KEY CHARACTERISTICS IN THE CHOICE OF INTERNATIONAL TECHNOLOGY TRANSFER MODE

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Abstract. The choice between licensing and direct investment as a vehicle for international technology transfer is hypothesized to be related to characteristics of the individual technology, parent corporation, and the host country involved in the transfer. A set of hypotheses regarding these relationships are developed and tested in a logit statistical model for a sample of 1,226 technology transfers. We find that hypotheses regarding the effects of technology and parent characteristics are strongly supported by this analysis; hypotheses regarding the effect of host country characteristics on transfer patterns receive mixed support.

OVERVIEW

The subject of international technology transfer has generated considerable research interest and activity in recent years. One of the most important paths of analysis in this area relies on the application in various forms of the theory of the firm, as originally developed by Coase (1937) and expanded by Williamson (1975) and others. The basic premise of this body of theory holds that intrafirm and market exchange mechanisms exhibit potentially different levels of efficiency in executing different types of transactions.

International technology transfer activity has proven a fertile ground for application of this theory. Research work has been stimulated by the perception that international transfers of technology occur within multinational enterprises because of inefficiences implicit in arms-length market mechanisms (Caves 1971; Vernon 1971; Buckley and Casson 1976; Teece 1976; Magee 1977; Casson 1979). One path of current research in this area

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focuses on how inefficiencies in international markets for technology affect transfer patterns for various types of technologies and companies (Leroy 1974; Davidson 1980; Contractor 1982; Davidson and McFetridge 1984). A second path of technology transfer analysis has examined the impact of receiving country characteristics on foreign direct investment levels and the choice between direct investment and licensing (Davies 1977; Dunning 1981; Casson, Buckley and Davies 1979; Contractor 1982).

This paper attempts to integrate these two approaches in the analysis of international technology transfer activity. It examines the joint impact of receiving country, company and technology characteristics on the choice of transfer mechanism. Hypotheses regarding the impact of these characteristics are then tested in a logit analysis for a sample of 1,226 international technology transfers.

TECHNOLOGY AND COMPANY CHARACTERISTICS

Circumstances Favoring Intrafirm Technology Transactions: Hypotheses

The theory of the firm implies that the relative cost of an arms-length transaction will be higher: (a) the more difficult it is for independent parties to verify the assertions of the seller regarding aspects of a potential transaction; (b) the greater is the degree of uncertainty surrounding the transaction; and (c) the greater is the extent to which the commitments required of the transacting parties are irreversible (Williamson 1981; Teece 1981).

It can be hypothesized that these three conditions are most likely to characterize a transaction involving: (a) newer technologies; (b) technologies which represent a radical advance in the state of the art; (c) technologies with limited transfer histories; and (d) parties with limited experience in similar transactions. Transactions with these characteristics can be expected to exhibit a greater tendency towards the use of intrafirm transfer mechanisms.

Circumstances Limiting Intrafirm Technology Transactions: Hypotheses

Compared to market exchange, there are significant fixed costs associated with organizing technology transactions on an intrafirm basis. Investments in legal, administrative and operating infrastructures must be incurred. In addition the parent will incur costs to monitor and control the performance of the firm formed or acquired to accept the transaction (Alchian and Demsetz 1972; McManus 1975). As a consequence, transactions involving single and small rather than continuing transfers of technology are less likely to be carried out on an intrafirm basis. Consequently, it can be hypothesized that transactions involving peripheral technologies are less likely to be internalized than transactions in the parent's "mainstream" lines. In addition, expectations about the development of additional generations of technology will influence the choice between internal and external transfer mechanisms, because of the fixed costs associated with

internal transfer. Expectations about forthcoming generations of technology will be related to expenditures on research and development. Firms with high R&D expenditures are hypothesized to internalize transactions more frequently than firms with low R&D spending levels.

The existence of an established affiliate in the receiving country is also hypothesized to influence the choice between internal and external transfer mechanisms. The presence of an established affiliate implies that many of the fixed costs of internalization will have already been incurred. Even small, single-shot transfers may be conducted internally in such cases. It can be hypothesized that firms will exhibit greater use of internal transfer mechanisms in countries where they have established affiliates.

The importance of an established affiliate is reduced when the technology is not closely related to the affiliate's principal line of business or research activity. In such cases, new fixed costs must be assumed to develop the organization and business in the host country. Since the prospect of continued transaction activity in a secondary product line is relatively low, there will be less willingness to assume such overhead investments.

