Foreign direct investment and technology transfer: a case-study of foreign direct investment in north-east China

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Based on empirical research in the city of Dalian in north-east China, this article explores the contribution of foreign direct investment to Chinese firms' technology development. The technology contribution of transnational corporations was deemed to be from low to moderate, with technology flow dominated by hardware transplants and training in basic operations. The absence of research-and-development capabilities restricted development potential, while lack of skills in areas such as marketing constituted a barrier to transfer on the software side. The integration of foreign direct investment with the local economy was also underdeveloped. The requirement for an innovation-oriented policy regime in the open coastal cities such as Dalian is discussed. By this means, technological upgrading could be facilitated, with foreign direct investment in labour- and resource-intensive investments being encouraged in inland areas. A wider recognition of the problems of technology transfer into developing countries like China is necessary.

Introduction

In the past decade, the rapid economic growth in the People's Republic of China has been accompanied by a large inflow of foreign direct investment (FDI). The relationship between the two has attracted much interest. However, the studies undertaken on the subject to date have been limited (Zhan, 1993; Conroy, 1992). The present research, based on surveys through postal questionnaires and personal interviews in the city of Dalian in north-east

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China, is designed to redress this inadequacy by exploring the contribution of FDI to Chinese firms' technology development and the factors limiting this contribution. Estimates are provided of technology transfer related to FDI in north-east China, that is, the potential for a "leap-forward" by Chinese firms through inward investment. The mechanisms of technology transfer are evaluated through an examination of the first and second-round transfer effects. Finally, a series of models of technology transfer, based on the Dalian experience, is presented, before considering policy implications.

Frameworks for analyzing technology transfer

In early work, which incorporated much of the existing thinking on the subject, James B. Quinn (1969) presented a framework for technology transfer revolving around the production presence of transnational corporations (TNCs) in host countries. The main premise was that technology transfer would take place when production activities were established in a host country. The entry of TNCs could increase the living standards of host countries and improve their competitiveness when the latter utilized effectively technologies which were available on a free or minimum royalty basis. Therefore the priority of national policies would be to require TNCs to install fully integrated production facilities in the host country. Within this regime, the concept of technology itself was comparatively simple, and the transfer mechanism was dominated by direct transfers.[1]

Compared with this technology-transfer paradigm, current thinking (Cantwell, 1992, 1993; Ostry and Gestrin, 1993; Young *et al.*, 1993; Cusumano and Elnkov, 1994; Dunning, 1994) reveals a number of important divergences:

- Technology is no longer limited to the field of production and shows greater diversity. Although there are differences among authors, technology is widely defined to include not only technical knowledge but also organizational know-how in such fields as finance, marketing and

[1] It was also accepted that the transfer environment was full of conflicts. One such conflict in policy was that between host and home countries, since most developing countries tended to regard a TNC as an instrument of its home country's policies. Another conflict was that between TNCs' strategy and host country goals, since most countries recognized that the self-interest of a TNC is not automatically congruent with their national goals.

management skills. Aside from the traditional distinction between hardware and software technology, a third component—mediumware or semi-embodied documents—has been identified (Kranzberg, 1986; Lan, 1995). There are two consequences. First, technology transfer is not necessarily a repeatable process because transfers of organizational skills always require certain innovations due to the economic, social and cultural diversity of host countries; second, technology flow can take different forms at different levels, such as material transfer, design transfer and capability transfer (Cusumano and Elnkov, 1994).

- Production and innovation activities are separated, and research and development (R & D) becomes a major focus of international technology transfer. Greater emphasis is, therefore, placed on the **quality** rather than the **quantity** of FDI in evaluating technology transfer to host countries. Major interest lies in the overseas development path of TNCs' R & D activities, and the factors influencing the expansion of foreign R & D laboratories (Pearce, 1992; Dunning, 1994).

- The dynamics of international transfer are widened from a predictable one-way flow from home to host countries to a global and interactive process of technology generation and application. Technology transfer not only occurs after technology maturity but in addition appears at the innovation stage within an innovation-network model (Ostry and Gestrin, 1993); and technology generation and diffusion may take place simultaneously. Foreign direct investment can perform two roles, either as a "downstream distributor of technology" or an "upstream hunter of technology".[2] In the former case, FDI may be the tool of TNCs to utilize effectively global resources and exploit global markets (UNCTAD-DTCI, 1993, 1994; Dunning, 1994); for the latter, FDI can be the mechanism employed to generate new firm-specific technological advantages (Cantwell, 1992, 1993; Tolentino, 1993; Young and Huang, 1994).

- The nature of technology and transfer processes means that indirect transfers assume more importance. Methods of transfer, such as local sales and customer education, which were previously categorized as direct transfers, are now treated as indirect transfers. This reflects the

[2] Hobday (1991) distinguished two paths of technology development based on the experience of the electronics industry in Pacific Asia.

difficulties of transferring knowledge-intensive and software-related information.

- Accessing technology is both difficult and expensive. Costs include not only direct costs such as royalty payments and tax concessions, but also a range of indirect costs. Among the latter are communication and training costs, derived from resistance to foreign technology, lower levels of entrepreneurship, education or absorptive capacities; the requirement for improvements in infrastructure, including scientific institutions and R & D facilities as well as vocational, technical and management training institutes; and changes in market structures to encourage a more competitive atmosphere and in policies on the role of foreign technology in host countries.

- In the period since 1969, the international business environment has changed fundamentally with a worldwide liberalization of national FDI policies. A shift in policy emphasis has occurred from one focusing on **firms' obligations and governments' rights** to one **emphasizing firms' rights and government obligations**.[3]

It is against this much changed technology transfer background that the present study was undertaken, the aim being to highlight characteristics of and impediments to technology transfer, and to consider the policy implications.

