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**TNCs and the diffusion of environmentally
friendly technologies
to developing countries**

By Daniel Chudnovsky and Andrés López

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Management in Transnational
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Background

The globalization of economic activity in general, and the growing role of transnational corporations (TNCs) in particular, have increasingly directed attention toward the environmental consequences of these developments. Increasingly, TNC activity in developing countries has become an issue for various normative initiatives at the international level, in the OECD and in the WTO. However, there remains a pertinent need to gain a better understanding of the environmental implications of TNC activity in developing countries. On this background, the United Nations Conference on Trade and Development (UNCTAD) and Department of Intercultural Communication and Management, Copenhagen Business School (DICM/CBS) in 1997 received a grant from the Danish International Development Agency (DANIDA) to conduct a study of environmental practices in TNCs. The project is called: "Cross border Environmental Management in Transnational Corporations". The project examines environmental aspects of foreign direct investment (FDI) in less developed countries by conducting case studies on environmental practices in Danish and German TNCs with operations in China, India and Malaysia. The project will produce a series of research reports on cross border environmental management seen from home country, host country as well as corporate perspectives. The reports will serve as input to a conference on Cross Border Environmental Management hosted by UNCTAD.

Abstract

This paper serves as substantive background input to the preparation of the pre-UNCTAD X seminar "Making FDI Work for Sustainable Development".

When it comes to the role of foreign direct investment in the transfer of environmentally friendlier technologies, the lack of sound evidence is evident. On the one hand, environmental NGOs tend to suspect that TNCs use obsolete and dirty technologies at affiliates in developing countries. The reverse approach is that of business-related organizations, which publicize successful case stories where TNCs not only employ clean technologies, but also gain more money by doing that; the so-called "win-win" solutions. Though there are examples that support both arguments, the paper argues that the real world is much more complex and uncertain and that there is a pertinent need to develop a better understanding of the issue, both at the conceptual and empirical level.

Consequently, the paper starts out by presenting a conceptual framework for analyzing the transfer of environmentally friendlier technologies through FDI. Secondly, the paper briefly examines the available evidence in regard to TNC transfer of environmental friendlier technologies and management practices, paying special attention to Latin American countries. Finally, since the evidence is generally inconclusive regarding if, how and to what extent TNCs do transfer environmentally friendlier technologies and practices to developing countries, the paper proposes some key issues for a research agenda.

Please note that the views and opinions expressed in this paper reflect those of the author and do not necessarily represent those of UNCTAD and CBS.

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TNCs and the diffusion of environmentally friendly technologies to developing countries

A background note

By Daniel Chudnovsky and Andrés López¹

I. Introduction

Differently from what happened in the 1960's and 1970's, when developing countries were mostly concerned with the need to tightly control and even restrict Transnational Corporations (TNCs) activities, most countries now welcome foreign direct investment (FDI). The change of attitude towards FDI is part of a broader change in many developing countries, from relatively closed and state-led to more open and market-friendly policy regimes.

One of the reasons for this changing attitude towards TNCs is that they are acknowledged by many analysts and governments as one of the main vehicles, or even the main vehicle, for allowing developing countries to start closing the gap with the world technology leaders. In many sectors, especially in the most dynamic and knowledge-intensive ones, TNCs have important technological assets. Besides, TNCs are often at the cutting edge in terms of their managerial and organizational routines. Hence, the way and the extent to which developing countries may benefit from these intangible proprietary assets possessed by TNCs to foster their social and economic development are key issues in the research and policy agenda.

Environmentally friendly technologies and practices are obviously part of the TNC's assets which may benefit developing host countries. In the past it was often assumed that TNCs invested in developing countries to take advantage of lax environmental regulations or to deplete their stock of natural resources, employing mostly obsolete and environmentally harmful technologies (or technologies which were banned in their home countries). Nowadays, TNCs are increasingly considered as leaders in the introduction

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of good environmental management practices and in the diffusion of environmentally sound technologies.