Country Characteristics and the Mode of Technology Transfer

The relative costs of intrafirm and market technology transactions will also depend on the broader legal, economic and social environment within which the transaction is to take place. The nature of this environment is, in turn, a function of government policies, economic conditions and political and cultural characteristics of the nations in which the transacting parties reside. We have held the home country constant in this analysis to focus on the economic, political and cultural characteristics of the receiving country.

Receiving Country Characteristics

National Policies Toward Foreign Direct Investment. Policies with respect to foreign direct investment vary considerably in form, intent and implementation. Foreign investment activity is subject to widely varying degrees of review and regulation from country to country, and receiving country policies vary by industry over time. In the extreme, receiving governments can preclude the internalization of technology transactions by placing restrictions on foreign equity holdings. Foreign investment controls such as those found in India, Mexico and the Andean Pact countries, among others, can dictate the use of licensing arrangements or joint ventures (Balasubramanyam 1973; Fajnzylber and Tarrago 1976; Furnish 1976).

Depending on sectoral criteria in these and many other countries, the use of joint ventures may be permitted. Although permitting partial internalization, the joint venture option is a poor substitute for intrafirm exchange. In such arrangements the partners' incomes depend on the terms of trade between the foreign firm, the local affiliate, and the local partner; as would occur in open market transactions. Both parties have an incentive, similar to that which exists in a market transaction, to take advantage of any opportunity to alter the terms of trade in their favor. Joint ventures do not

solve the underlying problems which lead many firms to internalize transfer of technology; that is, local partners may be unwilling to place an adequate value on the technology or to pay an adequate return to the parent firm. Second, once the local party has access to the technology it may attempt to alter the transaction terms in its favor.

In host countries with policies that restrict the use of internal transfer mechanisms, we of course hypothesize a greater reliance on external mechanisms. We also, however, would suggest first that such policies could reduce the total inflow of technology to the host country, and second, such policies could influence the composition of technology inflows. Corporations may opt not to transfer technologies in any form to host countries employing such policies. This tendency will be strongest for technologies which exhibit the greatest differential between the parent's valuation and the market's: the newest, most advanced technologies.

Another policy which frequently serves as an alternative or a complement to restrictions on foreign equity holdings is formal or informal screening of foreign investments. Unlike limitations on foreign equity holdings, screening does not preclude the possibility of intrafirm transactions. However, screening procedures for direct investment projects often involve significantly higher costs than those for other modes of technology transfer. To the extent that participation in the screening process and compliance with the requirements imposed by the screening agency add to the overall cost of an intrafirm transaction, the relative attractiveness of direct investment will decrease. We hypothesize that firms will exhibit a greater use of licensing in countries with extensive screening procedures. Screening may also influence the levels and composition of technology inflows to the host country, as discussed above.

In the absence of restrictions on direct investment, the choice between internal and external transfer mechanisms can be hypothesized to depend primarily on the expected present value of revenues from current and future transfers of technology. The higher the expected value, ceteris paribus, the more likely that the firm will choose the direct investment option. Many factors will influence expected returns. First, since many of the fixed costs of internalization will be independent of market size, it can be hypothesized that smaller markets will exhibit higher rates of licensing activity. A number of other host country characteristics can be hypothesized to influence the expected value of rents from technology transfer activity.

Public policies also influence the firm's assessment of returns from a given host country. For example, it can be argued that foreign exchange controls have the effect of reducing the expected value of revenues from technology transfers to a country (such policies may also be biased against revenues from direct investment as opposed to licensing fees). The presence of exchange controls is hypothesized to result in a greater use of licensing. Other public policies may have similar effects. For example, high tariff levels may increase the expected value of technology transfers to a protected market. If the expected value of technology transfer activity increases, the

relative attractiveness of direct investment increases. It can be hypothesized that high tariff protection increases the propensity to use direct investment to transfer technology. In addition to public policies, underlying economic and market characteristics are likely to be important.

Market Size, Sophistication and Similarity

The relative attractiveness of intrafirm and market transfer mechanisms is also hypothesized to be a function of the receiving country's market size and sophistication. Indicators of market size and sophistication used here include population, GNP per capita, electric power consumption per capita, the proportion of the population living in urban areas and the literacy rate. We expect each of these variables to correlate positively with the use of direct investment.