Research study

Although contributing to an understanding of the issues, previous studies on technology transfer to China through FDI are far from comprehensive. For example, some studies have analysed the characteristics of technology senders but failed to combine this with data on technology receivers (Beamish and Speiss, 1993; Ball *et al.*, 1993; Casson and Zheng, 1992); others have identified differences between transfer channels but have not gone further to compare technology transferability (Oman, 1989; Conroy, 1992; Casson and Zheng, 1992); while others have reviewed the role of

[3] This is discussed in the context of the changing philosophy in international investment agreements (see Brewer and Young, 1995), but applies equally at the national level.

government policy and technology transfer but at a mainly general level (Zhan, 1993; Zhang, 1994).

This study attempts to remedy some of these deficiencies, focusing upon a case-study of FDI and technology transfer in the city of Dalian in north-east China. Dalian was one of the 14 Economic and Technology Development Zones (open coastal cities) established by the Government of China in 1984. The city has a population of over 5 million (0.7 per cent of the total for the 467 cities of China in 1990) and accounts for over one per cent of GNP and three per cent of FDI inflows. The city has a diversified industrial base, and a special relationship with Japan.

Research for this article was based on a large-scale postal questionnaire survey, supplemented by personal interviews. Data from the Dalian Statistics Bureau indicated that over 800 FDI projects[4] were initiated during the years 1985-1991. Postal questionnaires were sent to a random sample of foreign affiliates in manufacturing, with 361 usable responses being received. Follow-up personal interviews were undertaken with 36 of these enterprises (10 per cent sample), so as to provide a range of experiences with technology transfer, albeit with a bias towards companies indicating positive technology transfer potential in the postal survey. In order to ensure a complete and balanced picture, a range of interviews were also undertaken with local officials and professionals, local academics and foreign bankers.[5]

The research results reported in this article relate to perceptions of the size and characteristics of the technological gap between foreign investors and local partners/firms; estimates of the potential direct technology-transfer effects of FDI; the contents of the technology-transfer package; and types of forward and backward linkages and FDI. An attempt was also made to categorize models of technology transfer among foreign investors, and to review policy implications.

[4] Foreign direct investment into China is divided into three categories, wholly-owned, joint ventures and cooperation projects. In a joint venture, the foreign partner is required to hold a minimum of 25 per cent of the shares in the enterprise; no such requirement is necessary for a cooperation project, which is set up and managed by an agreement signed by the foreign partner and the Chinese partner.

[5] The names and addresses of the foreign affiliates were obtained from the Dalian Commission of Foreign Economy and Trade. Postal questionnaires were mainly directed to the local manager, vice general manager or chief engineer, as appropriate, and follow-up personal interviews were undertaken with these same executives. For details of the research methodology, see Lan (1995).

The current technology transferability of foreign direct investment in north-east China

Technology gap

In the postal questionnaire, sample companies were asked to estimate the technological gap between foreign investors and local partners or local firms, and to identify the contents of this gap and the possibility of closing the gap through FDI. The objective was to provide a measure of the contribution of inward investment to the host region's technology development.

Table 1. Technology gap between foreign investor and local partner or local firms

(Number and percentage)

Size of technology gap[a] (Number of years)	Sample size	Firms' responses	
		Number	Per cent
Very large (over 15 years)	361	44	12
Large (10-15 years)	361	96	27
Moderate (0-9 years)	361	195	54
Negative (less than 0 years)	361	26	7

Source: Questionnaire survey.

[a] Two criteria were suggested to estimate the size of the technology gap: 1. Number of years to develop the technology brought by the foreign investor, based on the technology previously used by local firms; 2. Number of years needed for local firms to overcome this gap by themselves, based on their technology capability prior to FDI.

In terms of the perceived technology gap, table 1 confirms that possession of a technological advantage was a precondition for most foreign investors to enter north-east China. Accepting the subjectivity of the responses, however, the gap was not regarded as large: 54 per cent of firms estimated a moderate gap of 0-9 years between the technology level of foreign investors and that of local partners or equivalent local firms. A somewhat similar result was shown in research in another Chinese city Tianjing (Wu, 1989); but other research on United Kingdom exporters' perceptions (Ball *et al.*, 1993) suggested a technological gap of over 20 years. The Dalian results indicate that 7 per cent of the foreign affiliates estimated a negative technological gap, that is, the affiliates had lower technology than that of local firms. These investments seemed to be motivated by a desire to gain access to government incentives and were principally from Hong Kong, Macao and Taiwan Province of China. Some may have been "disguised investments", that

is domestic investments re-routed through Chinese affiliates in Hong Kong (Zhan, 1993; Harrold and Lall, 1993).

Table 2. The components of the technology gap

(Number and percentage)

Components of technology gap	Sample size[a]	Firms' responses	
		Number	Per cent
Product technology only	335	34	10
Process technology only	335	27	8
Product and process technology	335	105	31
Organizational technology only	335	92	28
Product, process and organizational technology	335	77	23

Source: Questionnaire survey.

[a] 335 firms identified the components of the technology gap.

The characteristics of the technology gap in table 2 show that production technology (product and process) was the major component; this has implications for the transferability or diffusion of the technology. In 31 per cent of cases, the product and process (equipment) constituted a package; and in a further 23 per cent of firms, this package also included organizational technology. A substantial proportion of sample firms (28 per cent) identified organizational know-how as the main element of the technological gap. Although this figure appears high, it is not uncommon for newly industrializing countries to invest in less developed nations using management skills as a vehicle (Cavusgil, 1985); and certainly in the present research this category is dominated by Hong Kong, Macao and Taiwanese investors and cost reduction motives for FDI.

Technology transfer through FDI

Having identified the level and constituents of the technology gap, the objective of the research was to establish the potential for diminishing or eliminating the gap through FDI. This narrowing of the technological gap indicates both the technology transferability of FDI and the capabilities and advancement of the technology receiver. While the size of the technology gap identified above is difficult to define and measure, the estimated gap diminished through FDI is even more problematic because technology development is interactive and technology transfer has many facets (Cusumano

and Elnkov, 1994; Rosenburg, 1982, 1994; OECD, 1992). In this research, a range of criteria was listed in the postal questionnaire to enable respondents to categorize the estimated technology leap-forward associated with FDI (summarized in note *a* to table 3).