The available evidence does not fully support the faith that is now put on TNCs as vehicles of technological modernization and "greening" of developing countries. The literature suggests that the contribution of FDI depends not only on its volume but also on its "quality" - the type of investment, the sector of destination, the kind of assets brought by the TNCs, the role played by the affiliates within the global network of the MNC, etc. - and on the characteristics of host countries, which affect not only the amount and kind of FDI that is attracted, but also its contribution to growth and competitiveness. Besides the macroeconomic framework and the economic policy regime in force, a crucial factor is the creation of what has been termed a "social" or "absorptive" capability (Dahlman *et al*, 1987; Dahlman and Nelson, 1993) -i.e., a capability to be able to assimilate and take advantage of foreign technology inputs.

In this sense, while there is no doubt that TNCs have the potential for introducing environmentally sound technologies in host developing countries, their actual environmental impact will, however, depend on many factors, including:

- the sectors in which they invest, the age of their facilities, their strategies -i.e., market, resource, efficiency or asset-seeking (see Dunning, 1994) - and the degree of export orientation of the investment (specially when the destination market is "environmentally-sensitive");
- their corporate environmental policies, their approach towards environmental management, and the magnitude and type of their linkages with domestic suppliers, clients and competitors;
- the host country environmental regulations and their degree of enforcement and the role played by stakeholder groups such as non-governmental organizations, consumers, workers and local communities;
- home country regulations regarding the responsibility of TNCs shareholders for their overseas operations and the role played by third party lenders -for example, international financial institutions- in reinforcing environmental standards as a condition of lending.

In this scenario, it comes as no surprise to find that the empirical evidence on the environmental impact of TNCs on host developing countries is mixed. In fact, although this issue has been widely -and hotly- discussed, the empirical studies are not as abundant as it could be supposed from the controversies generated around it. Even though there is a lot of anecdotal evidence, there are relatively few carefully designed studies, which are once and again quoted in the available literature. In turn, since the approach and methodologies of the empirical studies differ, it is not surprising to find that the related surveys are generally very cautious in their conclusions.

When it comes to the role of FDI in the transfer of environmentally friendly technologies, the lack of sound evidence is even more evident. On one hand, environmental NGOs tend to suspect that TNCs use obsolete and dirty technologies at affiliates in developing countries, basing this view on limited numbers of cases and examples. The reverse approach is that of business-related organizations, which publicize successful case stories where TNCs not only employ clean technologies, but also gain more money by doing that; the so-called "win-win" solutions. It is fairly evident that these case stories suffer from the same limitations as of those cited by the "green movement".

Though there are examples that support both arguments, the real world is much more complex and uncertain. The objectives of this paper are:

- to concisely set the conceptual framework for assessing the issue under examination;
- to briefly examine the related available evidence (with special attention to Latin American countries);
- since the evidence is generally inconclusive regarding if, how and to what extent TNCs do transfer environmentally friendly technologies and practices towards developing countries, to propose some key issues for a research agenda.

II. The conceptual framework

Essentially, there are four ways in which developing countries can obtain technology from TNCs: through FDI; through joint ventures between domestic firms and TNCs (including what has been termed "strategic partnerships"); by purchasing technology in contractual form (patents, licensing, turnkey contracts, etc.); and through reverse engineering, imitation, copying, etc. (in this case, without the consent of TNCs). The choice between these four ways, when there is a choice², depends mainly on the type of sector involved, the technological infrastructure of the host country, the availability of skilled domestic human resources and the existence (or absence) of native firms with endogenous innovative capabilities. Although this paper will mainly pay attention to FDI, the other ways of absorbing foreign technology possessed by TNCs also play a key role and should be addressed in conceptual as well as empirical studies³.

2. TNCs may be reluctant to engage in arm's-length technology transfer, or to associate with domestic firms. As for reverse engineering or copying, the international legal framework seems to have been moving for many years towards a more stringent enforcement of intellectual and industrial property rights.

3. In this sense, it is worth taking into account that many reports of transfers of environmentally harmful technologies towards developing countries by TNCs are related not to FDI but to the selling of second-hand production equipment to local firms in those countries. See for example the case of the Danish TNC DS Industries, who announced that it would sell the production equipment from a chlorine factory in Copenhagen, which had been closed down because this dangerous production was located in a densely populated area, to a Pakistani

Through FDI, TNCs may bring to the host country their best technological and organizational practices or, at least, they may introduce technologies and practices which are more up-to-date (though not necessarily more attuned to local conditions or domestic factor prices) than those applied by local firms. TNCs may also be an important source of spillovers. First, their entry may lead to increasing competition in domestic markets, forcing local firms to enhance their productivity by being more efficient in using existing technologies and, eventually, by adopting new technologies. Second, local firms may take advantage of the superior technologies and organizational and management practices of TNCs by imitating them, hiring workers trained by TNCs, or establishing forward and backward linkages with their affiliates (Blomstrom and Kokko, 1997). Finally, if TNCs develop innovative activities in the host country, they could generate significant externalities (for instance, through human capital upgrading).

