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ABSTRACT

This paper examines whether rivalry in host country markets may force multinational firms to increase the technology transfer to their foreign affiliates. Such technology flows should be interesting from the perspective of the host country and its firms, since they would increase the potential for "spillovers". Using detailed (unpublished) industry data from Mexican manufacturing industry we find that indicators for local competition are positively related to the technology imports of foreign owned affiliates. The effects appear to be strong in consumer goods industries, which suggest that foreign multinationals are especially sensitive to the local market environment when barriers to entry in the form of complex technology or high capital requirements are relatively low.

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1. Introduction

Technology transfer, which lies at the heart of the process of economic development, is of utmost importance for the economic performance of countries and firms. To a large extent, economic growth depends on the degree and efficiency of such transfers and many countries have therefore put much emphasis on policies regarding these matters.

Over the past decades, multinational corporations (MNCs) have undertaken a major part of the world's research and development efforts, and today they produce, own, and control most of the world's advanced technology. Multinationals also play a central role in the international transfer of technology. Over four fifths of the stock of foreign direct investment originates from only a half dozen countries - the United States, the United Kingdom, Japan, Germany, Switzerland, and the Netherlands - where most advanced technology is produced and from where it is spread to the rest of the

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world (Kokko, 1992). The developing countries, with limited indigenous resources for research and development, are particularly dependent on foreign MNCs for access to modern technology.

In quantitative terms, the flows of technology to MNC affiliates dominate all other types of formal technology transactions between countries. For instance, in the 1970-1985 period, over 80 per cent of the registered payments to the United States for technology sales were made by foreign affiliates of U.S. firms (Grosse, 1989). Data on Japanese and German technology transfers to developing countries are similar, with between 60 and 90 per cent of technology payments originating from their own foreign affiliates (UNCTC, 1988). A large share of these technology transfers are also pure intra-firm transaction - for U.S. majority owned foreign affiliates, the share in 1982 was well over 90 per cent (U.S. Department of Commerce, 1985). The intra-firm character probably also makes them differ from other transfers when it comes to age and value of technologies. Mansfield and Romeo (1980) found that the average age of a sample of technologies at the time of their first transfer to subsidiaries in developed countries was 5.8 years (and that for developing countries was 9.8 years), whereas the corresponding figure for outside licensing and joint ventures was 13.1 years. In other words, the technologies transferred to affiliates seem to be of a newer vintage than those sold to outsiders.

It might be argued that the affiliates' technology imports only lead to

a geographical diffusion of technology, but not to transfers to new users, because the ownership and control of technologies are largely kept in the MNCs' possession. However, it has been suggested that significant transfers of technology to local host country firms come from external effects or spillovers, rather than from formal transactions (Blomström, 1989). It is also likely that the magnitude of spillovers varies with the flows of technology to the MNC affiliates in the host country, viz. the more technology that is available, the larger the spillover potential. In fact, the available empirical studies of spillovers - focussing on Australia (Caves, 1974), Canada (Globerman, 1979), Mexico (Blomström, 1989), and Morocco (Haddad and Harrison, 1992) - differ in their estimates of the size of spillovers, which, at least to some degree, seems to be a consequence of differences in the affiliates' imports of technology (see Kokko, 1992). For this reason, flows of technology to MNC affiliates should be interesting also from the perspective of host country firms.

In an earlier study (Blomström and Kokko, 1992), we used aggregated data to examine technology imports by U.S. affiliates in 33 foreign countries. The results suggested that the affiliates' technology imports increased with the income level of the host country and (crude proxies for) the competitive pressure in the host economy, and decreased with the level of distortions and various host country performance requirements. In this study, we use detailed data from one host country, Mexico, to analyze some industry-level

determinants of technology imports by foreign firms. We are particularly interested in the role of market rivalry in forcing the multinationals to bring more technology to their foreign operations.

The rest of the paper is organized as follows. Section 2 discusses how rivalry in host country markets could force affiliates of multinationals to increase their technology imports from their parent companies. Section 3 describes the data and Section 4 reports the empirical analysis. The conclusions are stated in the final section of the paper.

