these linkages are mediated by US-based industry organizations (e.g. the Monte Jade Science and Technology Association in California) that enable domestic firms to integrate into US-based social networks to gain access to technological and market-related information and to absorb them effectively (Hsu and Saxenian, 2000).

State-initiated institutional learning appears at least to have kick-started a culture of R&D among the firms that was previously missing, though in Taiwan's case, the state's nurturing role soon gave way to that of a demonstrator's role where it did not target, as the Korean government did, large companies for R&D development. Sakakibara and Cho (2002) observe that compared to Japanese firms, Asian firms, at least before the 1990s, tended to be much more indifferent to R&D activities. Institutional learning that is enhanced by relational proximity, however, encouraged applied R&D among firms and quickly transformed firms from passive learning where GRIs led in tacit knowledge production, to active learning where firms play a greater role in scouting for new

technological knowledge themselves. Institutional learning is also complemented by embodied technology learning that deploys reverse engineering, technology licensing and returnees who had previously worked in US firms. In the initial stages of technological upgrading, most of the firms used technology licensing to source for knowledge. The second largest Korean chaebol LG Electronics even hired a German engineer in the early stages of its R&D process to access tacit knowledge. However technology licensing often met with limitations since foreign firms are reluctant to impart their key technological assets to Asian firms. Hence while LG Electronics may have learnt to produce black and white televisions in the 1960s through a licensing agreement with the Japanese Hitachi, it failed to acquire technology on color television when the former ran the course of its product cycle. Acquiring innovation capability through relational and institutional learning in the form of joint R&D with a GRI (Korean Institute of Science and Technology) helped overcome this problem to some extent, however, the company also engaged in reverse engineering such as taking apart microwave ovens imported from Japan and the US to supplement the learning process (Kim, 1997).

The above discussion suggests a more fluid interplay of local and global knowledge spatial relations with knowledge acquirers and assemblers circulating across the two scales in a dynamic fashion. Between the fluidity of these spaces lies a trans-regional dimension: the China factor is more than just an abundance of cheap labor. Chinese labor is also becoming highly skilled and top Chinese universities graduate a number of engineers and scientists every year whose wages are about one-third that of Korean and Taiwanese engineers.³ Geographical proximity to China has encouraged a trans-regional division of labor where more mature technologies are relocated to nearby regions like Guangdong, Fujian, Zhejiang and Shandong. The Beijing area also attracts considerable Asian R&D plants because of its thick skilled labor market as a result of the presence of the elite Beijing and Qinghua universities. Key R&D knowledge, however, is produced and retained in parent firm operations back in Taiwan and South Korea. A recent survey of 28 Taiwanese firms in China by one of the authors indicates that whereas 40% of the firms reported 'access to skilled labor' as being critically important, and another 30% as somewhat important, comparable statistics for US indicate that the shares are only 17.5 and 10%, respectively. The proximity of a relatively large pool of cheap but skilled labor in neighboring China has meant that R&D costs are kept at a reasonable level. In contrast, market-oriented R&D learning systems are oriented towards the US. This triangular division of R&D across the US, Taiwan and China is summed up by a venture capital executive in Taiwan who specializes in the information and communication technology (ICT) industry: 'the best business model in the ICT industries today is to combine the locational advantages of the three regions: while the Silicon Valley is good at innovation in business and management model, product design and technology frontier, the newly industrializing countries such as Taiwan and Korea can collect funding from the booming capital market, commercialize the product and improve the production very quickly by well-trained engineering teams. Finally, you can go to China to find the large number of

3 This information was consistently relayed to us in on-site qualitative interviews with twenty Taiwanese and Korean parent firms.

cheap engineers and workers and a rapidly rising market to get the final products done.’ (Authors’ interview, June 2004).

3.2. International learning and knowledge sourcing

3.2.1 Data and methodology

The previous section suggests that an important source of extra-local knowledge for Asian learners lies in innovation-fertile areas in the US. To examine the evidence, surveys of Taiwanese and Korean manufacturing firms in the US were conducted between 2003 and 2004. The survey consisted of two stages: (1) telephone surveys with 74 Taiwanese and 50 Korean manufacturing subsidiaries in the US from a population base of 210 and 113, respectively; and (2) on-site qualitative in-depth interviews with 20 parent companies in Taiwan and Korea. Targeted populations for the telephone surveys were based on manufacturing firm directories obtained from Taipei’s Cultural and Economic Office and the Korean Chamber of Commerce and Industry. The service sector is not very internationalized in both countries hence this sector was omitted from the study. A content analysis of company websites as well as telephone clarifications ensured that only firms with national origins from Taiwan and Korea and those that were engaged in technological activities in the US were surveyed.⁴ The telephone surveys were preceded by a pilot study of about 12 firms that helped fine tune the questions. The study further determined that telephone over mail survey would yield better quality responses because of potential language problems arising from formal translation.