Following this argument, TNCs may be a vehicle for the diffusion of environmentally friendly management practices and technologies in developing countries. Furthermore, FDI may lead to some standardization of technologies used across countries and may also promote the diffusion of environmentally friendly technologies through the expansion of the market for environmental goods and services (OECD, 1998). Besides, as some TNCs are at the frontier in research on, and the application of, the so-called "pollution prevention", "eco-efficient", or "process-oriented" technologies, their affiliates may play a positive role in diffusing those technologies in developing countries.

Historically, environmental compliance, and hence management, have focused mainly on treatment of pollution once it has been created ("end-of-pipe")⁴ rather than on prevention or recycling. Nonetheless, pollution prevention measures have economic as well as environmental advantages over more conventional solutions. According to many observers, pollution prevention technologies may not only be less costly than end-of-pipe treatment. They may also, in some cases, generate additional monetary benefits (the so-called "win-win" solutions)⁵.

consortium; due to public pressure, the sale was cancelled (Eriksen and Hansen, 1999). The export of products that are banned in their home countries has also been a common practice by many TNCs.

4. The end-of-pipe approach is based on the identification, processing and disposal of discharges or waste. It is thus a corrective approach, which tries to control the pollution after it has occurred.

5. Michael Porter has suggested that win-win solutions could be available for a wide range of industries and firms, through what he defines as "innovation offsets", i.e. process or product innovations that simultaneously generate less pollution and improve firms' competitiveness. (through higher productivity, decreasing costs or improved quality) (Porter and Van der Linde, 1995a, b). This hypothesis has been rejected on the basis of conceptual and empirical objections by mainstream economists (see Palmer et al, 1995). Nonetheless, some aspects of Porter's hypothesis may find support in another conceptual framework, namely, the evolutionary approach towards technical change (see López, 1996 and Bartzokas and Yarime, 1997). On the other hand, many studies find that pollution prevention technologies do really exist in many industries, but highlight the institutional and organizational obstacles to their diffusion, as well as the bias of regulations in favor of end-of-pipe solutions, confirming arguments already advanced by Porter (Hanrahan, 1995). See, for an overview of pollution prevention technologies in pollution intensive industries, Bartzokas and Yarime (1997) and for a test of Porter's hypothesis, Albrecht (1998). See also Jaffe et al (1995) and Jenkins (1998).

Hence, it comes as no surprise to find that pollution prevention technologies have been warmly received in developing countries, where social problems such as poverty or unemployment can only be mitigated in a context of sustained and sustainable economic growth. The idea is, thus, to shift from a corrective approach to a preventive one in environmental management. The development of an innovatory capability to find preventive solutions for pollution problems in the productive sector should therefore be a key element in making this fundamental change (Chudnovsky *et al*, 1997).

Pollution prevention measures normally include:

- good housekeeping, maintenance and operating practices;
- product reformulation and raw material substitution;
- relatively simple process modifications employing currently available technologies;
- more fundamental process modifications, mainly requiring technological innovation;
- external recycling.

Pollution prevention actions can be distinguished according to the level of complexity. There are some "simple" ones with small investment requirements, low technological complexity and short implementation periods, e.g. water, energy and input savings. At the other end, there are more "complex" measures, generally involving greater investments, longer lead times and higher technological complexity and uncertainty, e.g. the development of new cleaner technologies. At the same time, it has been stated that there are many similarities between pollution prevention and total quality management, a key instrument for competing in open economies (OTA, 1994).

Insofar as TNCs move from end-of-pipe towards pollution prevention environmental management approaches, they may employ pollution prevention technologies in their affiliates in developing countries. They may also influence the environmental management of their affiliates' suppliers, competitors and customers both by setting an example and by introducing their own environmental standards. Furthermore, the parent companies may also provide local engineers and technical staff with training in pollution prevention technologies and practices and waste minimization (O'Connor and Turnham, 1992; UNCTAD, 1993).

