Journal of Global Environment Engineering, Vol. 6, pp. 1-12, 2000

LINKING TECHNOLOGY TRANSFER WITH CLEAN DEVELOPMENT MECHANISM (CDM): A DEVELOPING COUNTRY PERSPECTIVE

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Abstract

Framework Convention on Climate Change (FCCC) expressly commits the Annex 1 countries to provide financial resources and technology to developing countries so as to control, reduce or prevent GHG emissions. The present paper argues that the ultimate goal of any action in the field of transfer of technology (TT) should not be just applying particular technological solutions to the GHG problem, but to enhance the capabilities of developing countries to assess the need, select, import, assimilate, adapt and develop the appropriate technologies. The paper also looks into the various dimensions of TT that results in capacity building in developing countries. High up-front costs and lack of awareness (information) has resulted in significant under-utilization of capacities, thus acting as major barriers in their diffusion. The paper also looks into the various market and government related barriers forestalling the diffusion of various GHG reducing technologies.

1. Introduction

Clean Development Mechanism (CDM) introduced in Kyoto protocol can provide opportunities for international co-operation in such a way that developing countries benefit in terms of technology and opportunities to go for sustainable pathways and the Annex 1 countries get cheaper ways to reduce Green house gas (GHG) emissions. It is time to focus on the article concerning technology transfer (TT) agreed in FCCC. Unfortunately, this article important to developing countries is not discussed adequately.

The reasons for linking CDM with TT are obvious. One of the major purposes of CDM is to initiate the process of emission saving and awareness about the climate change problem in developing countries also. The project by project approach of CDM may not lead anywhere compared to the large increase in emissions anticipated in the developing countries (DC). Thus, the fossil fuel-efficient policies and processes should be institutionalised through TT. To ensure this, each CDM project should have training and capacity building component in order to get the credit for emission reductions (CER). CER should be given if efforts are put in such that the DC can operate and even replicate the technology. In the absence of this, incentives to bring in successively new technologies will not be there. In fact, "semi-efficient" - and not the very best, technologies might be repeatedly

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installed even in the same country but at different places. If the CDM allows to profit from technology diffusion, there will be temptation to profit as much as possible from the same technology. Technology innovation needs to be ensured in by considering how much CER can be given for the same technology or up to what period, so that at the end of that period even better technologies may be introduced. One way to ensure is by suitably changing technology baselines upwards gradually. Other concerns regarding CDM could be that there will be greater demand for fossil-fuel saving technologies. This may increase the price of efficient technologies. Thus, "Green" technologies may be more expensive as they will be more in demand over "brown" technologies. To ensure their wide adoption - rather than making them expensive - there should be incentives such that they are more in demand. If barriers are created around the project, and people are allowed to earn premium, rent seeking behaviour may occur.

Let us examine the issues relating to TT and what kind of TT is needed.

So far, to a large extent, discussions on the transfer of environmentally sound technologies (ESTs) has mirrored earlier debates centering on legal, institutional and financial arrangements governing developing countries access to the technologies developed in the industrialized world.[2] As a result, a whole range of questions have been downplayed or ignored such as:

- the type of needs of a developing country
- the requirements of appropriate or better technologies to meet those needs
- the available expertise i.e., the capacity building needed to ensure effective transfer and
- the factors affecting adoption, assimilation and adaptation of imported technology.

A key constraint facing developing countries is the difficulty of matching their needs with appropriate technological solutions that reduce GHG emissions. These constraints are all the more binding in new and emerging fields, where trends in technology development are uncertain, corporate secrecy prevails, and sources of supply may span several industrial branches.

In their early critiques of technology transfer (TT), the developing countries focused mainly on reducing what they considered the excessive costs of technology transactions and the many restrictive clauses imposed on recipients by the suppliers. Increasingly, focus of attention has shifted from the costs and characteristics of imported technologies to include the factors affecting the creation and maintenance of technological capabilities in the developing countries.

