International technology transfer: A review

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This paper reviews the international technology transfer literature. We propose and use an organizing framework in line with key elements of international technology transfer; home country, host country and transaction component. Based on our review, we identify the key issues that merit further exploration.

1. Introduction

International technology transfer (ITT) as a subject of study has accumulated a vast body of research over the past twenty-five years. Given the inherent complexity of the subject, findings, conclusions and contentions of what we know about ITT are fragmented along various specialities. The work of Contractor and Sagafi-Nejad [47] represents one of the few attempts to pull this literature together into a systematic whole. We complement the above-noted work and attempt a comprehensive review of the work on ITT.

Any attempt at consolidation and review is only as successful as the organizing structure that permits synthesis of what we know and delineation of what else we need to know to paint a more complete picture. Prior efforts to impose a framework for the study of ITT have emphasized three distinct aspects: international political dimensions, commercial transactions, and issues of operational relevance. The international political framework concentrates attention at the level of the nation state and evaluates issues related to cooperation and confrontation between the transfer countries [160,199]. The commercial framework, on the other hand, by emphasizing firm-level activity, seeks to determine the outcome of individual projects as the interplay of corporate motives and negotiating strategies [2,178]. Predominant focus on the host country characterizes the operational framework. The primary intent here is evaluation of the preferred technology's contribution to the recipient country's social and economic development [3,123]. These frameworks, while clearly useful, fail to acknowledge fully the fact that ITT has a horizontal and a vertical component, each with its own constituent elements. On the horizontal dimension, the three base elements in ITT are a home country, a host country, and a transaction (the home country is where the technology originates; the host country denotes the recipient). The vertical aspect acknowledges that within the home and host countries, analyses and issues arise that are specific to the nation state, an industry or a firm. The implications of technology transfer can rarely be isolated to any one specific level given the interdependence in this system.

Our review therefore, uses the home–transaction–host classification to organize the literature. In so doing we isolate the specific issues of relevance under each category and the findings, to date. Table 1 presents our organizing framework and is keyed to each section in the paper. Although a comprehensive review is our objective, in the interest of parsimony (the length of the paper might dispute our intention), we have chosen to drop those citations whose findings/arguments are well covered in the material that we present.

2. Home country perspective

2.1. Impact of ITT on the home country

There is considerable controversy over the effects of ITT on the home country. Some theorists argued that ITT affects the home country's economy negatively in terms of overall benefits, em-

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Organizing framework for literature review

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ployment, and technological lead [14,98,128]. Recent studies [95,117,126], however, indicated growing support for the notion that ITT benefits the home country economically and technically. For example, studies by Michalet and Delapierre [129] (computers), OECD [140] (pharmaceuticals) showed evidence that investing in foreign countries and setting up research facilities there represents one way of gaining access to the world's scientific and technical capacity. In addition, studies by Mansfield and his colleagues have shown that ITT has enhanced U.S. R&D capacity [119] and has had no effect on technology leakage to non-U.S. competitors [117].

2.2. *Government policy*

Discussions of public policy implications of ITT from the home country's perspective have keyed in on the U.S. Government's inability to set forth a coherent ITT policy. The inability to formulate home country policies are attributed to two primary reasons [45]. First, they are meant to serve a large number of occasionally inconsistent objectives and interest groups. Second, empirical studies on the effects of technology exports provide inconclusive results.

A number of researchers have put forth conceptual frameworks to infer policy implications for the home country. For example, Feenstra and Judd [66] noted that an export tariff on technology transfer may maximize real income; Pugel [159] suggested that the benefits for the home country are a function of its insititutional setting. In an interesting study of the energy industry, Silverstein [181] argued for public policy emphasis on proprietary rights system and royalty rather than trade restrictions. As it currently stands, U.S. policy seems aimed at the free flow of technology with occasional controls emanating from National Security or protectionist concerns [42]. Hawkins and Gladwin [78] concluded that attempts at controlling the outflow of U.S. technology have, in particular cases, involved avoidable domestic costs; contributed to the decline of U.S. international competitiveness; and have not in general achieved their intended objectives.

2.3. *MNCs and technology transfer*

There is little debate in the literature that the primary "agent" of technology transfer from the home country is the multinational corporation (MNC) [67]. In 1960 international production by he U.S.-based MNCs, i.e. the production by branches and subsidiaries abroad, was estimated to be three times the value of U.S. exports [139].

By 1971 this ratio had increased to four (the production by subsidiaries to exports ratio is an often noted measure of technology transfer from a nation state). For both Germany and Japan, the same ratio rose from a small fraction in 1960 to about 2.5 by 1971 [143]. The conventional model of the MNC is that it tries to maximize the present value of expected global profits. The MNC's profit-maximization calculus involves the simultaneous determination of where to place both its production and R&D activities. The literature on this issue is considerable, e.g. [20,178].

Magee [1112], in his theory of the appropriability of technology creation, suggested that market imperfections are a likely result of conscious attempts by MNCs to create advantages for themselves. These advantages are in the form of technology that is not easily duplicated. Researchers argue that if MNCs compete in a foreign market against firms possessing local knowledge and the advantages of local nationality, they must possess some form of quasi-monopolistic advantage. This general proposition, originating in the work of Hymer [84] and Kindleberger [93], has formed the basis for a variety of more specific hypotheses aimed at explaining the pattern of foreign direct investment and ITT. Davies [58] argued that it is monopolistic advantages that allow the transfer of production into foreign markets, not technology or technical information per se.

A key issue in the transfer of technology from the MNC's perspective is the nature of the adaptation that the host country demands as it harnesses the transferred technology to economic growth. In the remainder of this section, we review various aspects of the MNC's adaptation process.

2.3.1. Adaptability of MNC technology

The adaptability of the MNC's technology is related to two points: first, the flexibility of technology itself; and second, the adaptability of a given MNC's technology. Much of the general literature on capital–labor substitutability in LDCs has argued that technologies are fairly flexible (e.g. [23,70,131,148,210,49]). However, doubts have been expressed about the flexibility of a technology once the products are specified [184]. Similar concerns have been expressed about the production function methodology used to produce high elasticity estimates [70,132,155], and about the economic and commercial viability of labor-intensive technologies, even for simple products for which alternatives actually do exist [69,155].

Stewart [185] correctly pointed out that the characteristics of technology are largely determined by the nature of the economies for which they are designed. The most significant determinants of the characteristics of new technology are the income levels, resource availability and costs in the society in and for which the technology is designed, the system of organization of production, and the nature of the technology in use in the society. Lall [100] argued that the total resultant adaptability may not be very great as far as MNCs are concerned, but some flexibility does exist.