Table 3. Estimated direct technology transfer through FDI

(Number and percentage)

Level of technology transfer[a]	Sample size	Firms' responses	
		Number	Per cent
High technology transfer	361	95	26
Medium technology trasnfer	361	173	48
No or negative technology transfer	361	93	26

Source: Questionnaire survey.

[a] **High technology transfer** indicates that a technology gap of 10 years or over can be overcome. Features of technology transfer would include: upgrade/develop new products; obtain advanced equipment; master new processes; obtain important trade secrets; access certain world networks; access important information channels; introduce international management practices.

Medium technology transfer indicates that a technology gap of under 10 years can be overcome. Features of technology transfer would include: improve product quality and appearance; obtain some advanced equipment; adopt international standards; expand export channels; use new trademarks, especially for exports; improve management, including training.

No or negative technology transfer means that there is no technology gap diminished. The following cases are included within this category: no technology supply or technology level of foreign investor is lower than that of the local partners; foreign partner as seller of readily available equipment; foreign partner as buyer of product only; foreign partner mainly involved in provision of capital with little management interest; simple operative-level training.

Through the 1950s, much of the civil technology in China was obtained by large-scale transfers from the Soviet Union and Eastern European countries (Lubman, 1984; Conroy, 1992). Subsequently, China's technological development stagnated for about 20 years owing to the "Cultural Revolution" and international isolation. Thus, while almost three quarters of sample firms suggested either medium or high technology transfer associated with FDI (table 3), this has to be viewed in the context of the low base-level of technology. Other research evidence (Rapakko, 1990) indicated that the mean time-lag from technology introduction to transfer abroad from developed countries to developing countries' firms through joint ventures was about 10 years. On this basis, the technology advancement recorded in the Dalian research seemed quite modest.

By comparing the technological gap and the technology transferability through FDI (tables 1 and 3), it is possible to ascertain the effectiveness of

Table 4. Estimated direct technology transfer and characteristics of foreign direct investment

(Number and percentage)

Characteristics	High technology transfer		Medium technology transfer		No or negative technology transfer		Total	
	Number of firms	Per cent	Number of firms	Per cent	Number of firms	Per cent	Number of firms	Per cent
Motive of foreign investor								
Access to Chinese market	47	51	30	33	15	16	92	100
Low production costs	36	20	90	51	52	29	178	100
Host government policy/ incentives	10	16	30	49	21	35	61	100
Access to natural resources	2	7	23	77	5	16	30	100
Origin of foreign investor								
Hong Kong, Macao, Taiwan Province of China	34	20	96	56	42	24	172	100
Japan	32	28	47	51	36	31	115	100
North America and Europe	29	39	30	41	15	20	74	100
Status of foreign investor								
Manufacturing company	47	43	38	35	24	22	109	100
Trading company	39	19	112	54	55	27	206	100
Individual	9	20	23	50	14	30	46	100
Motive of local partner								
Obtain production technology	31	68	14	30	1	2	46	100
Obtain organizational technology	8	17	29	63	9	20	46	100
Obtain production and organizational technology	14	48	14	48	1	4	29	100
Obtain foreign capital	20	28	40	56	12	17	72	100
Host government policy/ incentives	19	19	59	60	20	21	98	100
Ownership form								
Joint venture	79	35	117	51	33	14	229	100
Cooperation	13	21	39	63	10	16	62	100
Wholly owned	3	4	17	24	50	71	70	100

Source: Questionnaire survey.

technology transfer. It is understandable that there are differences given various transfer barriers (and problems of data collection), but the distance between the two sets of results is noteworthy. Thus, while 39 per cent of firms indicated a technology gap of 10 years or over (table 1), only 26 per cent suggested a similar level of technology transferability through FDI (table 3). Similarly, the figures in the moderate technology gap/transferability category were 54 and 48 per cent, respectively. These results imply not only that 26 per cent of foreign affiliates cannot exert positive impacts on local

technological development, but also that another 19 per cent of these affiliates that possess the technology capability cannot or will not undertake technology transfer effectively.

The findings on potential technology transfers through FDI are linked to a number of other classification variables in table 4. With regard to the motivations of foreign investors, domestic market-oriented FDI showed the greatest potential for technology transfer to local partners (51 per cent of sample firms in this category indicated a high level of technology transfer). Western investors also indicated higher levels of transfer than Japanese or investors from Hong Kong, Macao and Taiwan Province of China. In the case of Japan there is a wide divergence between the results relating to the size of technology gap as opposed to technology transferability: thus, 63 Japanese projects were perceived to be in the category of 10 years or over technology gap, whereas in table 4 only 32 recorded a high technology transfer potential. Apparently, Japanese investors were regarded as transferring far less technology than they controlled. As a final observation on table 4, the motive of the local partner to obtain technology (principally production technology) appeared to be associated with greater technology transfer possibilities.

Technology transfer mechanisms: first and second-round effects of transferring technology by foreign direct investment

In order to develop a deeper understanding of actual technology transfers to China, personal interviews were undertaken with a sub-sample of 36 enterprises. Emphasis was on identifying both first and second-round effects of technology transfer. The first-round effects represent the transfer of knowledge within foreign affiliates, and the second-round impacts the transfer of technology to indigenous enterprises and personnel.

Technology transfer within FDI firms

Six components of technology were identified, based on combinations of production (product and process) and organizational capabilities, and hardware, mediumware and software technologies.[6] The results, summarized

[6] Hardware represents totally embedded knowledge, that is, machinery and equipment. Mediumware is partially embedded knowledge, that is, various documents that possess an

in table 5, record the major constituents of technology transfer and the main impacts on the sample foreign affiliates in Dalian. Hardware transplant was the main ingredient of technology transfer, with over 70 per cent of interviewed firms obtaining new products and equipment, and 90 per cent receiving transportation, communication and office equipment. Regarding production hardware, however, the embedded nature of the technology and lack of information from the foreign partner about the product, equipment and suppliers meant that genuine technology transfer was limited, and company development was essentially dependent upon hardware upgrading from abroad. The limited positive impacts related to the manufacture of certain spare parts. In respect of organizational hardware, vehicles followed by telecommunications facilities (e.g., fax machines) and office equipment (e.g., photocopiers) were the main items; the provision of computers appeared to be a luxury. Because of the pattern of inflow, transfers were restricted, except in the encouragement given to adopt better organizational procedures.