In most cases, current practices of TT does not allow the recipient enterprises to accumulate such technological capabilities. For example, in a study of transfer of petrochemical technology to Middle East, the US office of Technology Assessment concluded that although the volume of technology transactions had increased, 'technology transfers (whereby recipient gains improved a capability to operate an industrial facility) have been limited' (UNCSTD, 1991). Hill (1988) stated that 'TT in Indonesia rarely moved beyond production'. In some cases, however, results are far more encouraging e.g., USIMINAS steel plant in Brazil, which not only assimilated and adapted imported technology

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2 Northern countries have generally stressed - the need to ensure adequate financial compensation to inventors (i.e., recognition of IPRs), technology to be provided on non-concessional (commercial) terms, to limit the range of technologies under consideration in particular by separating the climate change convention from other issues and a preference for working through existing institutions to channel funds to support technology transfer (TT) activities, particularly GEF.

successfully, but also used the knowledge to generate and commercialize new technologies.

1.1 Factors Influencing Technological Capabilities

Two factors are crucial in determining the extent to which TT contributes to building indigenous technological capabilities.

- first is the intensity of contact between the supplier and the recipient. Active and ongoing contact between recipient and supplier is crucial to the effective transfer of skills and knowledge. This does not mean that direct equity involvement of suppliers is essential. Far more important than the contractual form of a transfer is the extent of knowledge acquisition and training. Unfortunately, recipient firms and countries too often undermine or ignore training. For example, in an analysis of over 600 petroleum exploration contracts, Turner (1982) found that only 14% made any provisions for training, employment of nationals, and local technical services and concluded that the contracts displayed little concern for acquisition of critical skills.
- The second factor in strengthening local capabilities is the strategic orientation of the recipient enterprise. In a study on India, Nath (1987) concludes that 'the subsequent update or activities undertaken by the host country enterprise' is critical to successful transfers. These efforts require sound knowledge before transfer, a rigorous search for sources and intensive participation at all stages of project planning an implementation. Enos and Park (1987) confirm that local efforts have been the most significant factor in Korean success in TT.

Thus, the ultimate goal of any action in the field of transfer of EST should not be just applying particular technological solutions, but to enhance the capabilities of developing countries to *assess the need, select, import, assimilate, adapt* and *develop* the appropriate technologies. This is a matter of enhancing 'generic' technological capabilities rather than pursuing actions related to specific environmental technologies. In fact provision for capacity building in the long run should be made mandatory in any TT with crosschecks built-in for verification.

Several examples indicate that developing countries could not assess their needs and the donor preferences and disciplinary biases resulted in failure of widespread diffusion of ESTs or appropriate technologies (Wereko-Brobby, 1987;[3] Erickson and Chapman, 1995). After the first 'oil shock' in 1970s' govts. in many developing countries, international funding agencies and researchers operated on the assumption that any activity that increases or diversifies, energy supply options would be good for the country in the long run. Therefore, research was directed to developing and diffusing particular renewable energy technologies. In one of the instance, solar dryers were aggressively promoted in Africa. This bias for technology-push was made worse by the fact that R&D was conducted solely by the technologists with little or no input from social scientists. The process did produce several technologically superior dryers; however, success in applying the improved designs was limited. The root cause was the failure to adequately identify beneficiaries and assess their needs.

Sound technology choice is the backbone of any strategy for international TT. Unless developing

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3 As referred in Rath and Herbert-Copley (1993).

countries (DC) have the proper knowledge to make informed choices among technological options, there is a risk that the efforts to promote international TT may become overwhelmingly supplier driven, and geared more to transferring technologies that are available rather than technologies that are required by DC. Several disadvantages are faced by DC in terms of information available to them as well as its technical capacity to evaluate particular technologies.

With this backdrop, we try to answer the following questions in the present paper.

- What are the GHG reducing technologies which may be useful to the developing countries?
- What are the various steps involved in effective TT. How can they result in capacity building in developing countries?
- Using case studies of two GHG reducing technologies i.e., the compact fluorescent lamps (CFL) and photo-voltaic (PV) cell, has TT to Indian firms generated technological capabilities? What were the key issues in these case studies?
- If TT has generated significant capabilities, what are the barriers/factors militating against their widespread diffusion?

2. GHG Emission Reducing Technologies/Techniques

It is useful to take an overview of technologies needed for GHG reduction. A comprehensive overview can be found in chapter 2 of the Working Group I report (WG I, 1990). As per the report, CO_2 has the largest contribution to the greenhouse effect followed by Methane (CH_4) and Chlorofluorocarbons (CFCs). In percentage terms the contribution of various GHGs in the past decade was CO_2 - 56 percent, CH_4 - 17 percent, CFCs - 12 percent and Nitrous Oxide (N_2O) - 4 percent (IPCC, 1992). The present section deals with the techniques available for mitigation of GHGs.

