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Factors Impacting Technology Transfer: The Maquiladora Industry in Yucatan, Mexico

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Abstract

Technology transfer and knowledge transfer are the building blocks for innovation, efficiency and increased competitiveness. The topic of technology transfer in the context of multinational companies has been the focus of technology management researchers for well over two decades. Developing countries housing twin plans have been exposed to technology transfer from very diverse countries with different approaches to the technology transfer process and different levels of success. This cultural and national diversity adds an additional level of complexity to the technology transfer domain that has been largely unexplored. This paper will explore critical factors that had an impact in successful transfer of manufacturing technology to twin plants or maquiladoras. The study included data from 12 plants in the state of Yucatan, Mexico with corporate headquarters in the US and Italy.

Keywords
Technology Transfer, Manufacturing, Knowledge Transfer, Knowledge Management.

1. Introduction
Technology transfer is understood as the reception and utilization by a country of a technology that was developed by another country [1]. Technology transfer is indispensable in developing countries, which usually lack the capabilities and resources to independently generate new technologies. This is the case for transnational organizations, which require the transfer of technical and managerial capabilities from headquarters to their twin plants and suppliers in Mexico. The transfer is aimed at allowing the twin plants to meet quality standards while reducing production costs. There have been numerous successful outcomes from technology transfer in Asian countries such as South Korea, Taiwan, Malaysia and Singapore [2].

The impact of technology transfer from multinational organizations on the receiving country is determined by various factors, including the type of activity, existing production levels, technological capabilities of the receiving country (including absorption capabilities), quality, availability of local resources, and the policies and activity of the local government. The efforts made so far in Mexico to promote this transfer have not been enough even when considering the benefits of the export manufacturing industry, which utilizes national resources and Mexican labor, brings direct foreign investments, and in some cases promote the development of technology.

Proper combination and use of these resources could bring favorable outcomes for Mexico such as the promotion of scientific and technological independence, which has been so cherished by Latin American countries who still depend on developed countries in this area.

For this purpose, strategies have been established at the political, economic and legislative level, but without significant outcomes yet [3]. Both developed and developing nations have the potential to benefit from such

interaction, which highlights the importance of understanding the dynamics taking place in the transfer of technology in manufacturing settings. The adoption and development of technology in Mexico, would allow companies to become more competitive, attract and retain new business investment in the manufacturing sector. Determining the factors that facilitate or hinder the transfer of technological expertise is also of interest to multinational companies considering Mexico as a possible location for twin plants.

2. Technology Transfer

The economic prosperity of a society is subject to a process of technological change and adaptation of its infrastructure by which existing manufacturing methods evolve into more efficient and effective ones and support the introduction of new products and services to meet the changing demands of society. This process of technological change is facilitated through local technological development along with the transfer of foreign technology [4].

Paiva [5] states that technology transfer is any stream of technological content (licensing, research, technical cooperation, trade in goods and equipment and foreign investment). In turn, Soto [6] defines it as the transfer of intellectual capital and know-how among organizations with the purpose of its use in the creation and development of commercially viable products and services. For purposes of this study technology transfer is defined as the transfer of systematic knowledge between two parties: a transmitter and a receiver with the goal of using the knowledge transfer for the creation and development of commercially viable products or services according to their needs.

There are different key players in the process of technology transfer: *university researchers* are the primary producers of knowledge or technology, *university managers* acting as intermediaries in negotiations on the exchange of technology from the university to companies, and *enterprises* who are responsible of marketing the technologies adopted in the process of transferring [7]. In addition, Lopez et al [8], argue that there are also other actors involved in the process of technology transfer such as the *industry scientist* responsible for analyzing and incorporating the knowledge obtained from universities to use in the process of innovation, and the *Government* that through public policy regulates the process of technology transfer.

3.1 Factors that impact technology transfer

In order to understand technology transfer, it is very important to identify potential common features from Mexican companies that have succeeded in implementing imported technology. Peri and Urban [9] identified the following as factors that affect absorption of the flow of technology: investment in research and development (R & D), the human capital of the national company, the ability to respond to the Foreign Direct Investment (FDI), technological similarity between the multinational and national company, geographic location and proximity between the two countries involved and cultural differences.