2. Why Market Rivalry Matters

Considering the voluminous literature on technology transfer in general, there is surprisingly little said about what determines the technology imports of MNC affiliates. Empirical studies of technology transfers within multinational corporations have revealed a large variation in the age and amount of technology transferred to different MNC affiliates, but the available explanations in the theoretical literature have generally focussed on firm and technology characteristics that are not influenced by policy (see Kokko, 1992 for a survey). Wang and Blomström (1992) are an exception, in that they treat the MNC affiliates' technology imports as strategic variables in the interaction between MNC affiliates and host country firms.

More specifically, Wang and Blomström (1992) argue that the MNC's profit is a function of the size of the technology gap between the affiliate and

local firms. The affiliate is typically operating in a monopolistic market where its technological lead gives its products a 'quality advantage': the newer and more advanced the MNC's products, the more attractive they are to the consumers. More attractive products, in turn, translate into high demand and allow the MNC to enjoy a higher market share or a higher mark-up than the local firm. However, the marginal revenue from imports of technology is assumed to be diminishing (although always positive). At the same time, technology transfer is costly, and the latest technologies are the most expensive to import. These features of the transfer process outline a situation where the optimizing affiliate will import technology only to the point where marginal revenue equals marginal cost.

Figure 1 provides a simple illustration of the affiliate's optimal technology import decision. The horizontal axis shows all innovations that can potentially be imported, ordered according to "technology content", so that older and less advanced innovations are to the left and newer and more advanced ones to the right. The vertical axis measures the MNC affiliate's total revenues and costs from importing each innovation. The curve TC shows that transfer costs increase with the complexity of the technology, and that the most recent innovations are extremely expensive to import (i.e., the marginal cost is increasing). The curve TR is drawn to show total revenue as an increasing function of the technology level of the affiliate, given the technology level of local firms. The slope of the curve shows that marginal

revenue of newer technology is diminishing, although always positive.

Insert Figure 1

The optimizing MNC affiliate will decide to import the technology that maximizes profit, i.e. it will choose the technology where marginal revenue equals marginal costs. In Figure 1, the optimal import quantity is q1, where the slopes of the curves TR and TC are equal and the distance between the curves is maximized.

What happens if local firms begin to invest and become more competitive? The technology gap narrows, the MNC affiliate's 'quality advantage' becomes weaker, and its profits diminish. In terms of Figure 1, the affiliate's revenue curve shifts downwards and to the right, to TR', as a result of the increase in the local firms' competitiveness - we assume here that nothing happens with the cost curve TC.[1] The character of the shift, with a larger impact for less advanced innovations, and a smaller (perhaps negligible) effect for more advanced technologies, is explained by the local firms' lower technology levels: they are mainly able to compete with older and less advanced technology. Hence, TR' is always below (or, for very advanced technologies, equal to) TR, and the slope is always higher than (or equal to)

that of TR.

The revenue from importing q1 is lower than before, because local firms have captured a share of the market. The initial technology import decision is also suboptimal, because the increase in revenue from additional technology imports is higher than the marginal cost. Consequently, the affiliate will increase its technology imports until a new equilibrium is reached at point q2, where the slopes of the curves TC and TR' are equal.

Hence, Wang and Blomström argue that competition from host country firms is an important determinant of the rate at which MNC affiliates import technology. Since available empirical studies have not addressed this argument, we will use data from Mexican manufacturing industries to examine the relation between competition and the affiliates' technology imports in some detail.

3. Data

The data for this study come from the Mexican 1970 and 1975 Censuses of Manufactures, supplemented by some data from the U.S. Department of Commerce (1981). The Mexican data, which are at the four-digit level, are broken down by ownership, i.e. foreign and domestic, where a plant is defined as "foreign" if 15 per cent or more of its shares are owned by foreigners.[2] Thus, we are not able to separate joint ventures from other foreign affiliates. There are 230 four-digit industries, but foreign subsidiaries

only in 163 of these. Moreover, some industries had to be discarded due to missing information.

From the Mexican sources we use, for each industry, the following information: (for 1975) advertising costs and payments for imported patents, trade marks, and technical assistance; (for 1970 and 1975) capital stock, employment, gross output, and value added. From the U.S. source we use payment per employee for patents and trade marks in 1977 by U.S. multinationals' parent companies.

4. Empirical Analysis

We shall now examine whether local market rivalry may influence imports of technology by affiliates of multinationals in Mexican manufacturing industries, by employing indicators of local competition and MNC technology imports in multiple regression tests.