A key questions are whether TNCs follow the same environmental standards, technologies and management routines applied in their home country when operating abroad, and whether their affiliates in developing countries impose those standards and diffuse those technologies and routines to their suppliers, customers and even competitors. In this sense, some authors have argued that by standardizing environmental management systems and technologies TNCs may gain scale advantages and recoup sunk costs (Esty and Gentry, 1997; Hansen, 1999).

III. The empirical evidence

Even if the arguments presented in section I have found some conceptual as well as empirical support, by no means they can be taken as well-documented. In regard to the general debate on technology transfer by TNCs, there are two aspects that are crucial to developing countries interests:

- the degree of diffusion of their technological assets and their management and training systems throughout the local productive system;
- the internationalization of TNC's R&D activities towards developing countries affiliates.

These factors are decisive when analyzing whether TNCs constitute islands of technological (and/or environmental) modernity or, on the contrary, if they contribute to the building of domestic innovative capabilities and enhancing host countries' "national systems of innovation"⁶. In turn, this also depends greatly upon local firms' absorption capabilities, which are the result of cumulative learning processes fostered by adequate institutional settings, good macroeconomics policies, availability of skilled human resources and efficient management and organizational routines at firms' level.

Regarding TNC's technological spillovers, the available evidence on their actual magnitude is rather inconclusive. "Many analyses of the linkages between TNCs and their local suppliers and subcontractors have documented learning and technology transfers that may make up a basis for productivity spill overs ...". Nevertheless, "these studies seldom reveal whether the TNCs are able to extract all the benefits that the new technologies or information generate among their supplier firms, so there is no clear proof of spillovers" (Blomstrom and Kokko, 1997, p. 13). However, they readily argue that it "is reasonable to assume that spillovers are positively related to the extent of linkages". Regarding spillovers through the training of workers, the authors assert that there seems to be a definite accumulation of human capital skills among the TNCs' employees, but the extent to which these skills can be appropriated by local firms when these employees move to new jobs is an open question.

In turn, it is well known that TNCs undertake only a small proportion of their R&D activities outside their home countries. Although information technology may facilitate greater decentralization of R&D activities, it may also lead to a concentration of such activities in a few developed countries. Whereas in some cases affiliates in developing countries undertake some R&D work, it may well happen that the total expenditure on R&D in the host country may be reduced with the entry of TNCs. For example, an TNC which takes over an existing local firm that used to make significant investments in R&D activities may decide to discontinue these activities since it centralizes them in its home base or in affiliates in developed countries. Even without takeovers, the presence of

6. On the concept of National Systems of Innovation see Lundvall (1992), Nelson (1993) and Edquist (1997).

TNCs may discourage innovative activities in domestic enterprises and induce them to substitute licensing agreements for such activities.

At the same time, TNCs may not necessarily bring their latest technologies to the host countries. In fact, many cases have been reported regarding the use of outdated technologies - which are often highly pollutant - in TNC affiliates in developing countries. The use of a certain set of technologies depends, amongst other things, on the relative price factors, the intensity of competition in the host country market, the requirements of industrial and final customers, and the global strategy followed by TNCs.

Regarding environmentally friendly technologies, it has been observed that even if one may assume that TNCs from developed countries are at the forefront in terms of cleaner technologies, this is by no means the case of TNCs from developing countries (Zarsky, 1999). In this sense, it must be mentioned that according to Esty and Gentry (1997), the most egregious examples of environmentally deleterious technology transfers appear to involve firms from Hong Kong, Singapore and Taiwan, though in most cases these transfers do not implicate investment but rather involve simple sales of equipment.

In fact, from the available empirical studies, no clear-cut evidence on the extent to which FDI serves as a vehicle for the diffusion of environmentally friendly technologies and management practices arise. There are many empirical studies founded on solid basis which, nonetheless, are inconclusive on this issue, since in fact their original objectives were geared to discuss a slightly different set of questions. Take for example the paper by Aden *et al* (1999) on Korea. The authors find that the expenditure on pollution abatement by domestic *chaebols* is greater than in those plants with some level of foreign ownership. However, from this it cannot be concluded that the technologies employed in *chaebols* plants are cleaner or more environmentally friendly than in foreign owned plants; in fact, the situation could be the opposite, and that could be the reason why there is a need to expend more in pollution abatement⁷.