About half of the sample firms interviewed obtained operational documentation relating to different business functions, with a much smaller proportion receiving intellectual property (on the production side) or strategic marketing and planning information. Resistance from the Chinese partners or a lack of understanding presented a barrier to exploiting the latter, while the absence of R & D in the foreign affiliates in Dalian showed a limited absorption capacity in the production area.[7]

independent form but can only be used with particular hardware. Software is unembedded knowledge in the form of the experience and skills of individuals. Thus, production hardware includes products and machinery; organizational hardware takes the form of equipment and facilities which are used for handling non-production relations inside and outside the enterprise; production mediumware comprises documents relating to production criteria and production secrets; organizational mediumware concerns strategic and operational documentation. Finally, production and organizational software are respectively skills and experience utilized in production and management. For details, see Lan (1995).

[7] Among the sample of 36 enterprises, four claimed to possess R & D capabilities (all being "grafting enterprises"—see footnote 13), with a further 14 firms undertaking some very limited development work (modifying products for local markets). The objectives set for increased R & D in the foreign affiliates in Dalian would have to be realistic, meaning in the initial stages an improved understanding of the documentary material transferred from the parent firms and reverse engineering—essentially fostering a climate of intellectual enquiry; this could lead on to minor innovation, design imitation and assimilation, raw material adaptation, equipment modification and so on (Tolentino, 1993). Further incremental developments towards more advanced technological activities would depend upon the host country's own accumulated technological capabilities, in which the work of local R & D institutes might have an important role to play. Movements of local research personnel among foreign affiliates, indigenous enterprises and local R & D institutes would diffuse technologies and capabilities to the wider economy. However, there could be dangers that the use of host country resources by foreign affiliates might pre-empt some indigenous R & D capabilities (UNCTAD-DTCI, 1995).

Table 5. Contents and characteristics of technology transfer

Contents	Characteristics
Production hardware (Ph)	• 70 per cent of the foreign affiliates report inflow of Ph, mainly in the form of new products and supply of equipment. Products showed novel design and high quality, while equipment was highly automated. • Technology transfer was limited by information blockages from abroad and built-in computers. Inflow of Ph encouraged local partners/firms to obtain additional technology through FDI instead of through in-house R & D.
Organizational hardware (Oh)	• 90 per cent of the foreign affiliates reported inflow of Oh in the form of vehicles (principally), office equipment and telecommunications facilities. • Impacts were weak because of dominance of vehicles. Some encouragement provided to utilize modern management procedures.
Production mediumware (Pm)	• 60 per cent of the foreign affiliates obtained operation manuals, production standards etc.; 20 per cent received patents and other know-how. • Impacts were low because of reliance on personal contacts with foreign employees, controls over local personnel's access to technology and limited local R & D.
Organizational mediumware (Om)	• 50 per cent of companies obtained documentation on personnel management, accounting standards and quality control; 20 per cent of firms received strategic information, e.g., strategic plans, market analysis, international networks data. • Positive effects in terms of simplicity and effectiveness of operating, but some barriers due to negative attitudes or ignorance of Chinese partners.

Production software (Ps)	• Production skills transfer (linked to movement of foreign engineers & technicians) reported by 60 per cent of the companies. Mainly operation and maintenance skills transferred through on-the-job training. • Positive impacts on production, with increased quality of products, improved equipment utilization and higher productivity. Few innovation skills transferred.
Organizational software (Os)	• 50 per cent of the foreign affiliates revealed Os transfer, principally in management and marketing. Main method of transfer was informal personal contact. • Low level of involvement of foreign investors and ignorance of local partners constituted barriers to transfer of Os.

Source: Based on authors' interview survey.

Reflecting the patterns of hardware and mediumware transfer, the software transfers and benefits principally related to improvements in operation and maintenance skills. Few innovation skills were transferred; and the low appreciation by Chinese partners of the benefits associated with management, finance and marketing skills constituted a barrier to absorption.

Technology transfer through forward and backward linkages

Interview data were collected on certain of the second-round effects of technology transfer, viz. local sales and their impacts, local purchases and their stimuli and the effects of personnel movements.

Although Dalian was included within the government's export-led development strategy for coastal China, the export orientation of the sample firms was quite limited. The interviews revealed that many firms found it difficult to achieve their export targets in their early years of operation, partly because of the necessary learning process and partly because of a difficult operational environment. The consequence was that forward linkages, as represented by the level of local sales, were strong. Nearly one half of the sample firms sold over 75 per cent of their output in the domestic market; and only one fifth sold less than 25 per cent of output within China. Joint ventures recorded the highest local sales linkages, as did wholly owned subsidiaries. The principal orientations of local sales are shown in table 6, together with possible technology transfers. Where buyers were local enterprises (28 per cent of the sample), the major positive impact related to improvements in product quality from the use of higher grade components; a smaller number of foreign affiliates also suggested improvements in the technical skills of local enterprises and indicated that the provision of technical information could assist the generation of sales by their customers. In terms of sales to local consumers (44 per cent of the sample), there were two levels of knowledge flow: the first related to raising consumers' awareness and expectations of quality; and the second derived from the demonstration effects of foreign affiliates' marketing activities and, particularly, their tendency to bypass inefficient local distribution networks and control their own distribution.