The telephone surveys were designed to obtain quantitative data on the various dimensions of technological learning and acquisition. Quantitative data allow us to test the relationship between firms’ learning capability and US-based relational knowledge transfers. But a more detailed understanding of such a relationship requires more intensive interviews. For example while probit regression analyses below indicate the significance of various dimensions of relational proximity, they do not adequately explain how these relationships translate into technological learning. Hence twenty parent firms were also interviewed that sought insights on the nature of firms’ learning. Selection of the firms was based on two major considerations: first, that the firms have attained a relatively high level of technological autonomy; and second, that they report relatively high shares of expenditures in R&D. Both factors were surmised from the quantitative surveys. Most of the 20 firms were concentrated in the computer and electronics industries though interviews with the automobile and IT sectors were also secured. One of the major difficulties encountered in fieldwork was securing interviews in sensitive sectors (e.g. pharmaceutical). In a few firms, thorough security checks were conducted before we were allowed into the R&D facilities and interview sites. Firms in sensitive sectors clearly guard their proprietary technological knowledge fiercely resulting in relatively lower quality interviews; hence they are not reported below. In contrast, the more internationalized sectors of computers, electronics and automobiles appear to be far more open with a few respondents engaging in fairly long discussions.

4 Original populations from the directories located approximately 300 and 150 US-based subsidiaries for Taiwan and Korea respectively. However, many of them were irrelevant for the study from the telephone calls and web content analysis because they are predominantly sales units and have no R&D activity.

3.2.2. Results and analysis

A comparison of the quantitative survey data between Korea and Taiwan indicates two main differences: (1) Taiwanese firms are predominantly SMEs and nearly 95% of them have worldwide sales of less than \$250 million. In contrast, Korean firms are much larger reflecting a history of chaebolization with slightly over 40% indicating worldwide sales four times the size of their Taiwanese counterparts, that is, over \$1 billion; (2) Korean firms are also older internationalizers in the US with nearly 80% having established operations for more than 10 years. In contrast, the entry of Taiwanese firms to the US is more recent with 53% reporting as having been in the US for less than 10 years. Approximately 82 and 62% of Taiwanese and Korean companies respectively may be found in three sectors, namely computers, electronics and semiconductors. The dominance of these sectors is consistent with the national comparative advantage of these countries (Dicken, 2003) and constitutes the main sectors where technological progress has been relatively well documented (Mathews and Cho, 2000; Hobday *et al.*, 2004; Kim, 1997). In the case of Korea, the automobile and chemical industries were also significantly represented in the remaining one-third of the sample. Tests for survey response bias using the Armstrong and Overton (1977) method of early and late responses further suggest no significant differences in age, sector and size for each country.⁵

Relational-oriented learning began in the 1970s when Asian firms operated as OEM and ODM suppliers to American and other MNCs. However, the firms are becoming more than just passive recipients of knowledge from foreign MNCs and their inward investment. Many are actively sourcing for knowledge through outward FDI to knowledge-rich regions in the US. Firm addresses at the zipcode level reveal that approximately 70% of the firms are located in five of such US regions, namely, the New Jersey–New York city as well as Austin–Dallas conurbations, the Silicon Valley, Los Angeles–Riverside and Raleigh Research Park.

Table 1 shows an analysis-of-covariance that controls for firm size, sector as well as age of the influences on firm location with one being very unimportant and seven being critically important. Market expansion, proximity to users and competitors, market intelligence and distribution networks are ranked amongst the most important reasons for investment by the firms including in R&D investment.⁶ The importance of developing ‘relational market-based assets’ (Srivastava *et al.*, 2001), particularly with respect to the US market, customers and distributors in part stems from the need to interpret large volumes of market and technical information, a process made more complex by cultural and institutional gaps that Gertler (2003) has suggested. These factors appear to be far more important in Table 1 than technological building factors such as prototypical or technology process development. The only explicit technological building factor that is somewhat important is that location in the US is associated with improvement in product performance and quality (mean = 4.3). Relational proximity also

5 Non-responses bias analysis for sector, age and size reveals the following statistics: (i) Korea: Sector ($\chi^2 = 8.78$, $P = 0.553$), age ($\chi^2 = 1.38$, $P = 0.710$) and size ($\chi^2 = 7.45$, $P = 0.209$). The corresponding statistics for Taiwanese firms are sector ($\chi^2 = 15.16$, $P = 0.105$), age ($\chi^2 = 3.42$, $P = 0.378$) and size ($\chi^2 = 3.51$, $P = 0.561$).