It can be argued that the expected value of technology transfers will be lower not only for smaller but also for less sophisticated markets. Such markets may tend to prefer relatively rudimentary technologies which, by virtue of their age, command relatively small rents. The greater the extent to which a host country is expected to prefer low-rent technologies, the less likely it is that transactions to that country will be conducted on an intrafirm basis. This hypothesis runs counter to that advanced by Contractor (1982), who proposed that licensing activity is more likely to occur in countries with a sophisticated industrial infrastructure.

Market Characteristics

The relative attractiveness of intrafirm and market technology transactions may also be a function of other market characteristics of the receiving country. It can be hypothesized, for example, that intrafirm transactions will be more attractive if the receiving country has the same demographic characteristics as the source country. For consumer products, trade in technology between two countries will be greater the more common are the tastes of their respective residents (Vernon 1971). For industrial technologies, demand will be greatest in countries with factor cost conditions similar to the source market. For both types of technology, demand in countries with market conditions similar to the home market will be greater than in dissimilar markets, ceteris paribus. Higher demand, and the resulting higher expected value of technology transfer activities, will result in a preference for internal transfer mechanisms. This hypothesis will be partially covered by the market variables listed above. Additional demographic factors, such as predominant religion and language base, can also be hypothesized to correlate with the choice of transfer mechanism.

Demographic dissimilarities can result not only in lower demand for a technology; such differences can also increase the cost of transfer. Modification or adaptation of the technology may be required. This issue will work against the use of direct investment in countries with market characteristics that are significantly different than the source country.

Geographic Proximity

Geographic proximity can be hypothesized to increase the level of trade in technology and hence the attractiveness of intrafirm transfers. Also, monitoring costs associated with internalization may be less costly if the transacting parties are in close geographic proximity to one another.

SPECIFICATION OF THE MODEL AND INTERPRETATION OF EMPIRICAL RESULTS

We have tested the hypotheses advanced above using data on 1,226 intrafirm and market technology transactions carried out by 32 U.S.-based multinational enterprises during the period 1945-1978. These data are described in Vernon and Davidson (1979) and Davidson (1980). In brief, these 1,226 transactions include all cases in which manufacturing was initiated in a foreign country through a licensee or a wholly-owned affiliate for one of 407 new products introduced by these firms in the U.S. between 1945 and 1975. The sample of products was selected from a list of all new products introduced by these firms. They were selected on the basis of commercial and technical significance, as indicated by knowledgeable sources within and outside these firms. Technology transactions were recorded whenever a foreign licensee or an affiliate initiated manufacturing for one of these products.

The dependent variable in this analysis is binary, with 1 indicating transfer to a wholly-owned affiliate. Transfers to joint ventures are excluded from this analysis. The independent variables which measure the characteristics of the technology, the parent and the receiving country are listed in Table 1. The hypothesized relationships between each of these characteristics and the probability of internal transfer are also summarized in Table 1.

These hypotheses were tested using logit analysis.[1] This approach involves estimation of the parameters of the logistic function

$$E(Y_i) = P_i = 1/(1 + \exp(-\sum_{j=1}^{J} b_j X_{ji})) \tag{1}$$

where Y_i = a discrete random variable equal to one if the i^{th} observation is an intrafirm transaction and zero if the i^{th} observation is a market transaction;

P_i = probability that the i^{th} transaction is an intrafirm transaction;

X_{ji} = value of the j^{th} characteristic of the i^{th} transaction.

Estimates of the b_j, $j = 1 \ldots k$ were obtained by the Maximum Likelihood Method and are reported in Table 2. The b_j reported in this table reflect the effect of a change in variable j on the natural logarithm of P.

The effect of a change in X_j on P itself is:

$$\frac{dP}{dX_j} = b_j \exp(-\Sigma b_j X_j)/(1 + \exp(-\Sigma b_j X_j))^2 = b_j P(1 - P) \tag{2}$$

These derivatives of P with respect to the X_j, evaluated at P = 0.70, the actual proportion of intrafirm transfers in the sample, are also reported in Table 2.

Using (2) we can write the elasticity of P with respect to variable j as

$$\eta_j = (X_j/P)(dP/dX_j) = b_j(1 - P)X_j \tag{3}$$

The value of η_j evaluated at P = 0.70, and the respective sample means of the X_j are also reported in Table 2. In cases where the independent variable is in logarithmic form, $b_j P(1 - P)$ is the change in P resulting from a given percentage change in X_j and the elasticity j is simply $b_j(1 - P)$.