2.3.2. Do MNCs actually adapt technology?

Many researchers start to answer this question by studying the choices of technology transferred from MNCs to LDCs. Research by Wells [208] revealed that there were alternative technologies available in several light manufacturing industries he studied. However, in no case did the ten MNCs included in his study choose labor-intensive technologies for transfer. In the same context, there were thirty-three domestic firms that were using labor-intensive technologies. Morley and Smith [133] examined MNCs engaged in metal-working industries in Brazil. While they did find that there were alternative techniques, they also concluded that the choice among these techniques did not substantially alter the capital-to-labor ratio. Similarly, Mason [122] noted that the capital-to-labor ratio differed little when he compared the subsidiaries of MNCs with closely matched locally owned counterpart firms. In a more recent study, Prasad [157], who approximated the Morley and Smith approach but studied medium-sized U.S. firms that operate subsidiaries in the Republic of Ireland, found that the process and production technologies differed little between the U.S. parents and their Irish subsidiaries in light industries. These and other studies consistently show that the choice of technology by the MNCs seldom favors the social objectives of the LDC host countries.

Numerous other studies support the argument that MNCs actually do little to adapt their technology to conditions in LDCs. For example, Reuber et al. [165] found for their sample that about 70% reported no adaptations. The changes in technique that were made were mainly to scale down plant and equipment to lower production volumes. Stewart [184] presented evidence from different sources that very little adaptation was made to basic-production technologies in several cases. In their plant-level investigation of MNCs in Brazil, Morley and Smith [133] found little scope for adaptation of technology to low-wave conditions. Allen [4,5], in his study of U.S. and Japanese firms in South-east Asia, failed to find any significant technological adaptation by MNCs to local conditions. In his survey, Davies [58] found that only a small proportion of the U.K. MNCs sampled devoted resources to adaptation. MNCs were concerned solely with the provision of information on the British product or processes, leaving their Indian partners to make their own adjustments.

The reasons why MNCs generally do not adapt their technology have also been studied. Kojima's [96] perspective that foreign direct investment differs in significant respects from international capital movements shed some light on the economic logic of the MNCs. He stated that the "main role of foreign direct investment is to transplant superior production technology through training of labor, management and marketing, from the advanced industrial country to lesser developed countries; or, in brief, it is the transfer of superior production functions which replace inferior ones in the host country" (pp. 6–7). This point is consistent with Kmenta's analysis [94]. In short, MNCs seldom take the initiative, for reasons of costs or dysfunctions, to meet the demands of making their technology appropriate or relevant as viewed from the perspective of the LDCs [58,158].

2.3.3. Do MNCs adapt better than local firms?

As to whether MNCs adapt better than local firms, the findings are mixed. Cohen [41] and Mason [122] tried to compare matched pairs. Both failed to find consistent patterns of factory intensity in their samples of local and foreign firms once industry differences are accounted for and were, therefore, unable to conclude whether or not MNCs are better or worse at adapting technologies. There are several more general comparisons of the factor intensity of foreign and local firms, some using data aggregated over different sectors, others differentiating among industries. Lall and Streeten [102] did not find that multi-nationality makes a statistically significant difference to capital intensity, for their aggregated sample of 109 Indian and Colombian firms, but that the industry grouping does. Studies by Reidel [164] (in Taiwan); Jo [87] (in Korea); and Balasubramanayam [10] (in India) generally support their findings.

Vaitsos [203] found that foreign firms are more capital-intensive in Peru for all size except the largest ones. His findings are supported by Agarwal [2] (in India), Solomon and Forsyth [182] (in Ghana), and Gershenberg [71] (in Uganda). On the contrary, Pack [148] demonstrated that in Kenya MNCs are better at adapting technology than local firms. Leipziger [106], using Cobb–Douglas production functions, found that U.S. MNCs import less capital-intensive technology ex ante but use more fixed capital per man ex post because they have had to pay higher wages. Wells [208] noted that MNCs may be better at adaptation than local firms in Indonesia, especially when put under competitive pressure.

2.3.4. Determinants of MNCs' adaptation

Studies on the determinants of MNCs' adaptation of their transferred technology are sparse. Wells [208] contended that competition is a critical factor. Yeoman [214] suggested that U.S. MNCs' adaptation of process technology to foreign costs depends on two variables: the price elasticity of foreign demands and the relation of manufacturing costs to total costs. The larger the value of each of these variables, the greater the extent of adaptation.

2.3.5. Choice of technology to transfer

In the ITT literature, the most frequently cited theory for MNCs' choices of technology to transfer is the early work of Vernon [204]. He coupled to the process of international trade an analysis of technical change that highlights some implications for MNCs' choices of technology to transfer. Harvey [77] elaborated on Vernon's contention by applying the concept of technology life cycles to technology transfer.

Empirical work on this subject is sparse and scattered. In his study, Yeoman [214] contended that the nature and degree of competition faced by MNCs is a critical variable in the choice of technology. Other empirical studies, such as that by Wells [208], confirm Yeoman's basic contention. Another line of study has explored the relationship between the characteristics of MNCs and their choice of technology. For example, Jeannet and liander [85] found that, as MNCs expand and mature, the composition of their transferred technology switches from being primarily engineering based to development activity.

2.3.6. Overseas R&D investment

An MNC's overseas R&D investment is an important part of its technology transfer. The general finding in the literature is that MNCs make minor transfers of R&D capability abroad. Based on a systematic study of fifty-five R&D investments by seven U.S.-based MNCs, Ronstadt [172] identified four different types of foreign R&D units: transfer technology units, indigenous technology units, global technology units, and corporate technology units. He found that most R&D units abroad are established as technical service labs to help transfer U.S. technology efficiently before the product or process technology has stabilized.

Researchers have also tried to identify the factors influencing an MNC's transfer of its R&D capability. Hirschey and Caves [81] reported that the proportion of U.S. MNCs' global R&D outlays that are spent overseas depends positively on the extent to which the MNCs' foreign markets are served by their subsidiaries' local production, the need to adapt the product to local market conditions, and the importance of basic research; and negatively to scale economies in research activity. Jeannet and Liander [85] found that mature MNCs will turn heavily to foreign subsidiaries as a source of new technologies.

3. Host country perspective

3.1. Impact of ITT on the host country

Supporters of MNCs claim that host countries, the LDCs in particular, derive general economic benefits from the technology transfer by MNCs. Lewis [107] and Caves [35] argued that the benefits include the generation of exports and foreign exchange, tax revenues and employment, accumulated capital, and entrepreneurship skills. Mansfield and Romeo [117] supported this contention and argued that transferred technology can have benefits of various sorts to host countries, including the reduction of costs of products or processes and of supply inputs used to produce the product or process based on the transferred technology. They calculate the lower bound for the total annual savings to non-U.S. users and suppliers due to all technology transfer by U.S.-based firms to be $35 billion. Lake [99] argued that the activities of MNCs positively affect the structure of host country industry and the performance of host country firms with respect to technology transfer at three levels of operation: market, production, and R&D. R&D performed by MNCs plays an important role in adapting foreign technology to domestic markets and in contributing to domestic technological activity. Krugman [98] noted that the transfer of technology, in addition to its direct benefits, brings the indirect benefit of improved terms of trade. Streeten [189] held that technology transfer to LDCs closes the technology gap between developed countries and LDCs. Vickery [207] found that in 1981, Australia, Canada, and Ireland had 40–50% of their business enterprise R&D performed by foreign MNCs.