In terms of local purchases, backward linkages appeared significant. Thus, 22 of the 36 sample firms (61 per cent) purchased over 50 per cent of their inputs locally. As might have been anticipated, nevertheless, local purchases mainly comprised basic materials (from steel to agricultural prod-

Table 6. Types of forward linkages and possible technology transfers

Types of forward linkage		Possible technology transfers
Foreign affiliates[a]	Local enterprise (28 per cent of sample)	Improvement in quality of buyers' products from using higher quality components.
		Transfer of technical skills through component supply, after-sales service and training.
		Provision of technical information to generate sales.
		Competitive stimulus to other local suppliers.
	Other foreign investors (19 per cent of sample)	Some of the above.
		Products convey technical knowledge by themselves. Raises local customers' awareness of quality, and forces Chinese firms to improve their standards.
	Local consumers (44 per cent of sample)	Consumer education, including training of customers before purchase and after-sales service.
		Demonstration of marketing know-how, because most foreign investors market their new products instead of using fragmented local distribution networks.

Source: Based on authors' interview survey.

[a] Percentages are based on a sample of 32 foreign investors, since 4 firms sold all output abroad. Percentage total 91 per cent; the other 9 per cent (3 firms) showed no clear pattern in sales.

ucts) which were location specific and costly to transport. Large orders tended not to be placed with local suppliers, and local purchases did not show a rising trend. Sourcing from other foreign affiliates in China was, moreover, significant, and on the increase with the rise in the number of joint ventures.

Technology diffusion through backward linkages is influenced by the relationships between foreign affiliates and their local suppliers, and table 7

Table 7. Types of backward linkages and possible technology transfers

Types of forward linkage[a]		Possible technology transfers
	Shopping around (20 per cent of sample)	No or very limited effects
Foreign affiliates[b] purchase	Conditioned buying (59 per cent of sample)	Foreign investors set high product standards or new supply procedures (including provision of samples). Means improvements in product quality and supply methods. Technology diffusion is "passive".
	Controlled buying (15 per cent of sample)	Foreign investors set high standards and offer technical assistance to local firms.
		Management assistance is provided
		Comprehensive assistance package provided

Source: Based on authors' interview survey.

[a] "Shopping around" refers to "buying" without any interaction with local suppliers. With "conditioned buying", standards and procedures are set but no assistance is provided to local suppliers to achieve these. In "controlled buying", assistance is provided to local suppliers to develop their technological skills.

[b] No particular pattern was apparent in the remaining 6 per cent of firms.

identifies various types of relationships through which know-how flows could be stimulated. The majority of firms used a "conditional buying" approach, which could have some effects on suppliers' production methods and quality standards. Without further assistance from foreign affiliates, however, improvements would be limited; and only 15 per cent of the sample employed "controlled buying" in which management assistance or a comprehensive assistance package[8] was provided.

A third dimension of technology diffusion which was considered related to the impacts of local personnel movements. The survey results revealed that about three fifths of firms had very stable employment; among the remaining companies, staff turnover in the order of 10 per cent per

[8] One sample firm not only trained operators and managers in the supplier firms, but also assisted with organizational restructuring and the importation of machinery.

annum was not uncommon, albeit dominated by unskilled manual workers. In terms of reasons for leaving, dislike of the work (pressures for high productivity, for example) and low pay or poor working conditions were alleged. These reasons seemed to apply in particular to workers who had transferred from other, especially state-owned factories. Such movements clearly have only a rather limited positive multiplier effect. Movements of skilled personnel were more restricted, but a small number of positive technology spin-offs were recorded. Firstly, there was evidence of the diffusion of certain production technologies, and the rapid development of local detergent production was a prime illustration.[9] In addition to diffusing production know-how, improvements in management skills and a stimulus to entrepreneurship were also apparent. Some illustrations existed of personnel moving back to state enterprises and helping to promote reform, and of local personnel establishing new enterprises based on market and other knowledge obtained in foreign affiliates.

Models of technology transfer to north-east China through foreign direct investment and policy implications

Summarizing the above, the record of FDI in transferring technology to the local economy has been very varied. The range of issues discussed in this article are synthesized in table 8 which identifies a number of models of technology transfer within the sample foreign affiliates in Dalian. Although judgements on the size of the technology gap are arbitrary, the technology contribution associated with FDI was low to moderate and the technology package was incomplete. A production presence represented the main source of potential technology supply, with technology flow dominated by hardware transplant and training in basic operations. The absence of R & D restricted development potential and encouraged hardware technology dependency, while lack of understanding and appreciation of skills such as marketing by local Chinese personnel constituted a barrier to transfer on the software side.[10] The integration of FDI with the local economy was under-

[9] Local staff working in the laboratories of two foreign affiliates manufacturing detergents discovered the contents of production by repeatedly trying the combinations. They then moved out to set up their own firms. In only a few years, more than ten small local firms were manufacturing detergents.

[10] The survey found that, although local managers were not familiar with the market economy nor with modern management practices, they did not appreciate or welcome the skills of foreign managers. Over one third of interviewed joint ventures had problems in the sharing of management.

Table 8. Models of technology transfer among foreign investors[a]

(Number and percentage)

Model	Firms' responses Number	Per cent	Characteristics
1. Unbinding development model	2	6	Large technology gap and high technology-transfer potential (mainly mediumware). International market-oriented joint ventures with strong assimilation capabilities.
2. Unbinding diffusion model	5	14	Moderate technological gap and high technology-transfer potential (soft and mediumware, and organizational technology). Diffusion but more limited developmental capabilities than above. Joint ventures and cooperation firms.
3. Wholly consuming-dependence model	5	14	Technology transfer based on equipment and operations skills, but little potential for development or diffusion. Sample firms are mainly Western, joint ventures and in high tech sectors. Inflows require further inflows.
4. Partly consuming-integration model	11	30	Medium technology gap and incomplete technology package transferred. Main contribution in updating products and improving the performance of the sample firms. Medium assimilation capability.
5. Workshop transplant-accumulation model	4	11	Large technology gap. Complete technology package transferred, but tightly controlled by foreign investors. Some software transfer in production and management skills. Export-oriented. Japanese investment dominated.
6. Limited transfer-localization model	9	25	Small technological gap and limited technology transfer. Includes speculative investments and those motivated by government incentive policies. Hong Kong, Macao and Investment from Taiwan Province of China dominant.