In turn, the finding that many TNCs do not employ the same environmental practices in all their affiliates shows that they do not fully transfer their intangible assets in this field (Jha and Teixeira, 1994; Levy, 1995). Even worse, from a survey of 80 TNCs it has been found that the adoption of cost-effective and environmentally friendly practices had no significant relationship with environmental performance (Levy, 1995). These finding leaves room for exploring the possibility that many TNCs might be avoiding costly environmental investments and are perhaps engaged in a sort of "window-dressing" in their environmental practices. However, this does not necessarily imply that TNCs do not transfer some environmentally friendly technologies and management practices to their developing countries affiliates at all.

Even the studies engaged specifically with the transfer of technologies and skills from TNCs generally reach mixed conclusions. This is the case, for example, of a study on FDI in India, whose author suggests that the overall performance of TNCs is difficult to judge, partly because the cases of environmental violation receive more publicity than positive practices. Although the study illustrates both positive and negative environmental practices of TNCs, it is interesting to note that in the textile industry, it was found that TNCs have helped local firms to achieve ISO 14000 certificates and to adopt environmentally friendly management and process and product technologies. This collaboration however, seems to be limited to the large scale segment of local producers (Jha, 1999).

In the case of Malaysia, changes in production technologies, and improvements in legislation influenced the adoption of better environmental practices in a number of TNCs. In the electronics industry, for example, American, European and to a lesser extent, Japanese TNCs tend to demonstrate better environmental practices than other East Asian firms. Nonetheless, there is also evidence of environmentally inferior machinery transferred because of lower standards in Malaysia (Rasiah, 1999). In turn, Jenkins (1999) shows that foreign ownership does not correlate strongly with environmental practices when controlled for size, technology, market-orientation and industry-type. Size and market-orientation seem to be the most important variables explaining environmental practices in Malaysia. Nevertheless, since TNCs tend to be large and use more recent machinery, they tend to demonstrate better environmental practices.

In the case of Thailand, Japanese companies are seen as "greener" than their local counterparts, and have also induced their local suppliers to adopt their own production and product standards. These suppliers have profited from cleaner technology transfer, within long-term business partnerships, through human resources training and the introduction of green production and management methods. The same may be said, to a lesser extent, of the impact of US TNCs in Thailand (Hillebrand *et al*, 1998).

A recent study on China shows that TNC affiliates have varying environmental performance, depending on the size of the firms, type of ventures, source of investment, type of industry, motivation of investment and business performance. While large TNCs tend to consider their environmental performance as part of their image-building endeavors and standardize their production set up globally, small firms, especially those involved in short-term investment and footloose ones are sometimes reluctant to invest in environmental protection. In turn, export-oriented, efficiency-seeking FDI, in particular by firms that export their products back to home countries, is likely to pay more attention to the environmental implications of both their products and production processes, as the requirements of the importing countries are high. It has also been observed that

7. This, of course, is merely a hypothesis introduced with the sole purpose of illuminating the ambiguities of the available evidence on this issue. The authors themselves offer another explanation of their finding, i.e., the higher level of "public exposition" of the Korean chaebols (Aden *et al*, 1999).

when the ownership control of a joint venture is in the hands of the domestic partners - who are usually more "cost-sensitive" - less environmentally friendly technologies tend to be introduced (Guoming *et al*, 1999). In turn, another study reports that Chinese authorities have asked foreign investors which were interested in undertaking electric power projects in China to eliminate environmental components in order to cut costs (Esty and Gentry, 1997).

In the case of Latin America there are a handful of studies that illustrates certain features of the issue discussed in this paper. Although these studies do not fully support the confidence in the virtues of TNCs as diffusers of clean technologies, they do not on the other hand support the impression given by some of the Latin American case stories from the 1970s⁸. One of the most quoted studies is that of Dasgupta *et al* (1997). This study from Mexico analyzes the effects of environmental regulation, plant-level management policies, and plant/firm characteristics on the environmental performance of Mexican factories. Among other findings, the authors do not observe any significant association between environmental management/ performance and foreign ownership⁹. This observation is partly supported by findings of Dominguez Villalobos (1996), but this author also states that a higher proportion of foreign firms was found among the group of enterprises that were most environmentally advanced than among the least environmentally concerned firms. Another study by Dominguez Villalobos (1998) suggests that many TNCs producing chemical fibers in Mexico have transferred significant experience and technological expertise to their Mexican affiliates.