Our sample includes 1,226 transfers observed over a period of 30 years. In a pooled time series cross-section sample such as this it is important to allow for possible changes in the b_j over time. The approach taken here is to allow for a secular trend in the intercept of the logistic function using a time dummy YR (YR = 0 in 1944). This approach implies that the respective marginal effects of all other independent variables will also change over time. Specifically,

$$\partial^2 P/\partial X_j \partial YR = b_j b_{YR} P(1 - P)(1 - 2P) \tag{4}$$

where b_j = the coefficient of the j^{th} independent variable (X_j), and

b_{YR} = the coefficient of the time dummy (YR).

Expression (4) implies that if b_i and b_{YR} are both positive the passage of time will increase the marginal effect of X_j on P for $P < 0.5$ and decrease it for $P > 0.5$. It is also possible that the signs and/or statistical significance of some of the b_j could vary during the sample period. We have tested for what we consider to be the most likely shifts in the b_j. The results of these tests are discussed below.

Interpretation of Results

We find that our expectations regarding the respective effects of the following factors are strongly supported by the statistical results:

- the age of the technology
- prior transfers of the technology
- the relationship of the technology to the transferor's principal line of business
- the transferor's R&D intensity
- the prior existence of an affiliate in the receiving country, and other prior aggregate transfer activity of the transferor.

Our expectations regarding the respective effects of the radical/incremental innovation and innovation/imitation dummies on the probability of internal transfer are not supported.

More specifically it can be reported that the probability of internal transfer is greater: (a) for newer technologies; (b) for technologies with fewer previous transfers; (c) for technologies in the same three digit SIC class as the transferor's principal line of business; (d) the more R&D intensive is the

TABLE 1

TRANSACTION SPECIFIC CHARACTERISTICS

Technology and Parent Characteristics

AGE:	Age of the technology at the time of the transfer in terms of years since its U.S. introduction (−)*. The older the technology, the less likely is internalization.
PTEC:	Number of prior transfers of the technology outside the U.S. (−). The greater the number of prior transfers, the less likely is internalization.
PRND:	Annual R&D: Sales ratio of transfer at the time of transfer (+). The higher the ratio, the more likely is internalization.
RAD:	Dummary variable equal to one if the technology was considered a radical innovation when introduced, zero otherwise (+). Radical innovations are more likely to be internalized.
IMIT:	Dummy variable equal to one if the technology was an innovation when introduced, zero if it was an imitation of a technology already in existence (+). Innovations are more likely to be internalized.
SIND:	Dummy variables equal to one if the technology is in the same three digit SIC class as the transferor's principal line of business, zero otherwise (+). Technologies within the parents primary business are more likely to be internalized.
PTPAR:	Aggregate number of prior technology transfers by transferor at the time of transfer (−). The more transfers of all kinds the parent has made, the less likely is internalization.
YR:	Year in which the transfer occurs (1944 = 0) (−). More recent transfers are less likely to be internalized.
EXAF:	Dummy variable equal to one if the transferor had an affiliate in the receiving country in the year prior to the transfer, zero otherwise (+). The presence of an affiliate increases the internalization probability.
NOTES:	RAD and IMIT were determined by questioning knowledgeable observers within and outside the sample firms. PTPAR is the number of foreign manufacturing locations of the transferor prior to 1945 plus all transfers of individually defined new product technologies after 1945. The foreign manufacturing location data were taken from the Harvard Multinational Enterprise Data Bank. See Curhan, Davidson and Suri (1977).

* Sign in brackets denotes expected direction of effect of the variable in question on the probability of internal transfer.

Country Characteristics

NLOC:	Dummy variable equal to one if the receiving country borders on the U.S. zero otherwise (+). Proximity increases the probability of internalization (POI).
URB:	Percentage of the population of the receiving country living in urban areas (+). High urbanization increases the POI.
LIT:	Literacy rate of the receiving country (+). Higher literacy increases the POI.
RLG:	Dummy variable equal to one if the receiving country is predominantly Protestant or Roman Catholic, zero otherwise (+). A western religious foundation increases the POI.
LNG:	Dummy variable equal to one if the receiving country is predominantly English speaking, zero otherwise (+). A similar language base increases the POI.
GOVT:	Dummy variable equal to one if the receiving country had a democratic form of government, zero otherwise (+). A democratic form of government increases the POI.
GNPC:	GNP per capita receiving country (+). The POI increases with GNP per capita.
ELPC:	Electric power consumption per capita (+). The POI increases with consumption of power per capita.
MFR:	Percentage of receiving country's GNP emanating from the manufacturing sector (+). Higher manufacturing levels increase the POI.