The dependent variable should reflect the foreign affiliates' technology imports, and we use three alternative measures for that. First, the foreign affiliates payments per employee for imported patents, trade marks, and technical assistance in 1975 (TECHMNC). Although these payments, at least to some extent, include transfer pricing activities, this variable still probably underestimates the affiliate's real technology imports, since much technology is transferred in machinery, equipment, and personnel. Our second measure of the multinationals' technology imports is the labor productivity levels of the

foreign affiliates in 1975 (value added per employee, denoted LPMNC). Productivity levels are, of course, influenced by more than technology imports, but we try to incorporate these factors into other variables in the regression analysis. Finally, we use the rate of labor productivity growth 1970-1975 in foreign affiliates (LPGMNC) as a proxy for technology imports during the same period.

We also measure local competition (or market rivalry) in different ways. First, we use payments to abroad for patents, royalties, and trade marks per employee in 1975 by local Mexican firms in the same industry as the multinationals' affiliates (TECHLOC). The underlying assumption is that the local firms who are importing much technology are also relatively competitive. There are, of course, differences across industries in their propensities to use foreign patents, royalties, and trade marks, but we will attempt to account for these with a control variable, as will be discussed below. Another proxy for competition is the growth rate of the capital stock in local firms between 1970 and 1975 (INVLOC). The hypothesis is that the more local firms invest, the more efficient they become, which puts pressure on the multinationals to bring in more technology from abroad (mainly from their parents). Furthermore, we use the growth rate of output (or labor productivity) in local firms between 1970 and 1975 (OGRLOC and LPGLOC, respectively). Compared to the investment variable, this variable should also reflect the efficiency of the investment. Finally, we use a Herfindahl index to

measure the degree of competition in an industry.

Throughout the study, the method of estimation is ordinary least squares, and the results obtained from the different linear estimations are shown in Tables 1-4.[3] The form of the equation used is additive and we estimate the coefficients of the various independent variables.

Table 1 reports the results for the regression analysis of the foreign affiliates' payments to abroad for patents, royalties, and trade marks per employee in 1975 (TECHMNC).[4] Such payments differ considerably among industries, so we have to introduce some variable that takes care of the industry specific variations. We use the U.S. MNC parents' payments for patents and trade marks in 1977 (USLIC).[5] We also include the ratio of advertising to value added for each industry in 1975 (ADV). The variable is intended to account for the cases where trade marks are commonly used, and where TECHMNC can be expected to be high for that reason alone. Finally, we employ four variables to indicate market rivalry: local firms' payment for foreign technology in 1975 (TECHLOC), their investment 1970-1975 (INVLOC), their output growth during the same period (OGRLOC), and a Herfindahl index. The Herfindahl index was dropped, however, since it never came out significant in any of the regressions. The explanation is most likely that this concentration index, in a small economy like the Mexican, reflects economies of scale and specialization rather than market power of large firms.[6]

Insert Table 1

With the assumption of normally distributed errors, all our variables in Table 1 show up with the expected (positive) coefficients, that are generally significantly different from zero at the 1 per cent level (two-tailed test). Thus, all our indicators of local rivalry come out strongly significant, which suggests that the multinationals' decision to transfer technology to their foreign operations is influenced by the performance of competing firms in the host economy.

Table 2 shows the results for the regression analysis of foreign affiliates' labor productivity levels (LPMNC) in Mexican manufacturing industries, 1975. Most of the variance of this variable is obviously explained by the capital intensity in the multinationals (KLMNC), but also our two proxies for local competition (INVLOC and LPGLOC) register positive coefficients that are significantly different from zero at the 5 per cent level.[7] LPGLOC, which is the growth rate of labor productivity (value added per employee) in locally owned firms, 1970-1975, substitutes the output growth variable (OGRLOC) used in Table 1.

Insert Table 2

The regression analysis of our third proxy for technology transfer by multinationals, viz. the growth rate of labor productivity in foreign affiliates, 1970-1975 (LPGMNC), is reported in Table 3. Labor productivity growth is, as expected, strongly related to changes in capital intensity, but, once again, also to a proxy for local competition. The LPGLOC variable carries a positive coefficient that is significantly different from zero at the 5 per cent level.

Insert Table 3

One would expect local competition to be more important in industries where technology is simpler and where the technological advantages of foreign multinationals are smaller. We have therefore divided the industries into three groups according to product characteristics, viz. consumer goods, intermediates, and durables and capital goods. We assume that the consumer goods industries employ the least advanced technologies, and that the intermediates and durable and capital goods industries use more complex or

capital-intensive technologies.