On the other hand, opponents accuse MNCs of charging excessive prices on technology exports, manipulation of transfer prices, the provision of technology that is too sophisticated and inappropriate for the best possible use of local resources, the provision of technology that is obsolete and only capable of producing inferior products, and not providing foreign capital (e.g. [65,200]). Rafii [161], in his study of thirty-five joint manufacturing ventures in Iran, argued that a higher degree of foreign ownership and control imposed higher costs on the host country economy. Farrell [64] found that some of the technology transferred by MNCs to LDCs has been dynamic, but most of them have been static. The areas in which LDCs developed a capability have been those that the MNCs needed to develop locally to carry out their global activities.

Other researchers held that the impacts of ITT on the host country are situation specific. Mason [123] argued that whether technology transfers are beneficial or not depends on what MNCs can do to assist LDCs to alter their resource bases so that they can transform themselves through development to achieve a changing comparative advantage. Pugel [159] concluded that the welfare of the host country depends on the institutional setting of transfer; the highest welfare is achieved under its globally optimal royalty.

3.2. Government policy[1]

3.2.1. Determinants of LDCs' regulatory policies

Host country policies, usually couched under foreign investment legislation or rules, are aimed at monitoring the inflow of technology and lowering its short-run, balance-of-payment costs, while promoting indigenous scientific and technological development, in light of the country's endowments and objectives to lower the long-run costs of continued dependence (e.g. [134,177,215]). Jequier [86] and Todaro [197] pointed out that employment creation, income distribution, foreign exchange cost, basic needs, and regional distribution should be important criteria for LDC governments to evaluate in a proposed technology transfer to the nation. In addition to the factors listed above Stewart [185] suggested that the determinants of choice by the host country should include the nature and scale of the local market, income distribution and trading strategy, the distribution of investable resources among firms of different sizes and types, and the substantial wage differentials among firms of different sizes. Streeten [189] pointed to four policies that could close the technology gap between developed countries and LDCs: building up indigenous Science and Technology (S&T) by raising expenditure on R&D; a higher proportion of development aid to S&T; a larger proportion of R&D expenditure by developed countries to R&D that is directly relevant to the problems of LDCs; and improvement of access to what is available. Based on Katz's [89] evidence that it takes two or more decades for a given LDC firm to complete an indigenous learning sequence, Rosenberg and Frischtak [176] suggested that a country may not want to follow its present comparative advantages in deciding what technologies to adopt. Succar [190] echoed this sentiment and called for a relaxation of the numerous regulatory constraints imposed by LDCs. He argued that this relaxation will raise the level of technical assimilation and the productivity of capital in the modern sector.

[1] The dominant body of literature on host country government policy is from the perspective of LDCs.

[2] Dahlman and Westphal [50] drew roughly the same distinctions, using a different terminology: production engineering, product execution, capital goods manufacturing, and research and development.

3.2.2. LDCs' regulatory approaches

Through the early 1970s, in most LDCs (with the exception of India) foreign technology was imported by local industrial firms, including subsidiaries and affiliates of MNCs, without any restriction. Technology regulation was initially adopted in India, primarily with a view to conserve foreign exchange. During the 1970s, a number of LDCs introduced legal and regulatory measures to screen and review the inflow of foreign technology. In some countries such policies have been linked with those on foreign direct investments while, in others, the policies have been more closely related to indigenous technological development. Marton [120] classified LDCs into three broad groups in terms of their approaches towards the regulation of foreign technology: (a) countries where there is no regulation of foreign technology, and no restrictions are exercised on remittances of fees and royalties for technology; (b) countries where a certain degree of selectivity is exercised regarding the entry and operations of foreign companies but without the adoption of explicit regulatory measures towards foreign technology; and (c) countries where foreign-technology agreements are reviewed by a government agency, which administers the relevant laws or administrative guidelines. The trend among LDCs, however, is toward liberalization of technology policy.

There is a growing empirical and theoretical research base on public policy issues of ITT (e.g. Lall [101] (India); Lynn [109] (Japan); Katz [89] (six Latin American countries)), the implications of which at times are conflicting. Ghoshal [72] concluded that a major cause of the use of inappropriate policies is the distortion of price signals in factor and foreign exchange markets. He suggested that policymakers in LDCs concerned about the adverse effects of capital-intensive techniques on employment and income distribution should act to eliminate policy biases favoring such techniques. Long [108] put forward the eight means by which LDC governments can speed technology transfer: control of MNCs' activities; unpacking of MNCs' technology; improvement of public and private institutions; linkage between such institutions in LDCs and those in developed countries; improvement of technology marketing in LDCs; incentives and regulations aimed at boosting technology from the productive sector; development of regional integration schemes; and optimal acquisition of foreign technology in terms of product and factor market requirements. The most frequently referenced success story is that of Japan; Lynn [109] noted that the Japanese government agency (Ministry of International Trade and Industry) has at times used its control over technology imports to promote the use of advanced technology, improve the bargaining position of Japanese firms, facilitate the diffusion of new technology, and shape Japanese industrial structure.

The empirical studies in the literature reveal a wide variety of outcomes from similar policy experiments of protection of domestic learning, reflecting the complex relation between the transfer of foreign technology and domestic technological development. Lall [101], based on his case study of India, pointed out that "a low reliance on imports of technology in the process of industrialization clearly contributes to the buildup of a diverse and deep technological capability". He also pointed out that high self-reliance, protection of the domestic market, and an emphasis on technology export are important.

A number of empirical studies attest that there is nothing automatic about the acquisition of technological capability (e.g. Molero [130] (Spain); Lall [101] (India)). An active policy is required. Empirical studies such as those by Lynn [109] (Japan); Westphal, Kim and Dahlman [209] (Korea), and Ozawa [147] (Japan) demonstrate that, in most cases, it is the host countries' responsibility to develop their technological capabilities and this development process needs substantial regulatory effort.

3.3. Technological capability and appropriate technology

3.3.1. Concept of technological capability

Because of the nature of technology, technology transfer is not as simple as the purchase of a capital good or the acquisition of its blueprint. Recipients would normally be obliged to devote substantial resources to assimilate, adapt, and improve upon the original technology. Therefore, to the extent that the normal features of technical knowledge include imperfect understanding, incomplete availability, imperfect limitability, tacitness, etc. its successful use tends to be dependent upon firms and countries developing their own technological capabilities.

Typologies of technological capabilities are provided by many researchers. From a social perspective, Farrell [64] identified five elements of technology capability: people; operational experience; an effective organization; a problem sensing and solving mechanism; and necessary values and attitudes. Westphal, Kim and Dahlman [209] made a functional classification of capabilities (production, investment, and innovation). An analogous typology was suggested by Hayami and Ruttan [79]. Baranson and Roark [18] distinguished among operational, duplicative, and innovative capabilities and suggested that none of these capabilities will accrue as a matter of course to passive recipients as each requires an increasing level of technological effort. Desai [60] distinguished four types of technological capability: capability in purchase of technology; plant operation; duplication and expansion; and innovation. These conceptual distinctions, although not always easy to make in practice, are helpful in interpreting interindustry and intercountry differences.