2.1 Mitigation Options for CO_2

- **Fuel Switching to less carbon intensive fuels.** Fossil fuels are predominantly used for power production. Coal is the highest carbon emitting fuel, followed by oil and natural gas. Switching from one fuel to another would require replacing or retrofitting equipment and a change in modes of transportation.
- **Renewable energy technologies (RETs).** RETs include hydo-power, wind, solar thermal and solar photovoltaic (PV), ocean, biomass, geothermal etc. Some of these RETs like ocean, geo-thermal etc. are in the development phase but others have shown significant long- term viability.
- **Use of non-CO_2 emitting technologies for power production (nuclear energy).** Power production from nuclear energy is less carbon emitting but waste disposal and safety are two major concerns in using nuclear energy.
- **Efficiency improvements in energy consumption and use.** Demand side measures (DSM) like energy-efficient motors (EEMs), variable speed drivers (VSDs), compact fluorescent lamps (CFLs) etc. are some of the options that can be aimed to free the energy for other uses and hence reducing CO_2.

- **High efficient technologies in Power system.** Such as Steam Injected Gas Turbines (STG), non-thermal cycles like Kalina Cycles, pressurized fluidized bed boilers, gas turbines using gasified coal etc.
- **Sink projects for CO_2.** Plant sequester carbon when they grow. Afforestation, reforestation or even halting deforestation can help in the removal of CO_2 from the atmosphere.
- **Replacing energy with labour and Capital.** Replacing energy with labour and capital in the production process and increasing efficiency more generally can mitigate CO_2.
- **Improved technologies in energy-intensive sectors.** Cement, steel, pulp and paper, ceramic etc. are some of the industries which are highly energy intensive. Using techniques like dry process in cement, shuttle kiln or roller hearth kilns instead of down-draft kiln in ceramics, using continuous pulp digestor instead of batch digestor etc. can substantially help in reducing energy consumption and CO_2 emissions.

2.2 Mitigation Option for CH_4

Some of the sources of CH_4 emission are wetlands, rice agriculture etc. The emission of CH_4 can be reduced using following options/techniques.

- Using natural gas as a substitute for coal or oil would reduce methane emissions from gas flaring.
- Reducing gas pipeline leakage and leakage from coal mines.
- Improving ruminant digestion of the livestock to reduce methane etc.
- Paddies – shifting to dry paddy cultivation from wet paddy cultivation.
- Harvesting methane from sewage or landfills

2.3 Mitigation Option for CFCs

Chlorofluorocarbons (CFCs) or ODS (ozone depleting substances) are used as aerosol propellants, coolants in refrigerators and air-conditioners, foam blowing agents and gaseous cleansers for medical and computer equipment. CFCs can be mitigated by

- **Eco-refrigeration.** Refrigerator using synthetic chemicals as refrigerant such as hydrofluorocarbons (HFCs).
- **Switching.** Switching to organic compounds and water for cleaning and foam blowing instead of CFCs.
- **Conservation and Recycling.** A Dupont estimate suggests that by the year 2000, about 29 percent of the CFC market would be served by conservation and recycling (Goodstein, 1995).

Technology availability is not an issue as several developed countries have clean and efficient technologies in each field. For example, Germany, Switzerland etc. have already developed 'green or eco-refrigerators' and have phased out ODS ahead of the schedule. Similarly, most of the RETs have shown their long-term viability in US. California state in US produces nearly 80% of the world's wind power besides producing the virtually all of the world's thermal power. The question is the transfer of these technologies to the developing countries in a real sense that the transfer facilitates building up of significant capabilities in developing countries. The next section looks into the various steps involved in effective TT and how they interact resulting in capacity building.

3. Steps to Technology Transfer[4]

The various steps involved in the process of technological change and upgrading are – need assessment, technology selection, technology transfer, utilising technology to its designed performance, adapting technology to specific conditions, improving technology beyond its designed performance and developing new technologies. Figure 1, gives a schematic diagram of these steps.

3.1 Assessment of Technology Needs

This is the first but the most important step in the process of technology transfer. The need for a particular GHG reducing technology depends on the resource endowment of the country. A tropical country like India where sun-shine is in plenty would certainly benefit from solar thermal or solar photovoltaic (PV) RETs.