As Table 4 shows, the effect of local competition is obviously much stronger in consumer goods than in the other industries. This can be interpreted as support for the hypothesis that it is easier for local Mexican firms to compete with foreign owned multinationals in consumer products, because the minimum technology levels are easier to reach in these industries. This is consistent with the results presented by Kokko (1992), who argues that local competition is important mainly in the industries where the productivity gap between local firms and foreign affiliates is relatively small, or where the capital-labor ratios employed by the foreign affiliates are relatively low. However, it is also possible that the degree of substitutability between local products and MNC products is higher in these industries, irrespective of the technological characteristics.

Insert Table 4

In sum, our findings seem to suggest that local rivalry has an influence on the technology transfer activities by multinational firms. No matter which indicator we use for local competition and technology imports by multinationals, they all tell the same story (although some variables were

weaker than others). The more local market rivalry, the more technology is imported by the affiliates of the multinationals. This provides strong empirical support for the theoretical conclusions in Wang and Blomström (1992), and underlines the role of local firms in encouraging technology transfer through multinationals.

5. Concluding Remarks

Although there appears to be a wide consensus that multinationals may act as an important bridge between advanced and less advanced countries in the geographical diffusion of technology, there seems to be less agreement on what policy measures countries hosting multinationals should adopt to get these firms to transfer more (and more advanced) technologies. The more technology that is brought to the foreign affiliates, the larger the potential for "spillovers", which have come to play an important role in the recent growth literature.

In this paper we have examined whether competition in host country markets may increase the technology transfer by multinational firms. Using detailed (unpublished) industry data from the Mexican manufacturing industry, our results suggest that local competition is positively related to imports of technology by affiliates of multinationals. The effects are particularly strong in consumer goods industries, which suggests that foreign multinationals are especially sensitive to the local market environment when barriers to entry in

the form of complex technology or high capital requirements are relatively low.

These findings have some apparent policy implications for host countries that try to maximize the inflows of modern technology. Firstly, it is important that local policies aim to create competitive conditions in the industries where foreign MNC are present, so that competition may foster continuous imports of technology along the lines described above. Secondly, efforts to increase the domestic technological capability in more advanced industries - e.g. intermediates and durable and capital goods - may be necessary in order to expose the foreign multinationals to competition. However, the technology policies of many countries still focus on administrative controls and direct technology transfer requirements, rather than market conditions.

NOTES

1. Shifts in the TC curve would illustrate changes in, for instance, the host country's learning capability.

2. Data specified by ownership, which are unpublished, have been provided by la Dirección Estadística de la Secretaría de Industria y Comercio in Mexico. To the best of our knowledge, no other host country provides comparable data on the operation of foreign owned firms, not even Mexico after 1975.

3. See Appendix for a correlation matrix.

4. We also tried the ratio of the affiliates' technology payments to their capital stock, but this did not change the efficiency of the parameters. However, the adjusted R^2 were considerably lower.

5. 1977 was the closest year for which data on U.S. firms were available. Moreover, the U.S. data are available only at the two-digit level, and the Mexican four-digit industries have therefore been aggregated into 14 broad industry groups to construct this variable.

6. See Blomström (1986) for a fuller discussion of the Herfindahl index.

7. If local firms' investment (INVLOC) was correlated with the investment activities of the MNCs (INVMNC), higher labor productivity in foreign affiliates could be a result of high INVMNC rather than INVLOC. However, the simple correlation between INVLOC and INVMNC was not significant (0.048).

APPENDIX

Simple Correlation Matrix for Independent Variables

1.00						
0.46	1.00					
0.45	0.37	1.00				
0.19	-0.06	0.18	1.00			
0.07	0.13	0.11	-0.06	1.00		
0.29	0.20	0.20	-0.07	0.09	1.00	
-0.02	0.01	-0.08	-0.10	0.29	0.11	1.
0.01	0.07	0.06	0.16	0.40	-0.03	0.
INVLOC	OGRLOC	TECHLOC	ADV	KLMNC	LPGLOC	KLG