3.3.2. Acquisition of technological capability

Empirical studies show that acquisition of a technology does not automatically lead to acquisition of technological capability in any ITT project. For example, Farrell [64] noted that, after more than two generations of control of the local Trinidad–Tobago oil industry by foreign MNCs, a local technological capability still does not exist over the whole range of activities necessary for running the industry. Mytelka [135], in his study of the textile industry in Africa, concluded that substantial technical effort is essential to the acquisition of technological capability. Recent research indicates that a number of factors influence the acquisition of technological capability. Based on his study of six Latin American countries, Katz [89] concluded that the kind of technological capabilities that emerge and develop in any given social setting depend on the type of economic agents in such a setting, the resource endowments they control, and the public policies by which they are affected over time. He further pointed out that the size of the firm, its field of activity, type of production organization, degree of product standardization, and type of ownership are all important determining factors in the development of indigenous technological capability. Lasserre [104], among others, emphasized the importance of training. They correctly pointed out that the geographic transfer of technology may be of little use unless the appropriate human resources are simultaneously available. In addition, empirical studies such as those by Ozawa [147], Lynn [109] and Westphal, Kim and Dahlman [209] attested to the importance not only of the industrial but of the social environment as well. In particular, comprehensive educational systems play major roles in the assimilation of industrial knowledge.

3.3.3. Concept of appropriate technology

Although there are various definitions of appropriate technology, there is general agreement that such technology must be efficient, not be obsolete, and that it must vary according to the particular situation of each country under consideration. Bourrieres [25], from a macrosystems perspective, suggested that appropriate technology should be defined in the context of a complex system, and five levels have to be considered: the objective of the decision-making unit; resource availability; the action intended; the actors; and the results. From an economic perspective, Robinson [166] defined appropriate technology as one that makes possible the production of a given good at a price not exceeding the current world price, taking into account the scarcities and opportunity cost of factors of production, exchange rate, and the rate of interest or discount. From a financial perspective, the World Bank (in a study of nine LDC industries) defined the appropriate technology as one that provides the highest net present value relative to capital investment [73]. A composite of the nine industries shows that, with an investment of $900 million, the most capital-intensive technology produced $374 million of value added and generated 60,000 jobs. In contrast, the same investment in appropriate technology would have produced $800 million in value added and generated 300,000 jobs. Stewart [185], from an economic development perspective, argued that an appropriate technology to a LDC may be defined as a technology whose resource use is in keeping with the LDC resource availability and whose products are more suited to low-income consumers.

3.3.4. Availability of appropriate technology

A review of the findings on the availability of appropriate technology presents multiple perspectives and measures. Robinson [166] placed the availability-of-appropriate-technology issue in the context of the unemployment problem. He concluded that it is very difficult to find low capital-intensive technologies, in the full sense of using less capital per unit of product, as efficient as technologies used in advanced countries.

Lall [100] argued that one of the main sources of the MNCs' competitive advantage that enables them to grow is precisely the possession of advanced technology, combined in a profitable package with marketing, administrative and financial factors, which can be applied with little adaptation to different areas. By their very nature, MNCs do not specialize in the simple, labor-intensive products that can be adapted to LDC factor endowments. Magee [114] supported this argument by saying that MNCs cannot be counted on to create the types of technology that are most useful for LDCs. More an exception than the norm, research by Wells [208] revealed that there were alternative technologies available in several of the light manufacturing industries he studied. Morley and Smith's [133] study, which examined MNCs engaged in metal-working industries in Brazil, reached similar conclusions. In an interesting discussion, Vernon [204] pointed out that the best technology for low-cost production in the developed countries is often the best technology for production in the developing countries.

3.4. Technology acquisition and adaptation

3.4.1. Factors influencing the choice of which technology to acquire

In evaluating the acquisition of a technology, the task of a manager is to find the technology that combines factors of production, usually capital, labor and other factors, to yield maximum revenue and minimal production costs (see [72]). Conventional economic theory offers clear predictions of how technology would differ in developing and advanced countries. Faced with low wages and high capital costs, managers in LDCs would choose more labor-intensive techniques, and this choice would contribute to solving a potential unemployment problem. By the early 1960s, it was becoming clear to economists and management theorists that the conventional model was inadequate to explain the decision actually made by managers. Stewart [185] argued that the managerial choices are influenced by a mix of factors, some of which override the relative factor of cost consideration.

Wells' [208] study, which was along the lines of work done by Yeoman [214] and Strassmann [188], found that, when managers can escape severe price competition, they do not attempt to minimize costs through their choice of manufacturing technique. Wells offers two reasons: (a) apart from profit maximization, managers have other objectives — engineering objectives and managerial objectives; and (b) managers attempt to reduce the risks of liquidity problems and any errors in matching production capacity to demand by using capital-intensive plants. Empirical studies by Wells [208] (Indonesian firms), Keddie [90] (Indonesian firms), Lecraw [105] (Thai firms), Williams [211] (state-owned firms in Tanzania), and Amsalem [7] (textile and paper firms) confirmed Yeoman's basic contention that the nature and degree of competition faced by the manager is a critical variable in the choice of technology. Moreover, these studies demonstrated that the role of competition in determining manufacturing technique is important, regardless of whether the firm is a private firm or a state enterprise. Although the range of possible choices of technology varies from one industry to another, most of the factors that influence the decision are similar in all industries. Katz [89] suggested four sets of factors influencing LDC firms' choices of technology: strictly microeconomic determinants resulting from the product and production technology originally available; forces resulting from the competitive climate prevailing in the specific market(s) to which the firm is geared; macroeconomic determinants affecting firms in general; and new technical knowledge gained as the international technological frontier expands. An interesting empirical finding by Alam and Langrish [3] is that the prestige of a developed-country firm in the host country and international market is an important factor in the selection criteria of recipient firms in LDCs.

3.4.2. Nature of the technology acquired by LDCs

Numerous researchers (see Marton [120]) have pointed out that the nature of technology transfer differs in scope and magnitude between recipients in developed countries and those in LDCs. In the case of the former, the need for technology is primarily for patented or proprietary know-how. The advanced technological capabilities of recipient firms and their on-going production and research activities enable these companies to absorb and adapt acquired technology once the technical specifications and the rights to use patented or proprietary information are acquired. In the case of LDCs, the need of these firms is not only for product design and production know-how but for a much broader range of technological functions. The assimilation of foreign technology and its adjustment to different factor endowments and conditions is also a far greater task for firms in LDCs. Thus, the technological needs of firms in LDCs tend to be of a composite nature and cover various stages of project preparation, implementation, and operations.

Empirical studies on the nature and content of technology transferred to LDCs generally support this argument. Mansfield and Romeo [117] found that the age of technology transferred to LDCs is on the average four years older than that which is currently in use in the home country. This is not surprising because many newer technologies are inappropriate for developing countries or are difficult and expensive to transfer to LDCs. Teece [193] argued that technologies transferred to LDCs have a large technical-service component, comprising technical assistance, construction, engineering and other related services. Statistics in Vickery's [207] study support this contention.