Some anecdotal evidence illustrates about the transfer of environmentally friendly technologies by TNCs in Mexico. This seems to be the case of the US-based MNC Dupont, which undertakes R&D activities to search for alternatives geared to solving environmental problems in their Mexican affiliate. Moreover, in each Dupont Mexican plant there are different teams working on environmental issues, which are in contact with other similar groups within the global corporation. The parent company has given technical assistance and has transferred significant knowledge to their Mexican affiliates regarding environmental management, as well as occupational health and safety. The adoption of different pollution prevention initiatives has also been common in the Mexican plants of Dupont (Dominguez Villalobos, 1995). Nonetheless, a survey to 44 TNCs in Mexico found that environmental investment were still concentrated in end-of-pipe solutions such as water treatment facilities, and that investment in cleaner or pollution prevention technologies were less common (Husted and Rodríguez Oreggia y Román, 1998).

In the Brazilian aluminum sector, TNCs have successfully introduced environmental practices used abroad. It has been suggested that one of the main motivations for this

8. E.g. the case of the reconstruction of a former US oil refining plant in Cubatao, Brazil, in the 1970's, which, together with other large scale industrial activities, contributed to making Cubatao the region with the highest levels of environmental contamination in Brazil (see Barton, 1997).

behavior is the desire to preserve their international reputation. Even though domestic firms in this industry and industries like the bauxite mining industry have made progress in the use of environmentally sounder technologies and management practices, the more significant progress has been achieved in those firms with foreign equity (UNCTAD, 1995).

In Argentina, a survey of 32 large companies found that environmental management broadly speaking was more advanced in foreign firms than in domestic ones. Moreover, most foreign enterprises with an active environmental management approach apply the global policies defined by their headquarters at subsidiaries, even though, in some cases, the subsidiaries keep some autonomy to react to specific local circumstances. In turn, pollution prevention measures were more diffused among large firms, export oriented and/or controlled by TNCs. The headquarters appeared as a substantial source of technology for foreign enterprises. Besides that key source, TNCs affiliates relied for their technological inputs not only on specialized local enterprises and to some extent on local universities and/or research institutes, but mainly on their own in-house activities (Chudnovsky et al, 1997). A study on the Argentinean petrochemical industry reached similar conclusions, i.e., that foreign firms seemed to operate with more advanced routines of environmental management *vis a vis* their local counterparts (López and Chidiak, 1996).

Nonetheless, both studies found that even among foreign firms, the advances made did not cover the whole spectrum of environmental management. Whereas in several cases accumulated problems had to be solved, in other cases measures involving higher costs and/or investments had to be implemented. Likewise, for a greater and quicker diffusion of an environmental management system based on product life cycle criteria, customer and/or supplier interactions needed to be expanded. In fact, though several firms had attempted to strengthen the linkages with their suppliers to encourage them to provide environmental friendly products, only few firms had made efforts to develop linkages with their customers aimed at minimizing environmental impacts. This is a reflection of a more general phenomenon: the underdevelopment of linkages and of cooperation practices among TNCs and local firms in the Argentinean industrial sector.

In a study of the Chilean pulp and paper industry it was found that parent firms were not important sources of production technology. This is not surprising, since the paper and pulp industry is a "supplier-dominated" sector in the Pavitt's taxonomy (Pavitt, 1984) implying that the equipment suppliers and engineering firms play a key role in the provision of new technologies. Nonetheless, it was found that foreign affiliates relative to domestic firms, were more actively pursuing incremental improvements in their environmental performance (Herbert-Copley, 1999).

9. According to the authors, this finding is consistent with their previous studies on Asian plants (Hettige et al, 1996).