Murakami [10] used the investment in R & D as a measure of absorptive capacity of the technology transfer. Companies that focused on R & D experienced a positive effect on productivity growth due to technology transfer from foreign companies. The ability of the host region to respond to FDI was also detected as a necessary feature in the utilization of technology flows [11]. Costa and Rapini [12] highlight the importance of skilled human resources for the process of technology transfer. Highly skilled employees are more likely to absorb the technologies brought by foreign companies. Also, employees of multinationals have the ability to generate greater technology transfer and absorption, as these individuals transfer the "know how" possessed by multinational firms to domestic firms [13]. The production of graduates and publication of research results are still the most important form of dissemination of knowledge, but the transfer (person to person) of knowledge through technology transfer is an essential complement.

Shaojie et al. [14] concluded that the dynamism of the market has a stronger influence on the transfer of technology than the intensity of competition in the market. Their research also [14] found that cultural differences among nations are negatively related to technology transfer. On the other hand, Rodriguez and Cordero [15] mentioned the following as important factors on technology transfer: prices of labor, top management salaries, cost of raw materials, taxes, customs duties, transportation costs, exchange rates, proximity of raw materials and skilled labor, cost of training, facilities granted to officers and financial aid implementation.

Barrera [16] indicates that the difference in the degree to which technology flows into the countries depends on the access to information, which is determined by a number of factors, including domestic capabilities, infrastructure,

state of internal technology, trade and investment flows, and government policy. The nature of technology, technological capabilities and characteristics of both, the sender and the recipient country, are factors that affect the mechanism used to transfer technology. Radically new technologies, and those at risk of losing property rights are less likely to be transferred [17].

Table 1 presents a synthesis of the factors found in the literature that are relevant to technology transfer. Factors are classified as internal (within the boundaries of the recipient company), and external (out of the boundaries of the recipient company).

Table 1. Factors that Impact Technology Transfer

Type	Factors	Authors
Internal Factors	Nature of the technology	[17]
	Similarity between the manufacturing methods and technology of the companies.	[9, 17, 18]
	R&D Investment	[9,10,19]
	Responsiveness to FDI.	[11]
	Personnel costs	[15]
	Skilled labor	[13, 15, 16, 20- 24].
External Factors	Cultural factors	[9, 25]
	Access to the information	[16]
	Market dynamism	[9,14]
	Cultural distance	[14]
	Geographic location	[16, 27]
	Policies of the local government	[15, 25]
	Transportation cost, customs fees, and training	[15]
	Policies and resource availability of the host country	[25]
	Cost of raw material	[15]

Padilla-Pérez [26] argues that there are 4 different levels at which technology can be transferred. His model recognizes the impact of technology transferred to host countries it is not only the result of the interactions of the multinational enterprise with locally owned firms, but also with innovation-oriented organizations such as universities, research centers and industry associations. Furthermore, in the search of higher competitiveness and profits, some multinational enterprises deliberately transfer technology and interact with local firms and other organizations, thus their technological impact on host regions is not just reduced to unintended spillovers. The four levels identified by the author are:

Level I. Headquarters to foreign subsidiary

Level II. Headquarters to the local personnel in subsidiaries

Level III. Foreign subsidiaries interact with local agents

Level IV. Indirect spin-offs, (defined as private enterprises set up by entrepreneurs who work for private or public organizations).

4. Methodology

The initial sample included all 84 companies in the export manufacturing IMMEX directory of the Ministry of Economy within the State of Yucatan. Companies whose matrices were not foreign were eliminated from the sample. The final sample included 24 companies that had a foreign parent company. Of the 24 companies, one had closed production, 12 agreed to participate in the study, and 11 declined to participate in the study for various reasons including confidentiality of information, lack of time and company policies.

Managers from the companies underwent a guided face interview that consisted of 71 open and closed questions, which assessed the following factors: nature of technology, similarity between the production and technology

companies, R & D investment, response to FDI, geographic location, cultural factors, access to information, market dynamics, cultural distance, labor cost, government factors, attitudes taken by local governments, policies and availability of resources in the receiving country, skilled labor, effective planning. The interview also included questions to identify the level of technology transfer achieved by each company based on Padilla-Pérez's model [26].