Research has also been done on the technology transferred to LDCs by the type of developed-country firm and by country. For example, Alam and Langrish [3] found that there is little difference between the roles of MNCs and non-MNCs in terms of the technology transferred to LDCs. Mason [123], in a comparative study, concluded that the nature of technology transferred by U.S. and Japanese firms to LDCs differed on multiple dimensions. Japanese firms transferred technology aimed at primary production and manufacturing and invested mainly in low-technology industries. U.S. firms, on the other hand, transferred manufacturing and service capability, did not limit themselves to low-technology industries, and used technology transfer arrangements to surmount tariff protectionism.

3.4.3. Adaptation of technology

Much of the effort of recipient countries is geared toward the continuous adaptation of imported technology to local conditions and to the firm's operational characteristics and productive constraints. Empirical studies (see Westphal, Kim and Dahlman [209]) have shown that adaptations take place through changes that stretch the capacity of existing plants, break bottlenecks in particular processes, improve the use of by-products, adjust to new input sources, alter the product mix, and introduce a wide variety of incremental improvements in processes and product designs. However, such purposive actions do not take place easily or costlessly in any environment (e.g. [147]).

4. Transaction perspective

4.1. The role and nature of technology transfer

Technology is a major input requirement for economic development. Adam Smith was one of the first to examine manufacturing technology systematically in 1776. In the early works of Marx [121] and Schumpeter [179], technology was seen to be at the center of growth. Powerful evidence or confirmation of the impact of technical change on the economy was provided by Abramovitz [1] and Solow [183]. The rich literature on technological change (e.g. [59,74,115,175]) has attempted to address technology's role in productivity change and economic development. Sociological, economic, and management studies [22,127,160] also confirmed the central role of technology in economic growth. Strategic management theorists (e.g. [76,92,149,156]) treated technology as one the paramount forces in competitive strategy.

Most conceptual discussions of technology transfer [38,67,95,98,126,169] treated new technology as exogenous in their models. Other theorists, however, viewed technological progress as endogenous (see, for example, [62,66,67,159]). Thus, different treatments of technology result in different models and conclusions.

4.1.1. Nature of technology

A discussion of ITT is hampered by the difficulties posed in defining the concept of technology. Existing studies of technology transfer or international technology transfer define the term "technology" from different perspectives. The way technology is viewed or defined influences the research design and results, negotiations around a transfer, and government policies in general.

Received theory conceives of technology as information necessary to design and produce a given good by any number of alternative methods. This concept of technology as information holds that technology is generally applicable and easy to reproduce and reuse [8] and that firms can produce and use innovations mainly by dipping freely into a general stock or pool of technological knowledge [9,88]. However, assuming that technology is a free good does not help much and is, in any event, contradicted by the growing empirical literature on multinational firms and ITT. In the literature on ITT, technology is conceived as firm-specific information concerning the characteristics and performance properties of the production process and product design. The production process or operations technology is embodied in the equipment or the means to produce a defined product. The products design or product technology, on the other hand, is that which is manifested in the finished product. Technology, therefore, is mainly differentiated knowledge about specific applications, tacit and often uncodified, and largely cumulative within firms [153]. Because of this, technology is included among the firm's "intangibles" [36] or "firm-specific" assets [65]. These are assets that form the basis of a firm's competitiveness and that it will generally release only under special conditions.

4.1.2. Taxonomy of technology

Useful taxonomies have been provided in Mansfield [116] who used "embodied" versus "disembodied" classification; Madeuf [111], who elaborated this classification as capital embodied, human embodied and disembodied technology; Hall and Johnson [75], who distinguished not only among "product-embodied", "process-embodied", and "person-embodied" technology but also among "general", "system-specific", and "company-specific" technology; Robock [168] and Chudson [39] who separated product designs, production techniques, and managerial functions; and Madeuf [111] who draw a distinction between technology "alienated" by property rights (patterns) or secrecy and know-how which could not be transferred without an effective participation of the firm holding it. The National Science Foundation [137] decomposed technology into "research", "development", and "engineering".

4.1.3. Nature of technology transfer

The term "transfer" has been analyzed by Vaitsos [202] who laments its inappropriateness; for transfer connotes the free, noncommercial movement of something from one location or possessor to another. In fact, however, with technology, what is usually involved in a "sale" of such technology. For this reason the term "commercialization of technology" has been argued to be generally more appropriate (e.g. Farrell [64]).

In international business activities, however, the transfer of technology is viewed in more specific terms and is usually conceived as the transfer of specialized know-how, which may be either patented or nonpatented, from one enterprise to another. As Baranson [13] defined it, transmission of such knowledge enables the recipient enterprise to manufacture a particular product or provide a specific service. Other researchers (e.g. Teece [191]) defined the technology transfer as the transfer of know-how. As distinct from the sale of machinery and equipment which embodies technology, they argued that the transfer of technology, in most cases, calls for a sustained relationship between two enterprises over a period of time, so that the receiving enterprise can reproduce the product with the desired level of quality standards and cost efficiency. This relationship model of ITT is consistent with the work of Contractor [44] and Robinson [167]. Chesnais [37] argued that the transfer of technology implies the transfer to the recipient not only of the technical knowledge needed to produce the products, but also of the capacity to master, develop, and later produce autonomously the technology underlying these products.

Although any of the characteristics of ITT are also characteristic of technology transfer that occurs within national borders, there are some important differences to which attention should be drawn. Teece [191] characterized the differences of ITT as follows: the problems associated with the acceptance of external or "imported" technology are likely to be accentuated by the need for adaptation of the technology to local conditions, confrontation of large differences in infrastructure between home and host locations, and distance and communication costs.

4.1.4. Type and phase of transfer

ITT refers to the transfer of the capability to manufacture a product or process from firms in one country to firms in another (e.g. [13,37]). It is important to distinguish among several phases of the process as well as the types of technology transfer. Useful taxonomies were provided in Hayami and Ruttan [79], who distinguished among materials transfer, design transfer, and capacity transfer; Teece [192], who separated physical items transfer and information transfer; Mansfield [116], who distinguished vertical technology transfer and horizontal technology transfer; Baranson and Roark [18], who drew a distinction between technology transfers that impart operational, duplicative and innovative capabilities; and Lake [99] who identified three levels of technology transfer: the market level, the production level, and the research and development level.

4.1.5. Concentration of technology

It is well documented that technological creative resources are highly concentrated at three different levels: at the international level among countries [141,146,199,207]; at the sectoral level among industries (OECD's [145] statistics showed industrial R&D is highly concentrated and takes place essentially within five or six industrial sectors; Vickery's [207] study showed similar patterns of concentration); and at the industrial level among larger firms and particularly MNCs [138]. This concentration in resources is reflected by data concerning output such as patent activity [213] or international technology transfers, as indicated by technological balance of payments [110,142].

The world technology transfer network consists mainly of transfers among developed countries. Data concerning expenditures and receipts of OECD countries show that more than 90% of expenditures are remitted to other developed countries [111]. Three-quarters of world technology trade is between OECD countries [207]. Another aspect of the concentration of the technology transfer network concerns the part played by the United States as a leading technology supplier both to developed countries and LDCs. Although no comprehensive data are available on the worldwide diffusion of technology, it has been estimated by Vickery [207] that the United States is the source of between 50 and 75% of the world export of technology. Brown [28] and Baranson [12] reached similar conclusions. The United States is one of the few countries with a technological balance surplus, with a receipts/payments ratio of 10 : 1 [138].