In the Chilean mining sector, it has been found that foreign-owned companies have been early adopters of advanced environmental policies and management systems *vis a vis* state-owned firms. Besides, one foreign-owned smelter that has a successful environmental track has set the environmental standards and methods for other Chilean smelters. In this way, it has been stated that the more experienced foreign mining companies may play a very important role in the transformation of the state-owned mining sector, since they provide a showpiece of how environmental issues should be handled (Lagos and Velasco, 1999). In contrast, a study of the mining industry in Peru did not find any evidence on the use of superior environmental technologies and practices in TNCs *vis a vis* local firms (Núñez-Barriga, 1999).

Eskeland and Harrison (1997) state that TNCs frequently are less polluting than their peers in developing countries. This conclusion is based on the finding that foreign ownership was associated with cleaner and lower levels of energy use in Mexico, Venezuela and Cote d'Ivoire. Based on a series of case studies regarding agricultural and manufacturing activities in different Latin American countries Gentry (1998) suggests that improvement in environmental performance frequently is led by TNCs. Nonetheless, a critic has observed that the conclusions of Gentry are not supported unequivocally by all the case studies included in his compilation (Zarsky, 1999).

IV. A research agenda

The surveyed studies show that under certain circumstances TNCs may be, as presumed, a source of environmentally friendly technologies in developing countries and that in many cases they are more advanced than local firms in regard to the adoption of modern environmental management routines and technologies, including "pollution prevention" actions (though available studies generally have failed to find significant statistical evidence of these associations). In this sense, they depict a different picture from that of 1960s and 1970s, where the impression was that many obsolete and environmentally harmful plants and technologies were transferred to developing countries.

To take more advantage of the potential of TNCs for diffusing environmentally friendly technologies and practices in host countries, it is very important to have far more empirical evidence on the several factors influencing affiliates behavior and on the areas in which developing countries should concentrate their policy efforts to ensure a wider diffusion of these key technologies among suppliers, customers, research and training institutions, etc.

A point which should deserve special attention from researchers, as well as from policy-makers, is that of pollution prevention or eco-efficient technologies, since these may play a key role in improving the environmental performance of the production sector in developing countries without lowering its competitiveness. Examining the role

played by TNC's affiliates in this respect is therefore crucial, including not only the use of those technologies and practices in their affiliates, but also the extent to which they can help local firms to accomplish the organizational changes required if they are to move towards pollution prevention technologies.

On this basis, a policy driven research agenda on these issues could include:

- Taking into account different TNC strategies (i.e., market, resource, efficiency or asset-seeking) and sectors of operation of the affiliates, it is important to shed light on the more influential factors - i.e. mode of entry (greenfield or takeover), age of the investment, country of origin, market orientation, technological and environmental strategies of the parent companies, practices and management routines in the affiliates and/or in local partners, etc.- that make TNCs more prone to serve as a vehicle for the transfer of environmentally friendly technologies and more specifically to the passage from end-of-pipe towards pollution prevention or eco-efficient environmental management systems.
- Which host country characteristics (such as the availability of skilled human resources, technological infrastructure, competitive local suppliers, environmental regulations and their enforcement) have more influence on the actual transfer of environmentally friendly technologies via FDI (or eventually through other means such as licensing, imports of capital goods, consultants, etc.) and especially towards the diffusion of eco-efficient practices?
- How do absorption capabilities in host countries influence the extent to which cleaner technologies and practices employed by TNCs are diffused to their local suppliers, customers and competitors and which are the key capabilities that should be strengthened in that connection?
- Even if TNCs may improve their environmental performance - and that of their suppliers, customers, etc. - through cleaner technologies, it is important to learn, what they have been doing with the environmental legacy of their past operations in host countries. The use of the so-called "remediation" technologies should, thus, also be assessed.

These issues should be assessed on a case-study basis at national level in those developing countries in which the available evidence suggests that TNCs have already started to play a role in diffusing the technologies under study and/ or where there are policy initiatives to foster these developments. These national case studies should be undertaken in several countries with a common methodology to avoid the different approaches employed so far in previous studies that make comparisons very difficult indeed. A multi country program of studies should make possible to make useful comparisons and eventually provide evidence of best practices to be followed by companies and countries to diffuse environmentally friendly technologies. The proposed studies should also be of great help for policy-makers to be able to design and

implement better environmental and technological policies, aimed at enhancing the prospects of developing countries to engage in the path of sustainable development.

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