6 R&D investment on the average constitutes between 5 and 10% of total investment though a few firms reported a much larger share of more than 50%.

Table 1. Reasons for location of technology-related facilities in the US (analysis-of-covariance)

Reasons	Taiwan (mean)	Korea (mean)	F-statistics (P-values)
(1) Take advantage of skilled labor	3.2	3.1	0.03 (0.854)
(2) Collect market information	5.3	5.2	0.02 (0.879)
(3) Develop distribution networks	5.6	5.3	0.97 (0.327)
(4) Proximity to competitors	4.6	4.5	0.23 (0.634)
(5) Proximity to customers	6.3	5.4	5.24 (0.020)**
(6) Build partnerships in US	4.4	3.3	3.83 (0.05)**
(7) Develop new prototypes	4.0	3.7	0.43 (0.511)
(8) Develop new process technologies	3.2	3.3	0.26 (0.612)
(9) Improve product quality/performance	4.3	4.5	0.00 (0.986)

**Significant at 5% level.

Means are based on a Likert scale of 1 = very unimportant to 7 = critically important.

appears to be more important for the electronics, computer and automobile sectors with Korean and Taiwanese electronics firms reporting means as high as 6.7 and 6.4, respectively, on the importance of proximity to customers compared to all industries' means of 5.4 and 6.3.⁷ The case of a Korean auto supplier, Firm A, provides insights into how relational proximity enhances learning.⁸

Firm A is an auto-maker that supplies components to the US big three carmakers, namely Chrysler, Ford and General Motors (GM). While the company has a manufacturing plant in Montgomery County in Alabama, its US R&D unit is located in Detroit. R&D in Detroit focuses on applied research on vehicular movement and brake systems (anti-lock braking systems). According to the interviewee, a senior R&D manager, while the firm could have located all of its facilities in Alabama, which is preferred by its US-based engineers because of a warmer climate, 'being there' in Detroit helps strengthen relational market assets with its principal customer GM in particular. Emphasizing its long term relationship with GM, which began some 12 years ago, our interviewee indicates that the most important dimension of relational learning with GM is associated with its being among the first suppliers to be notified of GM's new car models when the specifications are formulated, and considerable access to its customer for tacit understanding of the information. This lead time, together with the supplier's ability to shorten delivery time by as much as 65% compared to its US competitors have enabled the development of brake systems that are customized for, and are cost efficient to, GM's newer models. Particularly noteworthy is that R&D investment in brake systems is highest with respect to their design and this tends to be undertaken back in Korea by its parent company rather than by its R&D team in Detroit. However, intra-firm transfers, specifically, subsidiary (Detroit) to parent (Seoul) knowledge flows significantly contribute to the parent company knowledge on the design process, a point that we will return to in a later discussion.

7 Sectoral differences are not reported here because of the relatively small sample sizes of sectors outside of computers and electronics; hence analysis-of-covariance *F* statistics would be suspect.

8 Where necessary, firms are assigned letter labels to preserve their anonymity.

The F -statistics in Table 1 also indicate that Taiwanese firms attach a greater importance to the development of relational market assets than Korean firms in locational considerations.

Part of the explanation lies in the small size of many Taiwanese firms which forces them to rely far more heavily on external relationships including those associated with partnerships with US companies in order to acquire complementary assets. In contrast, the larger size of Korean companies implies that more R&D may be conducted in-house. Another reason for the differences may also lie in sectoral variation. One Korean supplier to the US defense industry reported the importance of locational isolation (in this case in rural Iowa) because of the sensitive nature of its sector. Despite these differences, the mean scores for several relational market asset factors among Korean firms are still well above the neutral score of 4.0.