The oligopolistic character of the technology market lies partly, but only partly, in the patent system. According to an argument originally advanced by Schumpeter [180] the justification for patents, which confer a temporary monopoly right on firms, is to incite them to develop, market, and transfer technologies (see Penrose [154]). This argument is disputed, however, especially by LDCs [198], who regard the patent system as an impediment to local technological capacities and one of the main factors for excessive technological payments.

4.2. ITT costs and payments

4.2.1. Costs and resource requirements

Many researchers have pointed out that technology transfer is not costless (e.g. Mansfield [116]). Actors in ITT tend to perceive the transfer cost differently. Mansfield [116] distinguished the transfer cost as outlays for engineering consultation prior to building the plant, costs of transferring engineering information concerning the process and/or product and of supervising the detailed engineering, R&D costs involved in adapting the technology, and costs due to low labor productivity and poor product quality during the period when the workers are learning to utilize the new technology. Teece [192] suggested four groups of costs as operational measures of transfer costs: costs of pre-engineering technological exchange; costs associated with transferring the process/product design and engineering; costs of R&D personnel during transfer; and pre-start-up training costs and "excess manufacturing costs". As the studies by Teece [181] and Contractor [43,45] showed, transfer costs to the supplier are much higher than their theoretical value, which is nil or negligible. For instance, Teece [181] found that transfer costs averaged 19% of the total costs of the project (with a range from 2 to 59% for 26 projects). Mansfield et al. [119], in their study of 26 projects, noted that technology transfer costs averaged about 20% of the total cost of establishing an overseas plant.

4.2.2. Determinants of transfer costs

The determinants of transfer costs have been studied by a number of researchers. Brown [29] concluded that the costs are related to the size and nature of demand, production costs, and institutional differences that may exist between the host and home countries. Casson [32] argued that, in most cases, the costs will be higher in licensing than an internal transfer to an equity affiliate. Findings by Teece [194] indicated that transfer costs are higher when the underlying technology is labor intensive rather than capital intensive. The learning curve phenomenon significantly decreases the transfer costs. For example, Teece [192] found that transfer costs decline as a function of the number of transfers already executed for any product. Davidson [54] cited such experience effects as the principal cause of a rapid acceleration in transfer activity by U.S.-based multinational enterprises. Transfer efficiency appears to be largely determined by firms' abilities to realize such experience effects in executing transfer projects [55]. Teece [192] systematically identified and analyzed seven factors determining the transfer costs in manufacturing projects: size of the supplier firm; age of the technology; degree of the technology diffusion; understanding of the transferred technology; recipient's R&D capacity; recipient's general manufacturing skills; and level of the host country's development.

4.2.3. ITT payment

The issue of international technology payment is complicated by the measure of ITT. As noted earlier, technology is difficult to define. The ITT is correspondingly difficult to measure [153]. Teplin [196] and Boretsky [24] argued that royalty and fees do not provide a satisfactory measure of technological content. Quinn, who introduced the concept of a technological balance of payments, added similar qualifications in his research [160]. However, the difficulties of measuring ITT have not discouraged research in this field. Progress can be and has been made through information collected from other sources (e.g. [52,152,206]).

4.3. Conflict and code of conduct in ITT

ITT involves multiple parties in different countries often with conflicting objectives. Quinn [160] identified two kinds of potential conflicts: first, conflicts in policy between the host and home countries; and second, conflicts between company strategy and national goals. Baranson [12] studied the nature of conflict in the licensing versus direct-investment choice and concluded that the major conflicts over technology transfer between supplier firms and recipient firms (and their governments) concern pricing, ownership, and long-term technological development. Evidence [34,43,53,96,102,124,157,160] supports Baranson's contention.

4.3.1. Relationships between MNCs and LDC firms

Through the 1960s the establishment of a wholly-owned foreign subsidiary or a majority-owned foreign affiliate was the predominant method of foreign expansion by MNCs and a prime source of technology transfer. With the increased regulation of foreign investments in several countries, joint ventures have become a far more important form of operation for the multinational enterprise (e.g. [15,120]).

In addition, other new forms of interface between MNCs and developing countries are emerging and spreading: production-sharing agreements, management and marketing contracts, service agreements, technology licensing contracts, and numerous other forms of nonequity interaction. The new technology-sharing agreements represent a radical departure from the traditional approach U.S. firms have taken toward managing technological assets. Studies such as those by Baranson [15,16] revealed that a growing segment of industry in the developed countries is now prepared to transfer high technology under terms that ensure rapid and efficient implantation of an internationally competitive production capability in the host country.

4.3.2. International code of conduct

Technology imports are central to the economic performance and development prospects of LDCs. However, while imported technology has helped some nations to achieve rapid industrialization, critics have pointed to a host of actual and potential abuses in the laissez-faire transfer process.

Some of the LDCs have led a drive within UNCTAD to establish an international code of conduct governing North–South technology transfer and guidelines for restrictive business practices. After protracted and occasionally intense negotiation under UNCTAD auspices (see [199]) a code on restrictive business practices was adopted by the U.N. General Assembly in 1980, but several drafts and many meetings later there is still no universal agreement on a code for technology transfer due to the resistance of the industrial countries. Roffe [170,171], Mundkowski [134], Hope [82] and McCulloch [123] traced the major developments in this area.

4.4. Mode of technology transfer

Despite the new trends noted in the previous section, most commercial transfers are still intrafirm. Kroner [97] reported that "U.S. companies apparently prefer to exercise an equity interest in the use of their intangible property and proprietary knowledge in order to protect their competitive position". In 1983, for example, in U.S. corporations, 78% of the receipts from technology was from affiliated companies and this share showed relatively little variation throughout the 1970s. [3] Vickery [207] echoed this conclusion. He estimated, on the basis of a royalty rate of 5% of sales that, arm's-length licensing revenue is only 5–10% of the revenue generated by intrafirm transfers.

This skewed distribution of intrafirm to arm's-length transfer also influences a recipient firm's ability to acquire ongoing technological enhancements. For example, a recent comparative study by Parry [151] found that over 50% of the foreign-owned firms have access to foreign expertise from all sources, while only 23% of the domestic firms have access to overseas know-how from all sources.

4.4.1. Choice of transfer mode

The choice of mode for ITT is a subject that has generated considerable interest. Mason [12] described how the type of technology transferred, the commitment of the supplier firm, and the duration of the arrangement are a function of the transfer mode. His conclusions are supported by Allen, Hyman and Pinckney [6] Balasubramanayam [10], Coughlin [48], Mansfield and Romeo [117], Davies [58], Mansfield, Romeo and

[3] "Fees and royalty payments of U.S. affiliates and U.S. parents", *Survey of Current Business*, various issues.