Source: Based on authors' interview survey.

[a] Based on the level and impact of technology transfer on the technological development of local partners or local personnel. The models are ranked on the basis of technology transfer potential.

developed, and both forward and backward linkages were weak, confirming that the absorption capacity of the market was limited. Technology transfer varied with the origin of FDI, and the nationality of the investor seemed to be the most important factor in determining the behaviour pattern of FDI. Among the categories presented in table 8, both the "unbinding development model" and the "unbinding diffusion model" indicated significant technology-transfer potential, but only 7 of the 36 sample firms interviewed were represented.

As in many developing countries, China offers a variety of incentives to inward investment, such as reductions in taxation, provision of land or facilities and access to local capital. These are balanced by various ownership restrictions, including a 25 per cent foreign investment shareholding to qualify for joint venture status, ceilings on the share of know-how and industrial property in total foreign investment,[11] as well as some limitations on FDI in certain sectors or export requirements (Panagariya, 1995). Generally, however, the foreign investment regime is liberal, with policies and procedures being designed to facilitate FDI. Joint ventures enjoy incentives that are particularly generous in the Special Economic Zones and Open Cities. In relation to the characteristics of FDI and technology transfer in the Dalian case, a number of problems were apparent: the policy package was more suitable for labour-intensive investment than for technology-intensive investment; R & D capacities were not a concern of current policy; there was an absence of effective measures to promote integration between medium- and large-sized domestic enterprises and FDI; and insufficient attention was paid to human capital development.

These problems stem in part from a policy philosophy and practice that have not kept pace with the evolution of FDI and TNC activity, from the distorted motives of local partners,[12] and from a lack of skills and understanding among local management. Improvements in policy are therefore required in two interrelated directions: the first is to extend the scope of market-oriented reforms and establish a stable macroeconomic framework;

[11] The two ceilings are as follows: the proportion of industrial property of the foreign investor cannot be over 20 per cent of registered investment; and know-how's share in foreign investment cannot exceed 10 per cent.

[12] The results of the survey indicated that more than one third of the local partners did not aim at gaining anything from foreign investors when setting up cooperative projects. Rather, the objective was to access incentives offered by the Government of China, which were only available to foreign affiliates.

the second is to shift policy priorities from a production to an innovation orientation and thereby accelerate technology inflows. The former has been reviewed in previous studies,[13] and the present discussion, therefore, focuses on the latter.

In introducing an innovation-oriented policy regime, there are a number of key requirements:

- ***Relax the restrictions on the share of technology investment.*** The ceilings on technology investment within the current policy package have hindered technology flow, particularly that of mediumware. Aside from accelerating technology inflows, a relaxation of the rules would improve the investment environment, encourage a wider exchange of technical and business information and increase local technological service capabilities.

- ***Develop indigenous technological capabilities.*** A prominent characteristic of the new international technology transfer regime concerns its emphasis on the importance of indigenous technological capabilities. However, the present research has shown that, in Dalian, technology transfer is hindered, on the one hand, by the embodied nature of production technology and, on the other, by the relative absence of R & D in foreign affiliates. In addition to this, local R & D institutes are separated from FDI activity. Two requirements thus seem to relate to the development of an appropriate environment allied with incentive structures to encourage foreign investors to increase levels of R & D; and the improvement of cooperation between local research centres and foreign affilliates. Ambitions for R & D in foreign affiliates must clearly be realistic and hence limited, with initial objectives, for example, relating to improved assimilation of production and organizational mediumware (see table 5). In relation to the second point, encouragement may be given to the establishment of joint ventures between local research centres and foreign investors with capital support from the government. Relaxation of controls on access to the domestic market could provide a significant incentive for this form of joint venture activity. Aside from formal joint ventures, policies to develop staff exchanges between TNCs and R & D institutes will prove useful.

[13] In a Chinese context, see for example, Zhan, 1993.

As has been shown (UNCTAD, 1995), there is also a need to transform domestic R & D centres and increase the commercialization of their activities. This would not only make them more attractive partners for foreign investors, but their innovations could raise standards in local supply industries and in other less technologically advanced firms including small and medium-sized enterprises. Commercial activities (see UNCTAD, 1995) include very practical measures such as small product and process innovations, industrial engineering and design, and supporting services like quality control, certification and testing, training of personnel, etc.

- ***Encourage further integration between foreign investors and local firms.*** One possible policy development concerns the encouragement to establish so-called "grafting enterprises"[14] between foreign investors and local firms. This type of enterprise has several potential advantages such as savings in foreign exchange, shortening of the construction period and more effective transfer of technology. The survey identified numerous problems hampering the development of such enterprises, some of which were legal/institutional;[15] aside from solving these, further support for establishing grafting firms would seem to be necessary. At the same time, the reform process needs to be continued for local enterprises in order to improve their attractiveness to foreign investors.

  Further encouragement to strengthen forward and backward linkages is also necessary, since the poor quality and uncertainty of local supply are the two main barriers.

- ***Establish an Office of Technology Transfer.*** At present, there are several government departments dealing with technology transfer through FDI, including the Department of Technology Transfer in the Ministry of Foreign Trade and Economic Cooperation (MOFTEC) and

[14] A "grafting enterprise" is a specific type of joint venture, in which the established firm utilizes part or all of the assets of the Chinese parent firm. The enterprise would usually be co-located with its Chinese parent firm while at the same time having a number of different characteristics to that of the parent firm. In some regions in China, "grafting enterprises" represent up to one quarter of all foreign investment projects. In the case of Liaoning Province (where the city of Dalian is located), nearly one fourth of the large and medium-sized state enterprises have entered into such ventures (Zhan, 1993), but in Dalian the proportion is only 10 per cent.