TABLE 1 (Continued)

EQCO:	Dummy variable equal to one if the receiving country imposed no controls on foreign equity holdings at the time of transfer, zero otherwise (+). The absence of controls increases the POI.
EQC1:	Dummy variable equal to one if the receiving country imposed extensive controls on foreign equity holdings at the time of transfer, zero otherwise (−). Extensive controls reduce the POI.
EXCO:	Dummy variable equal to one if the receiving country imposed no exchange controls at the time of transfer, zero otherwise (+). Absence of controls increases the POI.
EXC1:	Dummy variable equal to one if the receiving country imposed extensive exchange controls at the time of transfer, zero otherwise (−). Extensive controls reduce the POI.
ENTO:	Dummy variable equal to one if the receiving country did not screen foreign direct investment at the time of transfer, zero otherwise (+). Absence of screening increases the POI.
ENT1:	Dummy variable equal to one if the receiving country engaged in detailed screening of foreign investment at the time of transfer, zero otherwise (−). Extensive screening reduces the POI.
NOTES:	All variables are measured at the time of transfer. URB is taken from *Business International*, LIT from UNESCO and *The World Almanac* and LNG and RLG from *Encyclopedia Americana* and *The World Almanac*. GOVT is taken from *The World Almanac* and miscellaneous sources. GNPC and ELPC are taken from the U.N. *Statistical Yearbook*. MFR is taken from Business International's *Market Size Indicators*. EQCO and EQC1 are based on country reports from *Business Asia, Europe and Latin America, Overseas Business Reports* and Business International's International Licensing and Trade publications among others. Countries for which both EQCO and EQC1 are zero have controls in a small number of industrial sectors. Japan after 1968 and Mexico prior to 1971 would fall into this category. EXCO and EXC1 are based on information taken from the International Monetary Fund's *Annual Report on Foreign Exchange Restrictions*. ENTO and ENT1 are taken from the same sources as EQCO and EQC1. Countries for which both ENTO and ENT1 are zero have foreign investment licensing boards but the licensing process does not involve an extensive, strict and time-consuming review of the investment.

transferor; (e) if the transferor had an affiliate in the receiving country prior to the transfer; and (f) for transferors with more prior technology transfers.

Insofar as the characteristics of the receiving country are concerned, the results support our expectations regarding the impact of geographic proximity and certain demographic characteristics on the probability of internal transfer. Specifically, the probability of internal transfer is greater: (a) if the receiving country borders on the United States; (b) if the receiving country is predominantly English-speaking; and (c) if the receiving country's predominant religion is Protestant or Roman Catholic.[2]

Our predictions regarding the relationship between the market size and sophistication of the receiving country and the probability of internal transfer are not supported by our empirical results. Specifically, while they are not statistically significant, the coefficients of the variables measuring GNP per capita, electric power consumption per capita, percentage of population living in urban areas and percentage of GNP originating in the manufacturing sector are all negative—the opposite of what was expected. There is, however, a positive relationship between the literacy rate of the receiving country and the probability of internal transfer.

Our expectations regarding the public policy variables receive modest support from our empirical results. Contrary to expectations, the coefficient of the democratic government dummy is negative implying a lower probability of internal transfer if the receiving country has a democratic form of government. Although contrary to our expectations, this finding is less surprising when viewed in the light of other empirical work. Green (1972) found that political conditions did not correlate with levels of foreign investment activity. Similarly, Kobrin (1976) found no relationship between variables reflecting the characteristics of the political environment and foreign investment activity.

The existence of extensive equity controls reduces the probability of internal transfer (variable EQCI). The complete absence of controls increases the probability, but the coefficient of the dummy EQCO is not significant. The probability of an intrafirm transaction is higher if the receiving country did not screen new foreign investments (ENTO), and reduced under extensive screening but the coefficient of ENT1 is not statistically significant.

We also examined the joint impact of foreign investment screening and equity controls on the mode of technology transfer chosen. We created two variables, ENEQ (equal to one if the receiving country did not engage in screening *or* maintain equity controls, zero otherwise) and ENEQ1 (equal to one if the receiving country maintained extensive controls *and* engaged in detailed screening, zero otherwise).