As mentioned earlier, there are a number of examples indicating that developing countries could not assess their needs. The application of GHG reducing technology was a result of 'donor preference' rather than a 'demand' from the developing country. Agarwal et al. (1983) described this kind of renewable energy technology transfer as a 'supply push rather than a demand pull', that very often leaves the technology recipient country without the technical or financial ability to apply and sustain the technology. They concluded:

"...most of these (renewable energy) systems were installed not because there was a local consumer demand for them but because a Northern entrepreneur was able to find a Northern aid agency to support their establishment as 'demonstration' projects."[5]

3.2 Selection of Technologies

The second step in the TT is the selection of technologies. In general, economic actors choose technology on the basis of highly imperfect information despite the fact that there exists overwhelming degree of choice. One of the problems is that there are high overhead costs in generating the sorts of information that are required to inform these processes of selection. This may either involve the acquisition of expensive source of data or the expenditure of considerable time or high transaction costs. The buyer is hindered by a greater or lesser degree of uncertainty in purchasing the technology. There is a classical 'information paradox' - when a firm purchases a given technology, it actually purchases the knowledge embodied in it, thus the firm is virtually ignorant of what it is buying. Another factor accounting for imperfect information is the fact that persons involved in a number of activities do not generally know where suitable information is to be found. As a consequence most entrepreneurs fall back on a range of imperfect mechanisms to identify the most