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FIGURE 1

The MNC Affiliate's Technology Import Decision

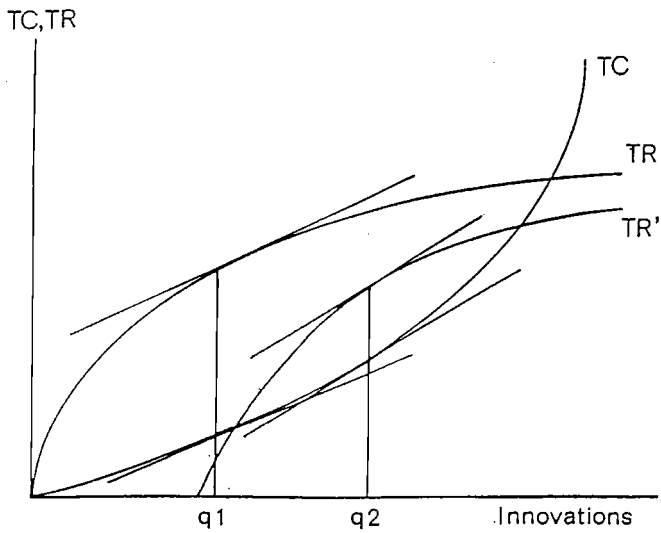

Table 1

Regression Analysis of Foreign Affiliates' Payments for Imported Technologies (TECHMNC) in Mexican Manufacturing Industries, 1975[a/]

Equations	Constant	USLIC	TECHLOC	INVLOC	OGRLOC	ADV	$\bar{R}^2$	Sample size
(1)	0.466***	0.315***	0.136***	0.119***	--	--	0.46	120
	(0.137)	(0.071)	(0.049)	(0.018)				
(2)	0.367***	0.296***	0.127***	0.114***	--	0.119*	0.47	120
	(0.146)	(0.071)	(0.049)	(0.018)		(0.067)		
(3)	0.421***	0.290***	0.197***	--	0.129***	--	0.38	120
	(0.147)	(0.077)	(0.050)		(0.028)			
(4)	0.224***	0.251***	0.160***	--	0.143***	0.233***	0.43	120
	(0.153)	(0.074)	(0.050)		(0.027)	(0.070)		

a/ Standard errors in parentheses.

Key:

TECHMNC: foreign affiliates' payments to abroad for patents, royalties and trade marks per employee, 1975.

USLIC: U.S. parents' payments per employee for patents and trade marks, 1977

TECHLOC: locally owned firms' payments to abroad for patents, royalties, and trade marks per employee, 1975

INVLOC: growth rate of capital stock in locally owned firms, 1970-1975 (deflated)

OGRLOC: growth rate of gross-output in locally owned firms, 1970-1975 (deflated).

ADV: ratio of advertising to value added for each industry, 1975

*, **, and *** Significant at the .10, .05, and .01 level, respectively (two-tailed test)

Table 2

Regression Analysis of Foreign Affiliates' Labor Productivity Levels (LPMNC) in Mexican Manufacturing Industries, 1975[a/]

Equations	Constant	KLMNC	INVLOC	LPGLOC	$\bar{R}^2$	Sample size
(1)	0.243***	0.757***	--	--	0.54	147
	(0.079)	(0.057)				
(2)	0.230***	0.746***	0.023**	--	0.56	147
	(0.078)	(0.056)	(0.009)			
(3)	0.060	0.746***	--	0.194**	0.56	147
	(0.118)	(0.057)		(0.093)		

[a/] Standard errors in parentheses.

Key:

LPMNC: value added per employee in foreign affiliates, 1975

KLMNC: capital (total assets) per employee in foreign affiliates, 1975

INVLOC: growth rate of capital stock in locally owned firms, 1970-1975 (deflated)

LPGLOC: growth rate of value added per employee in locally owned firms, 1970-1975 (deflated)

*, **, and *** Significant at the .10, .05, .01 level, respectively (two-tailed test)

Table 3

Regression Analysis of Labor Productivity Growth (1970-1975) in Foreign Affiliates in Mexican Manufacturing Industries (LPGMNC)*/

Equations	Constant	KLGMNC	LPGLOC	$\bar{R}^2$	Sample size
(1)	0.667*** (0.076)	0.333*** (0.054)	--	0.23	126
(2)	0.491*** (0.111)	0.032*** (0.053)	0.192** (0.090)	0.25	126
(3)	0.752*** (0.116)	--	0.252** (0.101)	0.04	126

*/ Standard errors in parentheses.