5. Results

5.1 Analyzed Factors

Of the 12 companies interviewed, 9 of them (75%) stated that the transfer of technology between its foreign parent company and themselves was the same as that of the parent company and other subsidiaries. Notably, only 3 of them (25%) said that the level of transfer between the parent company and their company exceeded the transfer to other affiliates.

Jordaan [27] argues that geographic location is a key issue for the absorption of technology transfer between countries. He suggests that the proximity between economic agents promotes the creation, transmission and dissemination of knowledge. The three companies that indicated a greater level of technology transfer from the matrix than other subsidiaries were in close proximity with their parent companies in North America, and had easy communication and flow of raw materials and natural resources.

Only half of the companies believed that the dynamic of the market is a factor that affects the transfer of technology from the parent company to the subsidiary. Of the companies surveyed, 11 of them (91.67%) believe that the technology used in the production area of the company, gives them the capability to change the design of products to adapt to new market demands. Similarly, 11 of the companies believed that the technologies related to the support and management activities, facilitate the processes of information processing and decision-making.

In terms of R & D investments, five of the 12 companies interviewed have a department specialized in research and development in the company. However, only two companies indicated having invested on it. One indicated a steady investment in the last 4 years (2008-2011) of 15% of its net annual income, and the other in 2011 has invested the 20 % of annual net profit. On the other hand, 7 companies have a department responsible for managing or adjusting imported technology in their businesses. Eight of the 12 companies (66.67% of respondents) indicated they developed new products independently of the parent company.

As for the cultural differences, 9 of the 12 companies surveyed indicated that those differences have not been an impediment for proper training. Only one of the companies claimed that the level of worker performance is affected by differences in culture between headquarters and the company. Companies do not typically consider cultural differences as a critical factor in knowledge transfer and technology transfer. Proficiency in the language of the parent country is required for the recruitment of staff. One notable reported result relates to the importance of holidays (especially those of religious nature). Employees in Mexico consider holiday observance very important. Holidays in Mexico sometimes differ from those of the parent country, which results in employees not showing to work on those days.

Labor costs differ across the firms in the study. Only two companies reported having research staff, and both report wages of 6 times the daily minimum wage (the minimum wage in Mexico is equivalent to 4.5 USD). Three other companies reported having R&D units but did not report R&D personnel wages. In the case of administrative staff, the most common range is 5 to 6 minimum wages. For technical staff, salaries were typically 3 to 4 times the minimum wage, and in the case of line operators is 1 to 2 times the minimum wage. The average educational level for common administrative staff is a bachelor's degree, for technical staff is a high school diploma; line operators usually have only completed elementary school.

Eight companies (66.67% of respondents) claimed to have a department or unit for its own internal training. We obtained data on the percentage of annual net income invested in training in the participating companies. Results indicate that in 2008 only five of them had a training budget with an average of 6.1% of the annual net income spent on training. In 2009, five companies allocated a percentage with an average allocated amount of 6.2% of the annual net income. In 2010, six companies allocated a percentage of its net annual income for training, averaging 6.0%. And finally in 2011, the same 6 companies allocated an average 7% of their net annual income to training.

For foreign companies transferring technology from headquarters to its subsidiaries, it is very important to have a planned partnership program between the parent and the subsidiary. It was noted that among the companies interviewed, only 5 of them (41.67% of 12 respondents) have a plan in place to carry out the transfer of technology from its parent to the local maquiladora.

Regarding the role of government programs that support innovation, only 3 of the 12 companies surveyed (25%) claimed to have heard about these programs. Only one of these 3 companies (33.33 % of those who know this information) claimed to have participated in one of the programs. On the other hand, 33% of companies (4 of 12 respondents) said that the tariffs applied by the government are an impediment to transfer of technologies from the country of its headquarters to the maquiladora in Mexico. It should also be noted that the eight remaining companies do not consider tariffs an impediment to technology transfer. Table 2 presents a summary of the factors identified in the companies taking part in the study.