4 This section is based on Kaplinsky (1990).

5 As quoted in Erickson and Chapman (1995).

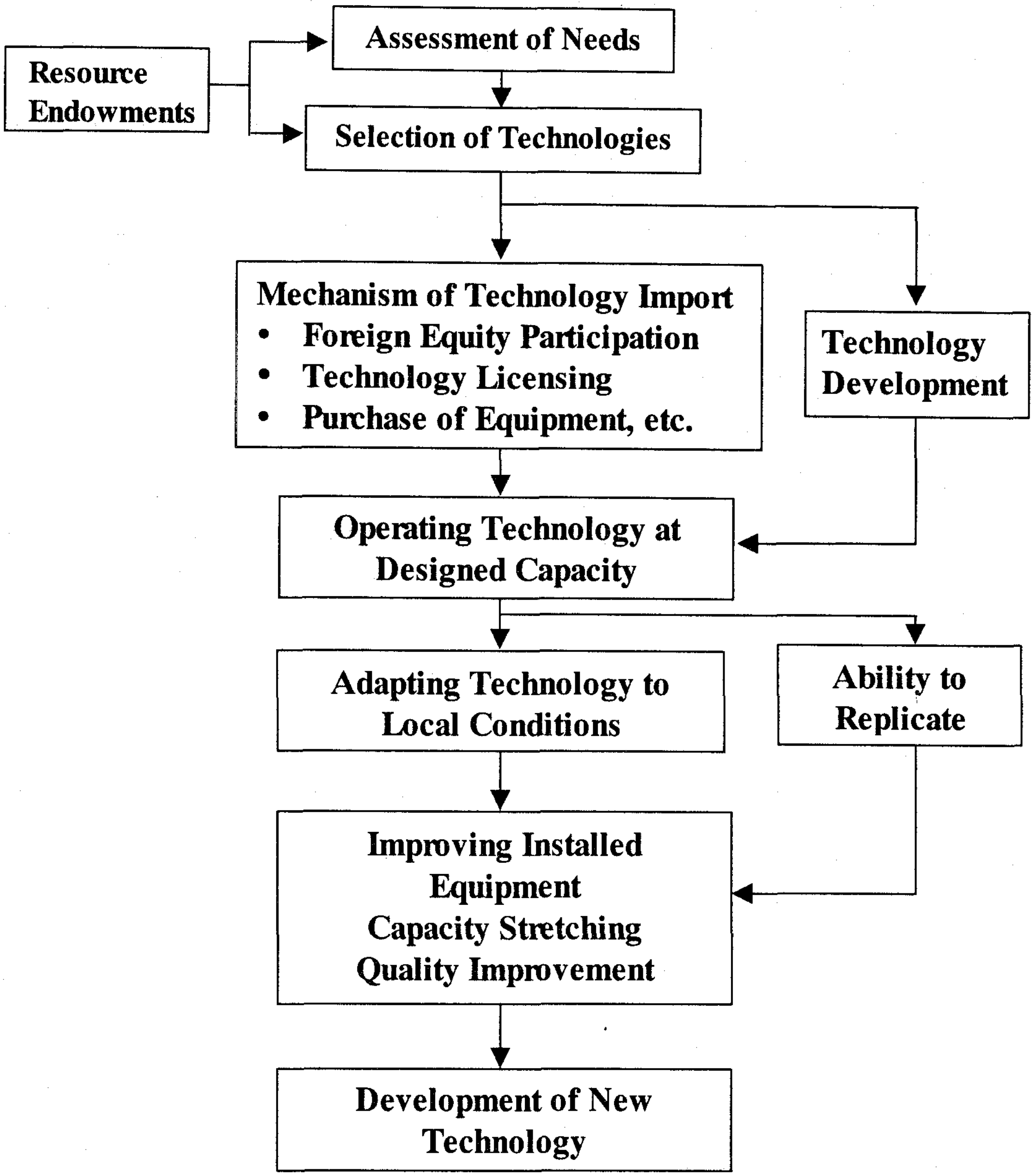

Figure 1. Steps to Various Levels of Technology Transfer

suitable sources of supply i.e., relying on well-known brand names, occasional advertisements, firms with whom they have dealt in the past, or firms from the country they have studied or where they have relatives. It is obvious that none of these criteria for choice are likely to lead a reliable determination of technological choice. It is the experience of many firms in both developed and developing countries that the costs of such ignorance would be very large.

3.3 Mechanisms for Technology Import

The five main mechanisms of TT in order of increasing control of the 'buyer' – in this case a developing country – are:

- foreign equity participation in the subsidiary which utilizes the technology - indeed technology itself may be the primary factor explaining the ownership by foreign firm.
- license agreement - this may be for process know-how, for product know-how, for managerial expertise, for technical services, for the utilization of a brand name or for the provision of basic inputs. Terms and conditions of license contracts can vary with their duration as well as in relation to a series of clauses imposed by technology suppliers restricting markets, prices, marketing, sourcing of inputs etc. to the recipient firm.
- acquisition of technological knowledge through the flow of human resources i.e., sending people abroad for training or foreign experts visiting the economy.
- purchase of know-how in the form of detailed specifications or blue-prints
- outright purchase of equipment or know-how[6]

The systematic attention to these mechanisms enables domestic entrepreneurs to reduce the cost of technology. Moreover, the mechanism utilized determines the extent to which technology is absorbed. Since foreign exchange (forex) is often a scarce commodity and is controlled by government policy, this acts as an important window through which govt. can legitimise their intervention in influencing firms in the mechanism which they utilize for acquiring technology. Such strategies have been effectively used in Japan and Korea in 60s and 70s. Both countries systematically tried to ensure that wherever possible, the mechanism utilized should veer towards the third, fourth and fifth options in increasing preference i.e., through the flow of human beings, the outright purchase of information or the purchase of equipment.[7] Even today most Japanese corporations are effectively organised when they send teams of their personnel abroad. Each member is commissioned with the task of absorbing a particular element of technology on a visit to competitor's plant and then subsequently the various pieces are put together to enable them to take maximum advantage of this exposure to the technology of other firms (Kaplinsky, 1990).

3.4 Operating Technology at its Designed Capacity

The relevance of this dimension becomes apparent from the fact that in developing countries where firms do not tackle the issue consciously, capacity-utilization rates, product quality and general technological efficiency are fairly low. There are a number of factors that determine the efficiency of utilisation. Some of these are macroeconomic in nature, such as resource availability in the country. The limited forex with the developing country, which do not permit adequate maintenance of machinery is one such example. Others may be industry specific e.g., mass-production industries may

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6 In case of developing countries, this mechanism has been the dominant form of technology transfer.

7 For instance, in early stages of development of Japan in 19th century, the greatest emphasis was placed on employing foreigners. For most of the period stricter controls were placed upon foreign direct investment (FDI) and the cases where technology could be obtained through foreign equity, this was restricted to a minority share.

be more difficult to operate effectively than those producing in smaller batches, or that continuous process industries create less problems than those involving discrete products. Third determination is firm specific. It has been shown in many countries that the firms which 'play around' with a new piece of equipment before they utilise it for commercial production often achieve significantly higher performance in the medium - to long term than those firms who try to achieve maximum performance as soon a possible. Similarly, when more complex sets of equipment or procedures are introduced, those firms, which devote specific skilled personnel to the task (rather than dividing responsibility between skilled workers) generally fare better.