Estimates of the model employing ENEQ and ENEQ1 in place of EQCON, EQCON1, ENT and ENT1 are reported in equation (3) in Table 2. The results imply that the probability of internal transfer is significantly higher if there is neither screening nor equity controls and lower if there is both detailed screening and extensive equity controls.

Comparing equation (2), Table 2 which employes EQCON, EQCON1, and ENT1 as independent variables and equation (3), Table 3 which employs ENEQ and ENEQ1 we note that equation (3) has the same predictive power (% correct predictions, McFadden's R^2) but requires the estimation of fewer parameters. By the Akaike Information Criterion, at least, (3) is the superior specification.[3]

As far as the other policy variables are concerned, we find, that the probability of internal transfer is higher if the receiving country had extensive foreign exchange controls than if it had some or none. Dunning (1981, pp. 7-9) argues that the existence of exchange controls and high tariffs increases the advantage of internalization.

To summarize, we have found close relationships among the mode of technology transfer and the characteristics of the technology, the parent firm and certain demographic and geographic characteristics of receiving countries. There is a weaker relationship between the mode of transfer and selected public policies of receiving countries. We found no relationship between transfer mode and the economic characteristics of receiving countries.

TABLE 2

EMPIRICAL RESULTS

	Equation 1				Equation 2				Equation 3			
Variable	$\hat{b}$	$\hat{b}/S_b$	$\hat{b}\bar{P}(1-\bar{P})$	η	$\hat{b}$	$\hat{b}/S_b$	$\hat{b}\bar{P}(1-\bar{P})$	η	$\hat{b}$	$\hat{b}/S_b$	$\hat{b}\bar{P}(1-\bar{P})$	η
Const.	−8.65	5.95			9.17	6.42			−8.95	6.40		
1nAGE	−0.30	1.92	−0.06	0.09	−0.30	2.01	−0.06	−0.09	−0.30	2.02	−0.05	−0.09
PTEC	−0.13	4.56	−0.03	−0.15	−0.14	5.16	−0.03	−0.16	−0.14	5.23	−0.03	−0.16
1nPRAND	0.79	5.43	0.17	0.24	0.76	5.39	0.16	0.23	0.75	5.33	0.16	0.23
RAD	0.22	1.20	0.05	0.04	0.11	0.66	0.02	0.02	0.10	0.58	0.02	0.02
IMIT	0.12	0.72	0.03	0.02	0.07	0.41	0.01	0.01	0.07	0.41	0.01	0.01
SIND	1.35	7.11	0.28	0.17	1.25	6.80	0.26	0.16	1.23	6.74	0.26	0.16
1nPTPAR	−0.29	2.97	−0.06	−0.06	−0.24	2.51	−0.05	−0.07	−0.25	2.58	−0.05	−0.07
YR	0.14	6.31	0.03	0.94	0.17	7.47	0.04	1.07	0.17	7.62	0.04	1.07
EXAF	1.24	6.60	0.26	0.18	—	—	—	—	—	—	—	—
NLOC	1.81	3.70	0.38	0.10	1.94	4.15	0.41	0.11	1.98	4.21	0.42	0.11
URB	−0.02	1.58	−0.01	−0.44	−0.03	2.07	−0.01	−0.56	−0.02	1.73	−0.01	−0.44
LIT	0.03	2.48	0.01	0.87	0.04	3.03	0.01	1.04	0.03	2.69	0.01	0.84
RLG	3.06	5.26	0.64	0.85	3.20	5.45	0.67	0.89	3.00	5.89	0.63	0.83
LNG	0.71	2.82	0.15	0.08	0.87	3.61	0.18	0.10	0.79	3.26	0.17	0.09
GOVT	−0.94	1.76	−0.20	−0.27	−1.01	1.84	−0.21	−0.29	−0.71	1.51	−0.15	−0.20
GNPC	−0.02	0.91	−0.01	−0.02	−0.01	0.56	−0.01	−0.02	−0.01	0.79	−0.01	−0.02
ELPC	−0.14	1.67	−0.03	−0.12	−0.13	1.51	−0.03	−0.11	−0.11	1.37	−0.02	−0.10
MFR	−0.01	0.55	−0.01	−0.12	−0.01	0.55	−0.01	−0.12	−0.01	0.61	−0.01	−0.12
EQCO	0.03	0.07	0.01	0.01	0.15	0.45	0.03	0.03	—	—	—	—
EQC1	−1.89	1.89	−0.40	−0.03	−1.87	1.93	−0.39	−0.03	—	—	—	—
EXCO	0.23	0.87	0.05	0.03	0.38	1.53	0.08	0.05	0.36	1.50	0.08	0.05
EXC1	2.12	4.20	0.46	0.13	2.38	4.91	0.50	0.15	2.55	5.49	0.54	0.16
ENTO	0.86	1.79	0.18	0.17	0.84	1.75	0.18	0.17	—	—	—	—
ENT1	−0.05	0.11	−0.01	−0.01	−0.34	0.79	−0.07	−0.01	—	—	—	—