But how successful are the above factors in internalizing learning among Asian firms? The answer to this may be found in Table 2 which examines the relationship between various locational and relational factors, including the industrial sector as a control variable, and ability of firms to capture learning rents. The dependent variable, that is innovation rent, is measured in terms of ability of firms to introduce new products as a result of their outward investment to the US. This variable assumes a scale of 1—7, with 7 indicating significant success in new product introductions. Given the indexed nature of the dependent variable, probit regressions are used to analyze the aforementioned relationship.⁹

The regression results indicate that partnership with a US firm and the development of new prototypes are common positive contributing factors among the two countries in enabling firms to successfully introduce new products with their US FDI. However, new product introductions are also significantly related to proximity of Korean firms to competitors and product improvements, while the development of distribution networks has a significant impact on Taiwanese firms. Interestingly, development of process technology in US locations is negative and significant for firms from both countries. What Table 2 suggests is that for Asian learners to acquire product than process innovation capability, tacit knowledge transferred through complementary partners (including certain strategic alliance relationships), competitors and distributors constitutes the main transmission mechanism. While firms consider proximity to customers to be important in Table 1, this locational factor does not directly result in any knowledge and innovation rent indicating that, at least in the Asian case, the benefits of user-producer interactions and proximity are not obvious in knowledge creation. One possible explanation may lie in the negative finding for process technology development. Consistent with the reverse product cycle model, if firms are seeking to improve their process technologies in the US arising from pressures from their users to lower costs or enhance efficiency, this is more likely to result in incremental product improvements than new product development since learning here

9 An ordered probit regression takes the form of $y_i^* = \mathbf{x}_i \boldsymbol{\beta}_i + \varepsilon_i$ where \mathbf{x}_i is a vector of explanatory variables, $\boldsymbol{\beta}_i$ is a column vector of parameters to be estimated with the first element being the intercept, y_i^* is the latent variable and ε_i is the random error term which is assumed to follow a normal distribution. The ordered probit model is derived from a measurement model where the latent variable, which ranges from $-\infty$ to ∞ , is mapped to an observable variable y such that the extreme interval categories $\alpha_0 = -\infty$ and $\alpha_j = \infty$.

Table 2. The effect of locational factors on firm's success in introducing new products since relocation to the US (ordered probit regression)

Locational factor	Parameter estimate (P-value)	
	Taiwan	Korea
(1) Sector	0.054 (0.103)	0.037 (0.356)
(2) Skilled labor	0.034 (0.604)	0.003 (0.980)
(3) Market information	-0.151 (0.155)	-0.180 (0.149)
(4) Distribution networks	0.203 (0.086)*	-0.073 (0.473)
(5) Proximity to competitors	-0.039 (0.622)	0.312 (0.029)**
(6) Proximity to customers	-0.124 (0.406)	-0.191 (0.880)
(7) US partnerships	0.214 (0.009)***	-0.265 (0.013) **
(8) Development of new prototypes	0.182 (0.065)*	0.418 (0.032)**
(9) Development of new technology process	-0.248 (0.029)**	-0.540 (0.006)***
(10) Improvement of product quality/performance	0.120 (0.157)	0.608 (0.001)***
α_2	0.358 (0.719)	0.0416 (0.961)
α_3	0.093 (0.925)	-1.147 (0.179)
α_4	-0.043 (0.966)	-1.525 (0.077)*
α_5	-0.593 (0.522)	-2.313 (0.009)***
α_6	-1.300 (0.194)	-3.209 (0.000)***
α_7	-1.823 (0.071)**	-4.092 (0.000)***
Loglikelihood ratio	34.076 (002)***	

***, ** and * denote significance levels at 1, 5 and 10%, respectively.

is much more associated with production and improvement capability than innovation capability.

On the other hand, knowledge transfers from distributors and competitors may have a more significant impact because innovations like new product development require changes in design and core features of products. The case of a major Taiwanese scanner maker illustrates this. The company was founded by three US-educated Taiwanese returnees who had worked in the image-engineering department at Xerox. From the beginning, this company pursued brand creation of its products. This is quite unique since most Taiwanese firms are quite weak in original brand manufacturing. Its first product was the in-circuit microprocessor, which sold well and won a prize for its innovativeness at a computer trade show in 1981. The company decided to enter the scanner industry in 1983, as the founders responded to market intelligence gathered from its competitors while working in the Silicon Valley. It produced the world's first 300-dpi black-and-white sheet-fed scanner in 1985, and the world's first USB and SCSI scanner in 1999. In fact, the firm was responsible for over 30% of the world's scanners at its peak in the late 1990s. It set up three subsidiaries in the US, one in the Silicon Valley, that assumed the primary roles of innovation and marketing. It developed significant technological capability in the scanner industry and was effectively responsible for introducing image processing in PCs.