Quazi (1982)[8] in his study of the fertilizer industry in Bangladesh finds that the productivity in two urea fertilizer plants remained below initial design levels - in direct contrast to the situation noted for similar plants in industrialized countries. Only very slow rates of improvements in energy efficiency were noted with no significant plant adaptations over the eight-year period of study. This performance reflects the availability of skilled man-power to the plant managers - while efficiency (including energy efficiency) rose as a result of the application of imported expertise, levels of efficiency began to fall once outside engineers and managers were withdrawn (Quazi, 1982).

3.5 Adapting Technology to Local Conditions

Once installed, it is often necessary to adapt imported equipment or procedures to local conditions. The adaptation is necessary because of physical or climatic factors (this is especially in agriculture), it may also arise when plant and equipment is sensitive to temperatures (e.g., thermal power plants as installed in tropical countries). Adaptation may also be necessary for locally produced inputs (e. g., leather in shoe-production, or wood in furniture-production) or if the inputs are sourced from different suppliers than those who serve the manufacturers of the equipment. Even managerial procedures may require adjustment. For example, quality-circles (QC) as originated from Japan is very much different from that prevailing in many developing countries.

Adaptation in some cases may require relatively sophisticated inputs of skills or information, drawing on the experience of other local firms. It has been found in various empirical studies both in Latin America and in Africa that the primary source of technological change within firms has arisen not from formal R&D activities but from an accretion of these relatively minor trouble-shooting efforts to adapt equipment and procedures to local conditions (Katz eds. 1987, Kaplinsky, 1978).

3.6 Improving Installed Equipment

This dimension is close to the attempt to run/operate the imported equipment to its designed efficiency and especially to adapt it to local conditions. This is often called as 'capacity stretching' technical change. 'Quality improvements' and 'material/energy saving' improvements are other important elements of change. In many Latin American countries this has been the dominant form of technological improvement and has followed directly from the shortage of foreign exchange which has limited the ability of these countries to import new, more advanced equipment and procedures.

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8 As referred in Rath and Herbert-Copley (1993).

3.7 Development of Technology

Any technology policy must have as one of its prime objectives the task of moving to the development of technology, even if this is in restrictive areas of activity. This is the area in which domestic value added is the highest.[9]

It is generally argued that the small developing economies have no prospect of ever moving to the edge of world technology. This may be true at the aggregate level but there are always narrow niches of specialization in which developing countries can compete with the best, especially in technologies which for climatic or other reasons are especially appropriate for developing countries.[10] It is also important to avoid what is often called 'blue-sky' research - that is, the exploration of basic research targets which have potential application only at some distant points in the future. The experiences of past few decades show that Japanese were sophisticated at avoiding these pitfalls and only moved to technological development when they had first learned from 'undoing', exploring and then improving other countries' technologies. Thus, related to Japanese experience, the ability to develop technology in an efficient manner usually follows on from first having mastered the ability to select, transfer, install, adapt and improve other people's technology. Any successful firm or country will be simultaneously involved in many of these six different technological activities. The difference between the leaders and the followers lies largely in the mix between them.

4. Concluding Remarks:

TT and CDM should linked to ensure wider adaption of the technologies beyond the CDM project. That is the "CDM project" should have a programmatic context of a long term nature.

a. **Operating and maintenance:** Unless the CDM provides training to operate by industrial countries (IC), it is not likely that it will be operated on long term basis. Very often one sees junkyard of equipment and technologies because the developing countries (DC) do not know how to operate this especially in small countries with limited personnel or in low income countries.
b. **Replication:** For example, if energy efficient refrigerators are manufactured within developing countries that would have large and sustained impact. Credit for TT for replication can be higher. Without this technology transfer to manufacture refrigerators in the DC exporting a few refrigerators will have very little impacts.
c. **Innovation and Development:** This may get more credit, if TT is adapted to DC conditions and people are trained to innovate and to develop new versions.

9 If we ignore countries which are rich in high-value raw materials (e.g., oil-rich countries), it is no coincidence that the countries with the highest per capita incomes are those with the greatest relative strength in developing technology.

10 The success and competitiveness of Taiwanese machine tool industry in conventional machine tools testifies this.

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