TABLE 2 (Continued)

Variable	Equation 1				Equation 2				Equation 3			
	$\hat{b}$	$\hat{b}/S_b$	$\hat{b}\bar{P}(1-\bar{P})$	η	$\hat{b}$	$\hat{b}/S_b$	$\hat{b}\bar{P}(1-\bar{P})$	η	$\hat{b}$	$\hat{b}/S_b$	$\hat{b}\bar{P}(1-\bar{P})$	η
ENEQO	–	–	–	–	–	–	–	–	0.57	1.72	0.12	0.11
ENEQ1	–	–	–	–	–	–	–	–	−2.22	2.51	−0.47	0.03
Likelihood Ratio Test			530.0 (26)			483.8 (25)				479.5 (23)		
AIC			511.9			535.0				534.2		
McFadden's R^2			0.35			0.32				0.32		
Proportion Correct Predictions			0.80			0.79				0.79		

Notes to Table II

(1) The asymptotic distribution of the ratio $\hat{b}/S_b$ is standard normal (Amemiya, p. 1497).

(2) AIC is the Akalke Information Criterion which is defined in n. 3.

(3) McFadden's R^2 is $1-(\ell_{\hat{\beta}}/\ell_0)$ where $\ell_{\hat{\beta}}$ is the log of the likelihood function of the model in question and ℓ_0 is the log of the likelihood function under the null i.e. when all slope coefficients are zero. See Ameniya, p. 1505.

(4) The proportion of correct predictions is calculated under the assumption that i^{th} transaction is to be assigned to the intrafirm category if $\hat{P}_i \geq .70$. This is equivalent to comparing the predictive power of the model with that of the sample mean.

A possible explanation for the pattern of relationships we have observed is the presence of EXAF (which reflects the existence of an affiliate in the receiving country in the year prior to the transfer) as an independent variable in the model. Once an affiliate is in existence it is much more likely that subsequent transactions will be internalized. The question is whether to attribute these subsequent intrafirm transactions to the existence of an affiliate or to the underlying country conditions, including, for example, the economic characteristics of the receiving country which stimulated the creation of an affiliate in the first place.

The effect of excluding EXAF from the model can be determined by comparing equations (1) and (2) in Table 3. As expected, the exclusion of EXAF results in an increase in the z-statistics of most of the other independent variables. The increases are not sufficient, however, to lead us to change any of the conclusions reached above. The exclusion of EXAF from the model does reduce its predictive power (from 80% correct predictions to 79% and from a McFadden's R^2 of .35 to .32), but the decline is surprisingly small.

The magnitudes of the respective effects of the independent variables on the probability of an intrafirm transaction are reported in columns headed $bP(1-P)$ and n in Table 2. Using the elasticity measure, n (see expression 3) we find that the literacy rate and the religion dummy are the most important country characteristics while the R&D intensity of the transferor is the most important company-specific characteristic.

Another way of assessing the effects of changes in circumstances on the probability of internal transfer is to insert appropriate values for the independent variables together with estimates of the b_j into expression (1) to calculate P. The results of an exercise of this nature are reported in Table 3. Given any set of technology, parent, and country characteristics, such an approach derives the expected probability of internal transfer.

Table 3 summarizes the model's predictions regarding the impact of two public policy variables on the probability that a given transaction will be internal. If, for example, there is no screening (ENTO=1) and some equity controls (EQCO=0, EQC1=0) and no affiliate existed in the year prior to the transfer (EXAF=0), the probability of internal transfer is 69% for a one-year-old technology with one prior international transfer.

If there is some screening (ENTO=0, ENT1=0) and other factors remain the same, the probability of internal transfer falls to 49%. If extensive equity controls (EQC1=1), are also present the probability that a one-year old technology with one prior international transfer will be transferred internally is 13%.