However, mastering imaging technology and possessing first mover advantage do not guarantee sustained competitive advantage. The company's market share was gradually eroded due to the entry of strong competitors such as HP and Epson who possessed more comprehensive marketing and distribution channels in 2001. The profit erosion was attributed to the lack of distribution channels by the firm's vice president who

concluded that: 'Even though our innovative capability was good enough to set the product standard in the early stage, it lost control as these established PC companies joined the game. They could promote their scanner products with their PC marketing channels and strong brand names. But we did not carry such an advantage, and what we could do was to focus on the niche market such as industrial-specific image processing equipment.' (Authors' interview, November 2004). Enjoying innovation rents from its initial success with the scanner technology, the company failed to develop extensive distribution networks that potentially supported wider market-derived innovations. Part of the reason lies in the complaint that contrary to perception, the US is not a monolithic market, so that success in distribution requires considerable knowledge of the nature of forward integration, the latter of which also requires cultural bridging across several regional markets. Indeed once its Japanese competitors successfully distributed its scanner-printer technology, US demand for Taiwanese scanners declined.

In Korea's case, domestic rivalry has been a traditional source of competitive advantage among its firms (Kim, 1997). Table 2 suggests that international rivalry and competition are complementing domestic rivalry as a source of knowledge rent; a factor that Malmberg and Maskell (2002) note is under-appreciated in the innovation literature. Taken together, for Asian firms to move from process to product innovations under the reverse cycle theory, a combination of relational-based learning and competition or rivalry is expected to aid the transition.

The above provides support for the positive effect of relational learning on the development of production and technological capability that realizes new product introductions. However, core R&D activities tend to be undertaken back home by parent companies with the R&D team being relatively small in the US. In other words, distanced knowledge, both codified and tacit, is largely transferred back to Taiwan and Korea rather than locally produced in the US. Currah and Wrigley (2004) have observed similar organizational learning among retail firms from transnational sources. A key role of intra-firm transfers among Asian firms is to retain proprietary knowledge within the organization. Another reason would seem to be that conversion of knowledge into production and innovation capability, or, absorptive capacity requires an optimal body of indigenous knowledge stock that supports new knowledge formation. As discussed in an earlier section, knowledge is enhanced with repeated and cumulative experience and practice, and, therefore more easily acquired if it is learned in the context of a shared social and organizational context.

The example of a Taiwanese company that manufactures connectors for computers should shed some light here. The key engineering knowledge for this product is mechanical and contains a higher level of tacit knowledge than most electrical components. Such mechanical engineering knowledge resists standardization and coding in objective forms particularly with respect to the product's design and development dimensions. R&D activities here require engineers with 'very full experience' and who have 'worked in-house for a period of time, and know what are our resources' because the technical process consists of 'a lot of knowledge that is cumulative'. The need for considerable communication with respect to the simultaneous conversion of knowledge, in this case, from tacit (design) to explicit (drawing) and back to tacit (development) is all the more necessary because customization is high. This customized knowledge is provided by the firm's R&D support team in the US. It was the US R&D subsidiary that brought to the parent company's attention, Apple's demand for a change in the

Table 3. Intra-organizational interactive and communicative patterns (analysis of covariance)

	Taiwan (mean)	Korea (mean)	F-statistics (P-value)
(1) Visits to parent company/plant or other US subsidiaries by engineers/technicians from US subsidiary	4.1	3.2	3.09 (0.08) *
(2) Visits to US subsidiary/plant by engineers/technicians from parent company	4.2	4.4	0.36 (0.548)
(3) Rotation of engineers/technicians between companies and facilities in US and Taiwan/Korea	2.2	1.7	1.23 (0.271)
(4) Communication of new technologies to parent company and other subsidiaries by phone, faxes or emails	6.1	5.2	0.029 (0.029)**

** and * denote significance levels at 5 and 10% respectively.

connector's material, which the vice-president maintained was far more expensive than the material that it uses for customers in Asia. This demand for costlier materials had puzzled the parent company initially, a response worth noting because it reflects a learning process that forces the supplier to think beyond costs and efficiency (process innovation) in favor of design (incremental product innovation). Furthermore, Apple's industrial design extends beyond the objective requiring 'the feeling, the touch ... something like art' that is reminiscent of Allen's (2002) description of aesthetic knowledge. Knowledge sourcing in the US in this case by its subsidiary has resulted in considerable tacit learning for the parent firm by increasing its sensitivity to industrial and product design which has generally been a weakness among Asian firms.

