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Experts Meeting on Technology
Transfer Trends
Vienna, 11-14 October 1993

REPORT*

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I. INTRODUCTION

1. The Experts Meeting on Technology Transfer Trends was held at the UNIDO Headquarters in Vienna, Austria on 11 - 14 October 1993.

2. The experts meeting was organized as a forum for analyzing the features and current worldwide trends on technology transfer and development and their implications on the access to and flows of technology to developing countries. The thrust of the meeting was to generate awareness on these developments, to identify the policy issues arising for governments from such changes, to stimulate discussions and analysis of how developing countries could identify and take advantage of opportunities arising from these developments while at the same time minimizing their negative effects, and to identify new opportunities for international cooperation in the form of new types of partnerships; redefinition of networking elements and mechanisms; and action to improve, strengthen and add new dimension and perspective particularly to the UNIDO programme on technology acquisition and negotiation.

3. Participating in the Meeting were high-level officials representing technology transfer and promotion agencies; research and development institutions and industrial associations from selected developing countries; experts representing international research and academic institutions; and representatives of other international organizations concerned with technology transfer issues. The list of participants appear as *Annex A*.

II. ORGANIZATION OF THE MEETING

Opening of the Meeting

4. The Meeting was opened by the Deputy Director-General of UNIDO. In his opening remarks, The Deputy Director-General stated that the meeting is taking place in the context of an environment characterized by new driving forces and policy changes in the global economy which are affecting the roles of governments, enterprises and institutions as well as the patterns of production, trade and technology flows. The global scenario for international technology transfer for one has become even more complex. The increasing "privatization" of knowledge; the growing technological protectionism among industrialized countries; the emergence of new technologies; the rise of new forms of collaboration primarily among firms in the high-technology field in developed countries represent threats of diminishing access to technologies and increased costs for developing countries. Against this scenario, the role of international cooperation cannot be overemphasized. He expressed the view that the meeting could produce recommendations which could significantly impact on the ongoing reorientation and the prioritization of services of UNIDO. Needless to say, this process is necessarily based on a proper interpretation of the changing needs and requirements of developing countries as they are influenced by changes in the global environment.

Presiding Officer

5. Dr. Junaid Zaidi, Director-General of the National Center for Technology Transfer of Pakistan presided over the Meeting with the assistance of Mr. Jose Adeodato de Souza Neto of Brazil as Rapporteur.

Business Arrangements

6. As one of the main objectives of the meeting was to present and elaborate on the current trends and developments in the international technology transfer, leading experts and international researchers were invited to present findings on current researches on relevant topics, as follows: Prof. J. Hagedoorn of the University of Limburg on the results of research he has undertaken on the globalization of technology and strategic technology alliances for the FAST (Forecasting and Assessment on Science and Technology) programme of the Commission of European Communities (EC); Dr. Slavo Radosevic of the Science Policy Research Unit (SPRU) of Sussex University and the Institute for New Technologies (INTECH) on the preliminary findings including provisional hypotheses of his ongoing study on technology transfer policy, its evolution from the '70s and the issues that determine technology transfer policy for the '90s; Dr. Nagesh Kumar of INTECH on the initial results of a study on the subject of foreign direct investment (FDI) and technology licensing as determinants of technology flows; Dr. Carlos Correa, UNIDO Consultant, on his paper on "Prospects and New Dimensions of International Technology Transfer" ; Dr. Georges Thill of the EC on the FAST Programme specifically Theme C on Science and Technology; and Dr. Manfred Fuchs of the Stamberg Institut of Germany on the preliminary results of a research on environmentally sound technologies, issues of access, barriers and opportunities for developing countries being prepared for UNIDO. In addition, the delegate from the Republic of Korea(ROK) presented a paper prepared for UNIDO reviewing the evolution of technology transfer policy and its effects on technology flows and technological capacity-building in the ROK. The other delegates likewise made brief presentations about their respective country experiences and agency concerns. as appropriate.