Such dramatic differences illustrate the impact that policies of host governments can have on the choice of technology transfer mode. Governments can oblige a technology transaction to be conducted in a manner that would not otherwise have been chosen. This type of transaction cannot be costless: the determination of the costs associated with such policies constitutes an important area for future research. Another important area for

TABLE 3

TECHNOLOGY CHARACTERISTICS, POLICIES OF RECEIVING COUNTRIES AND THE PROBABILITY OF INTERNAL TRANSFER

P	AGE	PTEC	EXAF	EQC1	ENTO
.89	1	1	1	0	1
.82	10	1	1	0	1
.83	1	5	1	0	1
.74	10	5	1	0	1
.69	1	1	0	0	1
.57	10	1	0	0	1
.57	1	5	0	0	1
.45	10	5	0	0	1
.49	1	1	0	0	0
.37	10	1	0	0	0
.36	1	5	0	0	0
.26	10	5	0	0	0
.13	1	1	0	1	0
.08	10	1	0	1	0
.08	1	5	0	1	0
.05	10	5	0	1	0
.33	1	1	1	1	0
.23	10	1	1	1	0
.23	1	5	1	1	0
.15	10	5	1	1	0

Source: Table 3—Equation 1 and equation (1) in the text with EQCO, ENT1, EXCO, EXC1, PRAND, RAD, IMIT, SIND, PTPAR, YR, NLOC, URB, LIT, RLG, LNG, GOVT, GNPC, ELPC, MFR equal to their sample means and AGE, PTEC, EXAF, EXC1 and ENTO equal to the values given above.

further research is the impact of political instability on transfer choices. Political instability can be hypothesized to reduce the expected value of technology transactions. This will discourage direct investment. Political instability can shift transfer activity from the investment mode to the licensing mode. It can also, however, reduce the attractiveness of licensing activity, and delay or reduce licensing activity in the receiving country. Examination of these effects will require additional research. An additional area for further theoretical research involves the role of joint ventures in technology transfer activity.

SUMMARY

These findings suggest that corporate technology transfer activities conform closely to behavior patterns derived from the theory of the firm. Actual transfer patterns are highly consistent with those derived from this body of theory. Other microeconomic factors, such as the presence of an affiliate in a receiving country and the parent's R&D spending, also appear to be important in corporate activity patterns.

Host country economic conditions, however, exhibit no consistent relationship with technology transfer patterns. Market size and sophistication, as measured here, do not appear to be significant factors in the choice between licensing and direct investment. We know from previous work that these

factors are positively related to levels of direct investment. Apparently they are similarly related to levels of licensing activity. However, social factors such as religious and language similarities are positively related to direct investment levels. These variables may be capturing some of the hypothesized effects of market similarity on the choice between licensing and direct investment.

Public policy variables appear to be important in the choice between licensing and direct investment. Screening procedures and equity controls appear to significantly reduce the probability of internal transfer. There may be significant costs associated with such policies in terms of reduced and delayed transfer activity.

The model presented here could be of use to host countries as a means of measuring the "natural" propensities of corporations in any given transfer situation. When the predicted probability of internal transfer is very high, insistence on alternative transfer mechanisms will be less effective than when the predicted probability is low. A flexible approach toward regulation of transfer activity could provide significant benefits.

For corporations, this analysis offers a frame of reference for technology transfer decisions. Behavior patterns from this sample of firms indicate managerial sensitivity to many of the factors discussed here. Detailed consideration of these factors may provide assistance in making transfer decisions.

NOTES

1. For a complete discussion of the derivation and interpretation of the logit model see Amemiya (1981).

2. The test statistic is distributed according to the X^2 distribution with 3 degrees of freedom (see Amemiya, p. 1498). The value of X^2 is 5.38 which is not significant at the 10% level. There are reasons to expect that geographic proximity and the demographic characteristics of the receiving country may have had a greater impact on the choice of transfer mode in the early part of the sample period. To test this proposition the coefficients of NLOC, LNG and RLG were examined before and after 1966, which is the sample mean transfer year. A likelihood ratio test indicated that the coefficients of the shift dummy variables were insignificant as a group implying that the influence of geographic proximity and cultural characteristics was not confined to the earlier part of the sample period.

3. The Akaike Information Criterion (AIC) is $-\ell_{\hat{\beta}} + K$ where $\ell_{\hat{\beta}}$ = log of the likelihood function and K = the number of parameters to be estimated). A lower value of AIC is equivalent to a higher R^2 in a conventional regression.

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