The transfer of distanced knowledge to parent firms calls for organizational proximity that is conducive to the efficient circulation of knowledge. Table 3 provides quantitative data on internal organization of firms in terms of their interactive and communicative patterns. Clearly, the simplest and most frequent mode of communication is by phone, fax or emails of new technologies to parent companies (and other subsidiaries) with means of over 5.0 on a scale of 1—7 (1 being very unimportant and 7 being critically important). However, virtual proximity facilitated by emails and faxes tends to be associated much more with codified knowledge transfers. Digital pictures and drawings for example are common communication features in using the Internet for knowledge exchanges. One firm indicated that product defects are typically photographed and digitally transferred to its parent company for improvement and further development. However, because knowledge is partly codified and partly tacit, virtual transfers are complemented by organizational transfers that support relational proximity. This includes the visits of engineers from parent companies to their US plants and facilities as well as the visits of engineers from US plants to their parent companies. Both factors receive slightly above neutral mean scores of 4.0 for Taiwanese companies. The frequency of visits is high, with some firms reporting up to bi-monthly visits particularly from parent to subsidiary plants. Knowledge circulation via intra-organizational rotations is ranked well below 4.0.

Intra-firm subsidiary-to-parent knowledge flows appears to have yielded innovation rents for both countries. Table 4 correlates each of the organizational variables to the ability of firms to secure US patents. Visits by parent engineers to the US as well as

Table 4. Correlations between intra-organizational communication and securing of US patents

US patents	Visits from subsidiary to parent firm/plant	Visits from parent to subsidiary firm/plant	Intra-organizational rotation of personnel	Telephones, faxes, emails
Taiwan	0.313 (0.008)***	0.329 (0.005)***	0.198 (0.099)*	0.137 (0.252)
Korea	0.251 (0.09)*	0.321 (0.029)**	0.160 (0.310)	-0.029 (0.846)

***, **, and * denote significance levels at 1, 5 and 10% respectively.

visits by subsidiary engineers to parent companies appear to be the most common form of knowledge exchanges that have contributed positively to patent making. The least helpful and insignificant medium of communication relates to telephones, faxes and emails. This is hardly surprising since telecommunication use is more likely to be associated with product improvement with subsidiaries largely conveying relatively non-complex information pertaining to product defects than more abstract knowledge that is difficult to codify through such mediums. Overall, the analysis here indicates that the transfer of distanced knowledge contributes to the augmentation of Asian parent companies' technological assets and that international technology sourcing necessarily supplements local and transregional scales of knowledge production for technologically weaker Asian firms.

4. Conclusion

Prevailing literature on innovation focuses on technological and scientific changes that are aimed at innovation in industrialized countries. A common theme finds the region to be a superior spatial architecture for knowledge creation and reproduction though this literature is increasingly being criticized. The tendency of this literature to correlate innovation with regional systems neglects the fact that knowledge systems are frequently not self-contained and regional spillovers in fact occur. Such spillovers result in extra-regional and international circulation and appropriation that lead to the creation of new knowledge elsewhere. Knowledge spillovers, when absorbed by foreign firms, contribute to international learning that stimulates innovations outside the region. This essay has examined such knowledge re-appropriation and reproduction by unpacking the geography of technological learning among Taiwanese and Korean firms, particularly learning that is manifested through their investment in the US.

The geography of Asian learners may be understood through the articulation of a multiscale spatial strategy. To catch up, state-initiated effort involves the establishment of regional production systems that the literature maintains has successfully created innovations in the US and Europe. These local regional systems such as Korea's DSP and Taiwan's HSIP are said to have fostered domestic institutional learning through the accretion of relational technological linkages between firms and research institutes. However, regional knowledge incubators are insufficient for narrowing the knowledge and technological gap between industrial countries, and, industrializing Asian countries whose competitive advantage until very recently has been largely based on cost advantages and mass production rather than advanced technologies. As OEM and ODM suppliers, institutional learning is often complemented by more

embodied forms of technology (e.g. reverse engineering) that are sourced from publicly accessible forms of both tacit and codified knowledge. To supplement regional systems of domestic learning, firms are also broadening their knowledge acquisition base to extra-local international scale through outward FDI, including R&D investment, in the US. Because the US is the largest market for most Taiwanese and Korean manufacturing firms, this geographical bias in knowledge sourcing is not surprising. US-sourced knowledge is largely obtained through relational proximity not only with customers, but also with distributors and competitors or through process innovations, and transferred back to parent R&D facilities in Asia. But material production of knowledge is increasingly farmed out to China where skilled scientists and engineers are plentiful and relatively cheap. Key tacit and proprietary codified knowledge, however, is retained in Taiwan and Korea.

The survey evidence suggests that firms are predominantly located in knowledge buzz and knowledge fertile areas, and the reasons for locating and investing in these US regions are associated with developing relational market-based assets such as proximity to customers, distributors and the collection of market information. What Malmberg and Maskell (2002) have termed the horizontal dimension of locational advantages or competition also emerged as important for Korean firms. While technology acquisition considerations like prototypical and technology process development may be somewhat important, firms however gave lower mean scores to these factors. It appears that tacit knowledge that resides in individuals is a stronger locational motivation perhaps because social interactions and relational-based knowledge access constitute the main mechanism of knowledge transfer here.