Key:

LPGMNC: growth rate of value added per employee in foreign owned firms, 1970-1975 (deflated).

KLGMNC: growth rate of capital (total assets) per employee in foreign affiliates, 1970-1975 (deflated).

LPGLOC: growth rate of value added per employee in locally owned firms, 1970-1975 (deflated).

*, **, and *** Significant at the .10, .05, and .01 level, respectively (two-tailed test).

Table 4

Regression Analysis of Foreign Affiliates' Technology Imports in Different Industries, 1975[a/]

Independent variables	Dependent variables			
	TECHMNC	TECHMNC	LPMNC	LPMNC
		Consumer Goods		
Constant	0.236 (0.294)	- 0.076 (0.303)	0.285** (0.131)	0.251 (0.194)
INVLOC	0.118*** (0.032)	--	0.028*** (0.009)	--
USLIC	0.475*** (0.153)	0.371*** (0.150)	--	--
OGRLOC	--	0.150*** (0.041)	--	--
TECHLOC	0.167* (0.096)	0.231*** (0.086)	--	--
ADV	0.085 (0.109)	0.260** (0.113)	--	--
KLMNC	--	--	0.641*** (0.139)	0.672*** (0.148)
LPGLOC	--	--	--	0.047 (0.116)
$\bar{R}^2$	0.53	0.53	0.31	0.22
Sample size	51	51	68	68

(Table 4 continues)

Table 4 (continued)

Regression Analysis of Foreign Affiliates' Technology Imports in Different Industries, 1975[a]

Independent variables	Dependent variables			
	TECHMNC	TECHMNC	LPMNC	LPMNC
		Intermediates		
Constant	0.445* (0.223)	0.458** (0.243)	0.286* (0.160)	- 0.078 (0.219)
INVLOC	0.097*** (0.026)	--	0.010 (0.020)	--
USLIC	0.216*** (0.076)	0.185** (0.085)	--	--
OGRLOC	--	0.108** (0.047)	--	--
TECHLOC	0.111 (0.084)	0.097 (0.093)	--	--
ADV	- 0.117 (0.437)	0.009 (0.474)	--	--
KLMNC	--	--	0.747*** (0.048)	0.704*** (0.082)
LPGLOC	--	--	--	0.454*** (0.194)
$\bar{R}^2$	0.34	0.22	0.60	0.64
Sample size	43	43	54	54

(Table 4 continues)

Table 4 (continued)

Regression Analysis of Foreign Affiliates' Technology Imports in Different Industries, 1975[a]

Independent variables	Dependent variables			
	TECHMNC	TECHMNC	LPMNC	LPMNC
	Durables and Capital Goods			
Constant	1.847*** (0.414)	2.136*** (0.457)	0.125 (0.106)	- 0.118 (0.245)
INVLOC	- 0.130 (0.158)	--	0.184** (0.065)	--
USLIC	- 2.206** (0.974)	- 2.708*** (1.001)	--	--
OGRLOC	--	- 0.467 (0.302)	--	--
TECHLOC	- 0.017 (0.051)	0.028 (0.054)	--	--
ADV	- 0.192* (0.103)	- 0.174* (0.100)	--	--
KLMNC	--	--	0.864*** (0.109)	0.870*** (0.126)
LPGLOC	--	--	--	0.243 (0.262)
$\bar{R}^2$	0.14	0.20	0.75	0.68
Sample size	24	24	25	25

*/ Standard Errors in Parentheses. Key:

TECHMNC:	foreign affiliates' payments to abroad for patents, royalties, and trademarks per employee, 1975.
LPMNC:	value added per employee in foreign affiliates, 1975.
INVLOC:	growth rate of capital stock in locally owned firms, 1970-1975 (deflated).
USLIC	U.S. parents' payments per employee for patents and trademarks, 1977
OGRLOC:	growth rate of gross-output in locally owned firms, 1970-1975 (deflated).
TECHLOC:	locally owned firms' payments to abroad for patents, royalties, and trade marks per employee, 1975.
ADV:	ratio of advertising to value added for each industry, 1975.
KLMNC:	capital (total assets) per employee in foreign affiliates, 1975.
LPGLOC:	growth rate of value added per employee in locally owned firms, 1970-1975 (deflated).
*, **, ***,	Significant at the .10, .05, and .01 level, respectively (two-tailed test).