Wagner [118], and Mansfield et al. [119]. A supplier firm's decision to transfer its manufacturing technology by licensing or by investing in a facility involves an evaluation of the benefits and costs to the firm of each approach. This is the application in various forms of the transaction-costs approach, as originally developed by Coase [40] and expanded on by Williamson [212]. The premise this body of theory holds is that intrafirm and market exchange mechanisms exhibit potentially different levels of efficiency in executing different types of transactions, and the choice of mode depends upon efficiency considerations.

Research work has been stimulated by the perception that international transfers of technology occur within multinational enterprises because of inefficiencies implicit in the arm's-length market mechanism [30,32,33,112,192,205]. Studies by Contractor [46], Rafii [161], Telesio [195], and Stobaugh [186] suggested that an MNC can often extract a higher return from the local economy by investing in a manufacturing facility rather than by licensing know-how to another firm. There is no evidence, however, that any one channel is ideal for all managers in all situations. One path of current research in this area focuses on how inefficiencies in international markets for technology affect transfer modes for various types of technologies and companies [53,56]. Another path examines the impact of host country characteristics on foreign direct-investment levels and choice between intra- and interfirm transfer [58,65].

4.4.2. Determinants of transfer mode

Studies of the determinants of transfer mode identify the following factors as being significant in the choice of how to transfer technology.

(1) The competition faced by supplier firm. Baranson [12] and Stobaugh [186], among others, found that, when only a few firms possessed competing technologies, most transfers were affected through wholly-owned subsidiaries but that, when many firms owned similar technology, the use of joint ventures or licenses as much more prevalent.

(2) The age of the transferred technology [163,194]. Studies such as those by Mansfield, Romeo and Wagner [118] found that supplier firms tended to transfer their newest technologies overseas through subsidiaries rather than licensing or joint ventures, but the latter channels became more important as the technology ages. A study of 36 U.S.-based MNCs [117] and work by Davidson and McFetridge [57] confirmed this contention. Furthermore, studies by Mansfield, Romeo and Wagner [118] and Mansfield and Romeo [117] supplement the above observations: more profitable and newer innovations tend to be transferred via subsidiaries. Coughlin [48] provides additional evidence of this phenomenon. These findings are consistent with the "transactional model" explaining the emergence of multinationals because of "short-comings in arm's-length markets with intangible assets" [36].

(3) The nature of the transferred technology. Vickery [207] found that technology transfer between associated firms is pronounced in high-tech. Brada [26,27] argued that certain types of technology are more likely to be transferred within a firm rather than between firms. Coughlin [48] finds that MNCs transfer the product technology internally by way of wholly-owned subsidiaries.

(4) The importance of the technology to the supplier firm. Davidson and McFetridge [57] found that suppliers tend to use intrafirm transfer modes for technologies that constitute their principal lines of business. Statistical evidence shows that in high R&D industries, where technology assets play an important role in competition, direct investment is the more frequent international strategy [30,31,150,201].

Other factors identified in the literature include industry characteristics [46,153]; the size of the supplier firm (e.g. [186,195]); supplier firm's foreign manufacturing experience (e.g. [195]); strategy of the supplier firm [19,187]; existence of a supplier's affiliate in the host country [57]; supplier's R&D intensity [57]; supplier's technology transfer experience [57]; public policy of host country [12,46,57,80]; recipient firm's characteristics [11,75]; the characteristics of the country in which the facility is located [44,46,58,66]; the bargaining power between the two contracting parties [12]; and social factors such as religious and language similarities [57].

4.5. Effective transfer of technology

4.5.1. Measure of effective transfer

The effectiveness of transfer activity is evaluated in several different ways in the literature. From the efficiency perspective, Teece [194] attempted to measure transfer effectiveness by calculating the transfer cost. Davidson [54], on the other hand, analyzed the speed, scope, and level of internal versus external transfer activity for a sample of MNCs. From intrafirm-transfer perspective, Schwartz [178] defined effective transfer as R&D sufficiency in the local facility. Similar construction is evident in the work by Alam and Langrish [3]. From host-country perspective, Madeuf [111] used control of imported technology as the measure. His concept of control refers to the range from the capacity to use the technology without foreign assistance to the capability to reproduce or even improve the imported technology. Zakariya [216] argued that effective transfer for petroleum technology should mean the ability of the host country to purchase or hire, in the international market, the most advanced equipment for exploration and development at a fair and reasonable cost. Mason [123] held that effective transfer should be measured by whether the technology transferred can assist with the development of new skills and technology that will alter the host country's comparative advantage. Mytelka [135] suggested that the imported technology must be assimilated, since it is only through technological mastery that its subsequent modification, improvement, and extension becomes possible.

4.5.2. Factors influencing effective transfer

A number of factors that influence the effective transfer have been identified and examined by a growing body of studies.

First, the amount commercial experience a firm has in another country is important. Vernon and Davidson [206] attributed the faster transfer speeds over time for a sample of 406 innovation transfers to the supplier firms' increased manufacturing experience in foreign countries. Teece [192] found that both the number of previous applications of the technology by the supplier firm and the amount of experience by the recipient firm are, ceteris paribus, negatively associated with the level of transfer costs.

Second, variables reflecting the degree of technological competition among supplier firms have also been examined. Studies by Vernon and Davidson [206], for instance, showed that the greater the degree to which domestic and foreign firms effectively compete on the basis of a technology strategy, the faster international transfers are likely to be.

Third, Baranson [12], among others, identified the willingness and ability to transfer technical knowledge as an important determinant.

Fourth, the supplier firm's organizational structure affects its transfer activities [55].

Fifth, Dunning [64], Baranson [12], and Driscoll and Wallender [61] showed that the effective transfer depends on the absorptive capacity of the recipient firm and level of technological development of the host country.

Sixth, the characteristics of the host country are found to be a major factor (e.g. [162]).

Seventh, the mode of transfer used is also noted in the literature. Hufbauer [83] was the first to elaborate the potential differences between international transfers that take place via licensing and foreign direct investment versus those that take place via "independent" means. He concluded that the "independent" means transfer technology at a slower rate than the alternatives. In examining technology transfer in the petroleum industry, Zakariya [216] reported that petroleum exploration and development contracts without MNCs' ownership are not the most effective instrument for transfer of technology to host countries.

Eighth, the relationship between interacting countries and firms is another important factor. Benvignati's [21] study showed that an open commercial relationship between countries can most benefit the transfer. Baranson [12] argued that a sustained relationship between suppliers and recipients is a factor influencing the effective transfer.

Ninth, based on an analysis of various cases of technology transfer, Lasserre [104] found that, among various operational parameters, training is of crucial importance.

4.6. Pricing of technology

Any discussion about technology transfer pricing must make a distinction between transfer cost and technology cost. Madeuf [111] argued that a technology cost is not a transfer cost; the former refers to marginal cost of the technology per unit of final product and the latter to the marginal cost per transfer agreement. How technology transfer prices are determined is a matter of the transactor's behavior in the international technology market. Like other markets for intangible assets, the imperfection of the technology market makes its transfer price indeterminate [36]. The market imperfection and price indeterminacy are further emphasized by the oligopolistic structure of the market served by the recipient firm itself. Such is the case when the market is protected by tariffs or by barriers to entry.