However, probit regressions indicate that not all relational market-based factors translate into learning and thereby innovation rents in the form of new product introductions. Collaborating with US partners to access proprietary knowledge is significantly associated with new product introductions. This positive relationship may also be found for proximity to competitors among Korean firms, and, a good network of distributors in the US among Taiwanese firms. User- or customer-oriented factors including proximity to customers and market intelligence both yield no learning rent. Furthermore, it would appear that learning is largely internalized within the organization through subsidiary to parent knowledge exchanges. Organizational proximity and intra-firm transfers indicate that R&D engineers from parent companies visit their subsidiaries and R&D plants in the US frequently. The reverse too happens, that is skilled personnel from the subsidiary also visit R&D plants in Asia. Both forms of personnel mobility are positively correlated with the securing of US patents. Overall, the analysis suggests that relational learning can be enhanced through two proximity forms: first, less complex information such as product defects relies on virtual proximity to overcome the problem of distance. Interpretation of such codified information is facilitated by tacit understanding between distant parties. Second, more complex problem solving utilizes organizational transfers by social proximity.

Finally, the comment of one electronics Taiwanese company best conveys the importance of extra-regional knowledge spillovers that enables the circulation of knowledge across spatial scales among Asian firms: 'We've continuously transferred technology from such cultural regions as Britain and US to Taiwan'. Asian firms increasingly view the need to source and transform new knowledge from various cultural regions in the world as essential to making the transition from low cost suppliers to medium or even high technology producers. Over time, the ability to successfully integrate various

spatial scales of knowledge flows may well help firms from these countries to move from process to product innovation, and from learner to innovator status.

Acknowledgements

Funding for this research was received from the National Science Foundation (award number BCS-0137045) and the National Science Council in Taiwan (NSC 93-2415-H-002-001). Any opinions and conclusions expressed here are those of the authors and do not reflect the views of the National Science Foundation. We thank three referees and Neil Wrigley for their constructive comments which led to significant improvement of the paper.

References

- Abernathy, W., Utterback, J.M. (1977) Patterns of industrial innovation. *Technology Review*, June/July, 4108.
- Allen, J. (2002) Living on thin abstractions: more power/economic knowledge. *Environment and Planning A*, 43: 451–456.
- Amin, A. (1999) An institutionalist perspective on regional economic development. *International Journal of Urban and Regional Research*, 23: 365–378.
- Amin, A., Cohendet, P. (2004) *Architectures of Knowledge: Firms, Capabilities and Communities*. Oxford: Oxford University Press.
- Armstrong, J., Overton, T. (1977) Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, 16: 396–402.
- Bathelt, H., Malmberg, A., Maskell, P. (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28: 32–56.
- Britton, J. (2003) Network structure of an industrial cluster: electronics in Toronto. *Environment and Planning A*, 35: 983–1006.
- Bunnell, T., Coe, N. M. (2001) Spaces and scales of innovation. *Progress in Human Geography*, 25: 569–89.
- Camagni, R. (1995) The concept of innovative milieu and its relevance for public policies in European lagging regions. *Papers in Regional Science*, 75: 317–340.
- Cantwell, J., Odile, J. (1999). Technological globalization and innovative centers: the role of corporate technological leadership and locational hierarchy. *Research Policy*, 28: 119–144.
- Castells, M., Hall, P. (1994) *Technopoles of the World: the Making of the 21st Century Industrial Complex*. London: Routledge.
- Cohen, S., Fields, G. (1999) Social capital and capital gains in Silicon Valley. *California Management Review*, 41: 108–130.
- Cooke, P., Uranga, M. G., Etxebarria, G. (1997) Regional innovation systems: institutional and organization dimensions. *Research Policy*, 26: 457–491.
- Currah, A., Wrigley, N. (2004) Networks of organizational learning and adaptation in retail TNCs. *Global Networks*, 4: 1–23.
- Dicken, P. (2003). *Global Shift: Reshaping the Global Economic Map in the 21st Century*. New York: the Guilford Press.
- Dunning, J., Lundan, S. M. (1998). The geographical sources of competitiveness of multinational enterprises: an econometric analysis. *International Business Review*, 7: 115–133.
- Dyer, J. H. (1996) Does governance matter? Keiretsu alliances and asset specificity as sources of Japanese competitive advantage. *Organizational Science*, 7: 649–666.
- Florida, R. (1995) Towards the learning region. *Futures*, 27: 527–536.
- Gertler, M. S. (1995) ‘Being there’: proximity, organization and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography*, 71: 1–26.
- Gertler, M. S. (2003) Tacit knowledge and the economic geography of context, or the undefined tacitness of being (there). *Journal of Economic Geography*, 3: 75–99.
- Hobday, M., Rush, H., Bessant, J. (2004) Approaching the innovation frontier in Korea: the transition phase to leadership. *Research Policy*, 33: 1433–1457.