Table 2. Summary of Factors Influencing Technology Transfer

Factors	Description
1. Geographic Location	Only 25% (3 of 12 respondents) reported having a level of technology transfer superior to that of other subsidiaries. 75% of the remaining firms considered having a level of technology transfer comparable to other subsidiaries.
	75% of companies (9 of 12 respondents) acquire at least part of their raw materials in their country.
	83.33% of companies (10 of 12 respondents) acquires at least a portion of their indirect goods in the country. One company reports manufacturing 100% of their indirect goods, two acquire 90%, three of them 80%, two report acquiring 50%, one 40% and the remaining one 10%.
2. Market Dynamics	50% of companies (6 of 12 respondents) reported that the market dynamics is a factor that affects the transfer of technology from the headquarters to the subsidiary.
	91.67% of companies (11 of 12 respondents) considered that the technology used in the production area gives the company the ability to change product design in order to adapt to new market demands.
	91.67% of companies (11 of 12 respondents) indicated that technologies supporting management processes help facilitate information processing and decision-making
3. R&D Investment	Only 41.67% of companies (5 of 12 respondents), report having a department (or institution) specializing in R&D.
	58.33% (7 of 12 respondents) reported having a department responsible for managing or adjusting imported technology.
	66.67% (8 of 12 respondents) reported the development of new products.
	33.33% (4 of 12 respondents) reported that they conducted research projects.
	16.67% (2 of 12 respondents) indicated they allocated a percentage of its net annual income to be invested in research and development in 2011.
	91.67% (11 of 12 respondents) indicate that ideas contributed by employees are taken into account.
	75% (9 of 12 respondents) reported that when adopting technological changes in the company, all related personnel are trained. 25% (3 of 12 respondents) reported training only the supervisory personnel who are directly responsible for the department in which technology will change.
4. Cultural factors	75% (9 of 12 respondents) indicated that cultural differences between headquarters and subsidiary have not been an impediment to proper training. 25% (3 of 12 respondents) found such cultural differences were an impediment to proper training.
	91.67% (11 of 12 respondents) thought that the performance levels of its workforce, is not affected by the cultural differences between their employees and those in headquarters.
	91.67% (11 of 12 respondents) reported making adjustments to the processes, machinery and equipment based on employees' needs.

	Only 25% (3 of 12 respondents) reported having research personnel. Two report an average educational level of a bachelors and one graduate studies.
	For administrative staff, 8.33% (1 of 12 respondents) report average level of graduate studies, 83.33% (10 of 12 respondents) bachelor's, and 8.33 % high school.
	For technical staff, 16.67% (2 of 12 respondents) report average level of undergraduate studies in business, 58.33% (7 of 12 respondents) high school, 16.67% (2 of 12 respondents) is ???, and the remaining company reports not having such staff.
	For operators: 50% of companies (6 of 12 respondents) reported an average educational level of Junior high school and 50% is elementary school.
	66.67% (8 of 12 respondents) report having a training department inside the company
	50% of respondents (6 of 12) indicated they allocated a percentage of annual net income to be invested in training in 2011. Budgeted percentages are 15%, 10%, two with 5%, 4% and 3%.
	All 12 firms report providing training to employees (11 dedicate an average 7.82 hours per month to train their employees, and one trains based on specific needs)
5. Effective Planning	41.67% of respondents (5 of 12) indicate having a partnership program with headquarters to support technology transfer.
6. Government Factors	25% of respondents (3 of 12) knows of government programs to support innovation and only one participated in such program
	33.33% of respondents (4 of 12) believe that tariffs applied by the government are an impediment to the exchange of technologies.

5.2. Technology transfer levels

Based on the levels established by Padilla-Perez [26], results of this study show that almost all the interviewed companies achieve the first two levels. However, less than 50% reached Level III and only 1 company reached the level IV. Table 3 reports the results of the companies for each one of the criteria for the different levels of technology transfer.