As regards pricing for ITT, there has been little theoretical work to model price determination. The discussion by Root and Contractor [173] on a negotiating model for transfers between parties at arm's length is an exception. There has also been little empirical research. Baranson and Harrington [17] identified the different components and sources of costs and profit for the supplier, and suggested measuring the profitability of the transaction to the supplier in a statistical regression model based on variables relative to supplier, recipient, technology transferred, and country concerned. Reference should also be made to the interesting findings of a study by Contractor [43] on arm's-length transfer agreements.

The setting of the price obtained by the technology supplier is patterned on the bilateral monopoly model [113,173]. As part of the price-setting process, the foreign and local firms negotiate over how to divide up the local market rent. On the supplier's side, as various studies show (e.g. [45,113,191]), revenues anticipated from the transfer are assessed in the light of direct-transfer costs and of indirect-opportunity costs. On the recipient side, the upper limit to the possible payment by the licensee can be shown to correspond to the benefit to him from selling the product produced under license and/or the cost savings afforded by using the new process. Madeuf [111] argued that, for the transfer to take place, the increase in the recipient's income must be higher than the transfer cost for the supplier. Negotiation between the two parties deals precisely with how that portion of the revenues exceeding the transfer costs is to be divided.

Empirical research into transfer price setting has been made difficult by the fact that so many intrafirm transfers occur. The study by Contractor [43], based on 102 licensing agreements between 39 U.S. and foreign firms in 41 countries, examined both costs and the price of the transfer in arm's-length licensing agreements. His findings note that the supplier firm's total revenues largely exceed costs, with the average revenue/cost ratio at 35.7 and the gap between revenues and costs narrower for transfers to LDCs. Baranson [15] reported that U.S. licensors set royalty rates that correspond to one-third of profits made by efficient licensees.

A few studies have been done on the specific factors influencing pricing. Baranson [12] held that the competition among supplier firms is one of the major determinants of technology pricing. Caves [36] made a similar argument, suggesting that the licensor's ability to extract the rent forming on the licensee's market mainly depends on competitive conditions prevailing in the technology market: the less competitive, the stronger. Alam and Langrish [3] found that the prestige of the technology supplier firm affects the rate of royalty, and import restrictions on raw and intermediate materials. They suggested that recipient firms in LDCs would get more favorable terms if a non-MNC is willing to transfer technology to them and if the LDC firms made less frequent use of the brand names of supplier firms.

5. Summary

From the *home-country* perspective, there seems to be general agreement that ITT does accrue economic and technological benefits to the supplier. These benefits are manifested in the maximization of real income and being able to access the world's scientific and technical capability. The primary transfer agents remain the MNCs. These agents, however, have done little to adapt their technologies to local conditions, and when they have done so, it has been to scale down plants to suit local conditions. Local competitive conditions emerge as the primary determinant of incentives to adapt technology. Finally, MNCs view foreign subsidiaries as an important source of technology as they mature.

Of the three elements in our organizing framework, the literature based on the home country is by far the smallest. Additional research aimed at the linkage between a supplier firm's business and ITT strategy may move a substantial portion of the findings reported in this paper into the managerial realm. In addition, given the importance and the confusion around adaptation, efforts need to be focused on defining what adaptation signifies and how best to achieve it. As adaptation concerns differ between the acquisition of a technology and its assimilation over time, a series of longitudinal studies may provide insight into the role that the technology supplier could/should play to maximize its payoff from the transfer agreement.

Although research on the *host country* is somewhat more substantial, the primary focus has been on regulatory issues of LDCs. In spite of ongoing controversy, the evidence does tip the scales toward the notion that ITT has and continues to benefit the host country (especially the LDCs) by stimulating exports, accumulating foreign exchange, reducing unemployment, and providing and impetus to local R&D effort. The nature of the regulatory mechanism to manage ITT best draws passionate arguments from either side of the fence. Those who argue for relaxation of regulation suggest that such relaxation will enable the LDCs to internalize the benefits of the transferred technology faster and close the technological gap between LDCs and developed countries. Proponents of a well-defined set of regulations argue that ITT has to be evaluated in the context of building an indigenous science and technology base and managing employment creation. This line of reasoning proposes regulation to control MNCs and emphasizes the unpacking of technology and promotion of technological literacy. Another issue of some significance at the host-country level, is the problems encountered in integrating the acquired technology into its economic system. Theorists have noted the fact that it remains one of the most problematic elements of ITT and stress the importance of building the capability to internalize new technologies. There is little argument that acquisition does not equate with assimilation and integration.

As far as the host-country research agenda goes, the most pressing need has to be how best to enhance the rapid diffusion of a transferred technology, with a clearer understanding of the impediments that may span the spectrum of market, regulatory, institutional infrastructures, and the level of technical capability. The adaptation/integration issue is inherently tied into the diffusion/commercialization dimension. It is ironic that the vast body of literature on technology diffusion (e.g. [103,136]) has not been tapped by ITT theorists. By drawing upon the rich explorations into economic history by theorists such as Rosenberg [174] and David [51], ITT theorizing not only may enable more focused discussion of the institutional dimensions of diffusion/adaptation but also will bring a methodological variety to ITT research. Linking the transfer of technology to its diffusion in a host country may also force theorists to draw a clearer distinction between product and process technology. More research is also needed on the cultural, social, and institutional aspects of host countries to balance the overly economic perspective that currently dominates the work on ITT [91].

The transfer or *transaction* element has occupied the bulk of the ITT researcher's time (as is evident from our review). Most technology that is transferred is firm specific, i.e. a "private good", with the United States being a dominant supplier worldwide. For both sides, transfer costs are clearly more than the costs of technology. Transfer costs as system costs include not only the costs of initial transfer but also costs of ongoing enhancement of the recipient structure to harness the technology to economic growth. Transfer costs are affected by geographic distances, communication needs, the nature of the technology, and industry and country characteristics. Very few ITT agreements are spot transactions; thus, the importance of managing and maintaining a sustained relationship is well emphasized. This relationship nature of ITT carries with it the potential for conflict as both sides maneuver to create and sustain a mutually profitable arrangement. Recent research points out that pricing, ownership, and long-term technology development concerns are the primary sources of such conflict. Although intrafirm transfers dominate, new forms are emerging, and the trend may be toward longer term, equity-based interactions. The nature of these arrangements is in part determined by the competition facing the supplier, the nature and age of the technology, the size of the supplier, and host-country regulatory policy. Finally, effective transfer as a concept remains ephemeral, as does the pricing mechanism in ITT.

Transaction, by its very definition, suggests at least two parties interacting with the objective of consummating an exchange. Given the substantial stakes that enter into an ITT transaction, negotiation by both sides to effect the outcome in their favor underlies the ITT process. Furthermore, since technology is defined as firm-specific knowledge, negotiation at the firm level (host and home country) is a key dynamic of the technology transfer mechanism. A review of the literature indicates a surprising neglect of this dimension. Work from social psychology on exchange theory, and from sociology on interorganizational arrangements, may prove suitable to explore this issue. Further explorations of effective transfer may be meaningfully tied into the adaptation/integration issues noted earlier.

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