[15] For example, the valuation of an old factory's assets is always debatable.

the State Industrial Production Bureau, a high-profile organization with subsidiary offices located in provincial and municipal governments (one of the functions is to provide policy guidance on and supervision over technological development and transfer). However, there must be concern as to the adequacy of coordination between them, and also as to whether FDI-linked technology transfer fits into the government strategy for national science-and-technology development. Whether establishing a new office or restructuring and strengthening certain established departments, a number of tasks have to be fulfilled. First, a properly mapped out strategy and policy formula to guide companies in technology acquisition is required. By this means, the effectiveness of technology transfer would be improved and technology dependency reduced. Second, the development of a sound technology base in China is needed. Without the appropriate physical and financial infrastructure, and a high standard of manpower and management training, significant technology transfer is highly constrained. The Office would also have the role of organizing and promoting studies on FDI. Technology development through FDI is a comparatively new issue in China; many problems exist in the interactions with policy, national and local environments and local enterprises. Systematic research is required to guide policy.

It has to be recognized that the above policy implications derived from research in north-east China may not be relevant or applicable country-wide. The economic, technological and other infrastructural parameters are very different in the countries over 20 provinces; and there is a striking contrast in economic development between the eastern and western regions of China, and in industrial structure between the northern and southern parts of the country. However, since Dalian is one of China's open coastal cities and a focus for FDI and technological upgrading, innovation-oriented policy would seem to be a requirement for socio-economic development in the region. In the same way, the encouragement of efficiency-seeking FDI in the form of labour- and resource-intensive investments in inland areas would effectively utilize the locational advantages of these regions.[16] Admittedly, China has been very successful in attracting FDI and the overall impact of this investment has been substantially positive. Confirming the conclusions of X. J. Zhan (1993), a key challenge for the future is to replicate within

[16] A drive to redirect resources towards the underdeveloped hinterland is contained in China's ninth five-year plant (1996-2000) and its 15-year strategy, both of which were approved in September/October 1995 (*The Financial Times*, 5 October 1995).

China the sequential pattern of FDI-linked development observed elsewhere in the Asia-Pacific region.

A final point worth mentioning concerns China's approach towards legislative changes. In November 1995, it was announced that China would phase out tax exemptions for capital equipment imports by foreign invested enterprises from 1 January 1996.[17] From a foreign business perspective at least, this continues a tendency for China to change abruptly "the rules of the game", and is, therefore, an issue which merits consideration for the future.

Undoubtedly, a key element in China's success has been connection with Hong Kong and Taiwan Province of China (Panagariya, 1995). Attracted by low labour costs as wages rose rapidly at home, entrepreneurs shift manufacturing facilities from the mid-1980s to mainland China. Without losing the dynamism associated with these large-scale flows of economic activity, particular attention needs to be given to encouraging geographical diversification of this investment. At the same time, there is a case for closer financial scrutiny of some of these investments, given their disguised or speculative nature.

General conclusions

It is arguable that the positive experiences of the high-performing East Asian economies with TNCs and technology transfer have led to over-optimistic expectations of the contribution of TNCs in developing countries. The *World Investment Report 1992* (UNCTC, 1992, p. 191) pointed out that "countries at low levels of development are likely to be able to induce FDI only into low-technology activities . . . ." (see also UNCTAD, 1985; UNCTC, 1987). And Paz Estrella E. Tolentino (1993) has argued that theories of underdevelopment will continue to be relevant in lower-income developing economies where firms lack competitive, indigenously generated technological capacities. In support of these observations, the evidence of this research shows that a wider recognition and study of the ***problems*** of technology transfer into low-income countries such as China is necessary.[18]

[17] *The Financial Times*, 24 November 1995.

[18] The work of UNCTAD (1995) on country experiences in technology capacity-building and technology partnership is a useful example of a way ahead.

There are also major policy dilemmas which arise in a huge market like China and which are almost unique. Rather than simply a dual industrial structure which would be characteristic of most developing countries, the industrial structure in China has multiple tiers and levels; at the very least, the scale is totally different. For sectors and particularly enterprises at the forefront of development, outward FDI will likely play an increasing role in acquiring advanced technology (Gang, 1992; Young and Huang, 1994). At the opposite extreme are the problems of attracting labour-intensive investment and introducing factory routines and disciplines to an unskilled, labour force. The case for a holistic approach, involving public policies in areas including physical infrastructure, human resources development, R & D, competition, international trade and factory pricing, as well as technology and FDI, has been regarded as necessary. Within this, there would be a requirement for policy targeting at facilitating the technological upgrading of the different tiers in the industrial structure. The obvious danger in such circumstances is that of legislative overload and excessive bureaucracy (exacerbated perhaps by a continuing culture of suspicion towards FDI) and market distortions. In the face of such complexities, especially in a country the size of China, a very sharp policy focus would appear to be required, with the emphasis on a stable macroeconomic environment and improvements in the physical infrastructure; and, thereafter, on the upgrading of R & D capabilities and capacities of human resources and of domestic support industries. At the level of FDI policy measures and incentives, there is a case for simplicity even at the cost in terms of policy circumvention.

There are many countries like China which have operated for long periods with state controls and planned economies. This has generated a production orientation and philosophy and human resource policies emphasizing production skills. Greater attention needs to be paid to other corporate functions, including sales, advertising and marketing, procurement, accounting and finance, and research and development. The potential benefits include a greater recognition of the value of these functions to corporate performance and a stronger capacity for technology absorption; wider opportunities for labour mobility and hence for entrepreneurial spin-offs; and possibilities to attract a broader range of foreign investments and create dynamic industry clusters. ■

References

Ball, D. F., R. Zhang and A. W. Pearson (1993). "Perceptions of United Kingdom exporters in transferring technology into People's Republic of China", *R & D Management*, 23, l, pp. 29-41.

Beamish, Paul W. and Lorraine Speiss (1993). "Foreign direct investment in China", in Lane Kelley and Oded Shenkar, eds., *International Business in China* (London: Routledge), pp. 152-171.