- Hsu, J. (2004) The evolving institutional embeddedness of a late industrial district in Taiwan. *Tijdschrift voor Economische en Social Geografie*, 95: 218–232.
- Hsu, J., Saxenian, A. (2000) The limits of guanxi capitalism: transnational collaboration between Taiwan and USA. *Environment and Planning A*, 32: 1991–2005.
- Keeble, D., Lawson, D., Moore, B. (1999) Collective learning processes, networking and ‘institutional thickness’ in the Cambridge region. *Regional Studies*, 33: 319–330.
- Kim, L. (1997) *Imitation to Innovation: the Dynamics of Korea’s Technological Learning*. Boston: Harvard Business School.
- Lundvall, B. A. (ed.) (1992) *National Innovation Systems of Innovation: towards a Theory of Innovation and Interactive Learning*. Oxford: Oxford University Press.
- MacPherson, A. (2002) The contribution of academic-industry interaction to small firm innovation: the case of New York State’s medical devices sector. *Papers in Regional Science*, 81: 121–130.
- Malmberg, A., Maskell, P. (2002) The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering. *Environment and Planning A*, 34: 429–449.
- Mathews, J., Cho, D. (2000) *Tiger Technology: the Creation of a Semiconductor Industry in East Asia*. Cambridge: Cambridge University Press
- Nelson, R. R., Winter, S. G. (1982) *An Evolutionary Theory of Technical Change*. Cambridge, MA: Belknap Press.
- Nightingale, P. (2003) If Nelson and Winter are only half right about tacit knowledge, which half? A Searlean critique of ‘codification’. *Industrial and Corporate Change*, 12: 149–183.
- Nobel, R. (1999) Knowledge transfer in international acquisition. *Journal of International Business*, 30: 439–450.
- Nonaka, I., Toyama, R., Nagata, A. (2000) A firm as a knowledge creating entity: new perspective on the theory of the firm. *Industrial and Corporate Change*, 9: 1–20.
- Park, S. (2004) The city of brain in South Korea: Daedeok Science Town. *International Journal of Technology Management*, 28: 602–614.
- Polanyi, M. (1967) *The Tacit Dimension*. London: Routledge.
- Porter, M. (1998) Economics of competition. *Harvard Business Review*, November/December, 77–90.
- Sakakibara, M., Cho, D. (2002) Cooperative R&D in Japan and Korea: a comparison of industrial policy. *Research Policy*, 31: 673–692.
- Searle, J. (1983) *Intentionality: An Essay in the Philosophy of the Mind*. Cambridge: Cambridge University Press.
- Shan, W., Song, J., (1997) Foreign direct investment and the sourcing of technological advantage: evidence from the biotechnology industry. *Journal of International Business Studies*, 28(2): 18–29.
- Shin, D. (2001) An alternative approach to developing science parks: a case study from Korea. *Papers in Regional Science*, 80: 103–111.
- Srivastava, B. K., Fahey, L., Christensen, H. K. (2001) The resource-based view and marketing: the role of market-based assets in gaining competitive advantage. *Journal of Management*, 27: 777–802.
- Storper, M. (1992) The limits to globalization: technology districts and international trade. *Economic Geography*, 68: 60–93.
- Storper, M., Venables, A. J. (2004) Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography* 4(4): 351–370.
- Thrift, N. (2000) Performing cultures in the new economy. *Annals of the Association of American Geographers*, 90(4): 674–692.
- Viotti, E. B. (2002) National learning systems: A new approach on technological change in late industrializing economies and evidence from the cases of Brazil and South Korea. *Technological forecasting and Social Change*, 69: 653–680.
- Yeung, Y., Li, X. (2000) Transnational corporations and local embeddedness: company case studies from Shanghai, China. *Professional Geographer*, 52: 624–635.
- Zeller, C. (2004) North Atlantic innovative relations of Swiss pharmaceuticals and the proximities with regional biotech arenas. *Economic Geography*, 80: 83–110.