Table 3. Levels of Technology Transfer

Levels	Description of Participating Companies
I. From headquarters to the local subsidiary (97.22 %):	91.66% of respondents reported using at least one of the following knowledge sources provided by the parent company: plans, manuals, formulas, implementation of new machinery in their process 100% of companies import capital and technological services 100% of the companies are provided with technical assistance in various areas from the parent company abroad
II. To the personnel in the subsidiary (81.67 %):	91.67% of respondents provides education and training to engineers and technicians 91.67% are visited by foreign experts from headquarters to train local staff 58.33% have developed new products other than those developed in the parent company. 100% of companies provides training to their employees in the use of technology 66.67% have an internal unit that provides training
III. From the subsidiary to the local agents (31.60 %):	*a) the company has interacted with locally-owned companies*
	41.66% of respondents have purchased raw material from local companies or national suppliers 75% of respondents bought indirect goods from local or national-owned businesses. 33.33% of respondents have trained engineers and technicians from local or national owned business customers.
	b) The company has interacted with local organizations

	50% of respondents interact with local or national universities in matters of innovation and technology. 50% interact with technical education schools in matters of innovation and technology 25% interact technology research centers in matters of innovation and technology 16.67% collaborates in research or technology development with public institutions 8.33% provide training to employees of public organizations. 41.67% work with schools to improve educational programs to students. 8.33% transfer highly skilled workers of the company to research centers to conduct research-related activities.
	c) Activities from local management related to technology transfer
	For 16.67% of respondents the administrator of the company provides technical assistance to local and national business customers. In 8.33% of companies, management works simultaneously in another place the company. In 58.33% of companies, administrators have presented at local conferences. 8.33% of the companies reported administrators who work or lead a research group.
	d) Spin-Offs
	16.67% of respondents indicated that former employees of the company have created their own businesses and became suppliers.
IV. Indirect spin offs (8.33%):	One company claimed to have interacted through research projects with former employees of a private organizations and who now have their own companies that provide suppliers to the company (Indirect Spin-Offs).

All of the 12 interviewed companies reached levels I and II of technology transfer according to Padilla-Perez's model. However, only four companies have reach levels III and IV, and, out of these four companies, only one reached level IV. In order to understand what factors helped them reach the highest levels of technology transfer, responses from the four companies that reached levels III and IV where analyzed separately. The goal with this approach was to identify what factors are helping them reach the highest levels of technology transfer.

It is worth noting the industrial activities of these four companies: textiles and clothing, aerospace, electrical and plastic industry. The matrices of the four companies are located in the United States. The four companies indicate that market dynamics are a factor that affects the transfer of technology. All of them indicate that the technology used in the manufacturing gives the company the ability to change product design in order to adapt to new market demands and headquarters requirements. Three of the four companies believe that the technologies that support management activities facilitate the information processing and decision-making that the dynamism of the market demands.

Investment in R&D was highlighted by these four companies as being a determining factor for the transfer of technology. However, none of the companies have a department (or institution) specializing in R&D. 75% (3 of 4) indicated having a department responsible for managing or adjusting imported technology. 75% of companies (3 of 4) perform the independent development of new products different from those made in the parent company. 75% of companies (3 of 4) said that if they conduct research projects. 50% of companies (2 of 4) reported planning to allocate a percentage of its net annual income to research and development in 2011. 100% of companies said that the ideas that employees contribute, are taken into account. 75% of companies (3 of 4) said that when technological changes are made in the company, training is provided to all employees.

Although having skilled labor was not mentioned as a key factor in technology transfer by any of the four companies, the data collected suggests it might play a role. The only company that reached the fourth level of technology transfer is the only one with a staff dedicated to research. In the four companies, engineers develop or translate technical manuals. Likewise, these four companies spent between 10 and 20% of its net income on training programs for floor level staff. The only company that reached level IV pointed out the existence of a partnership program for technology transfer between the subsidiary and headquarters as a key element for a successful technology transfer process.

Two factors that attracted attention for not being considered as determinants of technology transfer were the cultural and governmental factors. 75% of companies (3 of 4 characterized) believe that the performance levels of its

workforce, is not affected by the cultural differences between their employees and those in headquarters. As far as governmental factors, none of these four companies said that the tariffs imposed by the government adversely affect the transfer of technology.

6. Conclusions

Countries like Mexico still have a way to go to achieve adequate transfer and absorption of technology that will allow for the local development of technological innovations. This paper provides an in-depth analysis of the key factors perceived by subsidiaries as having an impact in the transfer of technology from headquarters. A better understanding of the impact that key factors have had on companies achieving high levels of technology transfer opens the door for the design of strategies that integrate the various actors responsible for this transfer. Likewise understanding these factors can assist multinational companies to identify the important role they play in the transfer and support the design of programs promoting technology transfer to its affiliates.

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