Brewer, Thomas L. and Stephen Young (1995). "Towards a multilateral framework for foreign direct investment: issues and scenarios", *Transnational Corporations*, 4, 1, pp. 69-83.

Cantwell, John (1992). "Innovation and technological competitiveness", in Peter J. Buckley and Mark Casson, eds., *Multinational Enterprises in the World Economy* (Aldershot, Hants: Edward Elgar), pp. 20-40.

_____ (1993). "Technological competence and evolving patterns of international production", in Howard Cox, Jeremy Clegg and Grazia Ietto-Gillies, eds., *The Growth of Global Business* (London: Routledge).

Casson, Mark and J. Zheng (1992). "Western joint ventures in China", in Mark Casson, ed., *International Business and Global Integration* (London: Macmillan), pp. 25-62.

Cavusgil, S. Tamer (1985). "Multinational corporations and the management of the technology transfer", in A. C. Smali, ed., *Technology Transfer: Geographical, Economic, and Technical Dimensions* (New York: Quorum Books), pp. 3-50.

Conroy, Richard (1992). *Technology Change in China* (Paris: OECD).

Cusumano, Michael and Detelin Elnkov (1994). "Linking international technology transfer with strategy and management", *Research Policy*, 23, pp. 195-215.

Dunning, John H. (1994). "Multinational enterprises and the globalization of innovatory capacity", *Research Policy*, 23, 1, pp. 67-88.

_____ (1994). "Re-evaluating the benefits of foreign direct investment", *Multinational Corporations*, 3, 1, pp. 23-51.

Gang, Ye (1992), "Chinese transnational corporations", *Transnational Corporations*, 1, 2, pp. 125-131.

Harrold, Peter and Rajiv Lall (1993). "China: reform and development in 1992-1993", World Bank Discussion Paper No. 215 (Washington, D.C.: World Bank).

Hobday, Michael (1991). "Semiconductor technology and the newly industrializing countries: the diffusion of ASICs (Application Specific Integrated Circuits)", *World Development*, 19, 4, pp. 375-397.

Kranzberg, Melvin (1986). "The technological elements in international technology transfer: historical perspective", in John R. McIntyre *et al.*, eds., *The Political Economy of International Technology Transfer* (New York: Quorum Books), pp. 31-46.

Lan, Ping (1995), "Technology transfer to China through foreign direct investment", PhD thesis, Centre for Planning (Glasgow: University of Strathclyde), mimeo.

Lubman, S. B. (1984). "Technology transfer to China: policies, law and practice", in M. J. Moser, ed., *Foreign Trade, Investment and the Law in the P.R.C.* (Oxford: Oxford University Press).

Organisation for Economic Co-operation and Development (1992). *Technology and the Economy: The Key Relations* (Paris: OECD).

Oman, Charles (1989). *New Forms of International Investment in Developing Countries* (Paris: OECD).

Ostry, Sylvia and Michael Gestrin (1993). "Foreign direct investment, technology transfer and the innovation-network model", *Transnational Corporations*, 2, 3, pp. 7-30.

Panagariya, Arvind (1995). "What can we learn from China's export strategy?", *World Development*, 32, 2, pp. 32-35.

Pearce, Robert D. (1992). "Factors influencing the internationalization of research and development in multinational enterprises", in Peter J. Buckley, *et al.*, eds., *Multinational Enterprises in the World Economy* (Aldershot, Hants, Edward Elgar), pp. 75-95.

Quinn, James B. (1969). "Technology transfer by multinational companies", *Harvard Business Review*, 47, 6 (November-December), pp. 147-161.

Rapakko, T. (1990). "Industrial property rights and transfer of technology to joint ventures", in UNCTAD, *Joint Ventures As A Channel for the Transfer of Technology*, pp. 3-11. Sales No. 90.II.D.5.

Rosenburg, Nathan (1982). *Inside the Black Box: Technology and Economics* (Cambridge: Cambridge University Press).

——— (1994). *Exploring the Black Box* (Cambridge: Cambridge University Press).

Tolentino, Paz Estrella (1993). *Technological Innovation and Third World Multinationals* (London: Routledge).

United Nations Centre on Transnational Corporations (UNCTC) (1987), *Transnational Corporations and Technology Transfer: Effects and Policy Issues* (New York: United Nations). Sales No. 87.II.A.4.

United Nations Conference on Trade and Development (UNCTAD) (1985). *A Strategy for the Technological Transformation of Developing Countries*. Sales No. 85.II.D.19.

_____ (1993). *World Investment Report 1993: Transnational Corporations and Integrated International Production*. Sales No. E.93.II.A.14.

_____ (1994). *World Investment Report 1994: Transnational Corporations, Employment and the Workplace*. Sales No. E.94.II.A.14.

_____ (1995). *World Investment Report 1995: Transnational Corporations and Competitiveness*. Sales No. E.95.II.A.9.

_____ (1995). *Technological Capacity-Building and Technology Partnership: Field Findings, Country Experiences and Programmes*. Sales No. E.95.II.D.6.

Wu, Jie (1989). "The big achievement of ten years operation of FDI enterprises", *International Economic Corporation*, 1, 1, pp. 33-34.

Young, Stephen, and Chun-hua Huang (1994). "The internationalisation of third world MNEs: case-study evidence from the People's Republic of China". Working Paper No. 9, Strathclyde International Business Unit (Glasgow: University of Strathclyde).

Young, Stephen, Neil Hood and Ewen Peters (1993). "Multinational enterprises and regional economic development", *Regional Studies*, 28, 7, pp. 657-677.

Zhan, Xiaoning James (1993). "The role of foreign direct investment in market-oriented reforms and economic development: the case of China", *Transnational Corporations*, 2, 3, pp. 121-148.

Zhang, L.Y. (1994), "Location-specific advantages and manufacturing direct foreign investment in South China", *World Development*, 22, 1, pp. 45-53.