III. SUMMARY OF PRESENTATIONS

A. Globalization of Technology

7. Prof. J.Hagedoorn gave a broad perspective of the general distribution of technological capabilities on a worldwide scale which has been determined to be very much skewed against developing countries. The main findings of his research are as follows:

i) Data on distribution of worldwide R & D covering the second half of the eighties show that global R & D is highly concentrated in the OECD countries, in particular, the Triad of USA, Japan and the EC, representing 74%. The share of developing countries is extremely small at 6%, a major part of which is captured by the Newly Industrializing Countries (NICs). A comparison of R & D efforts of countries as a percentage of GNP for the same period shows that R & D expenditures of major OECD countries generally measure over 2% of GNP while those of developing countries range from 0.5 to 1% of GNP. Furthermore, worldwide R & D is generally accounted for by the private sector which tend to keep their R & D activities in their home base or, otherwise to countries where a certain level of technological capability already exists. Over 90% of R & D of MNCs are concentrated in the OECD countries.

ii) Over the past ten years, the main trends in global R & D have been: a rapidly rising R & D in Japan, in Germany and a few other EC countries; slower growth in USA, UK and other OECD countries; sharp decline in Soviet and East European R & D; decline in much of Third World R & D; rapid rise in R & D in the "Four Asian Tigers" of South Korea, Singapore, Hongkong and Taiwan. The same pattern as above is observed in the world distribution of patents. The comoined share of Third World countries in global patents is estimated to be between 1 to 3 per cent, with the

exception of the "4 Tigers" whose patenting activity also began to rise very rapidly in the late '80s indicating increasing technological sophistication.

iii) A similar study on strategic technology alliances (STAs), e.g., joint ventures, joint R & D, minority investments, during the '80s show a correlation between strategic technology alliances and trends and distribution of R & D and patenting; thus further strengthening the R & D potential of companies which are already benefitting from the latter concentration. Over 95% of STAs studied are made between companies from the developed countries, 2.3% were made between a Triad-company and a firm from an NIC and an extremely small share of 1.5% cover STAs between Triad and LDC companies.

iv) Figures on the international distribution of STAs by sector blocks off developing countries from a large part of important technological developments. For instance, biotechnology, new materials, computer, software development, telecommunications and medical technology instrumentation are closed shops where 99% of the agreements are between companies from developed countries. Only in automotive, chemicals and food and beverages is there a relatively "reasonable" share for STAs between Triad and developing country companies. It is observed that NIC and LDC participation in these sectors coincided with a low or medium technology character of these sectors. Then again, a predominance of STAs within the developed economies is found in those fields that can be characterized as high technology sectors.

v) Core technologies (information technology, biotechnology and new materials, which consist the heart of many future technological developments affecting manufacturing, services and everyday social life) play a very important role in both STA and inter-firm technology transfer within the developed economies. Data available show that nearly three-quarter of STAs within the developed economies are made in the three core technologies and 60% for technology transfer agreements. For Triad-NICs, it is 53.6% and 52.4% respectively and for Triad-LDCs, it is 23.4% and 38.5%.

vi) The distribution of different modes of STAs by region show that over 43% of STAs for developed countries consist of joint R & D pacts and 10% only for STAs between Triad-NIC and Triad-LDC. This again represents a skewed distribution in STAs where R & D cooperation is concentrated within the developed countries. One can also expect that technology transfer in terms of joint R & D is not a major vehicle in alliances with NICs and LDCs. In the case of technology transfer agreements where licensing is an important part, the picture is not that different.

vii) One notes that in these relationships, while there exists an extreme dominance of agreements made within developed economies, there is a growing share between Triad and NIC companies. This leads to the conclusion that what companies are looking at are regions of economic and technological development that has some competitive advantage, in other words, those countries which have developed their indigenous technological base, have set up a reliable technological infrastructure and have laid the foundation in terms of human capacity (engineers, scientists, etc.) on which companies could further develop. On the whole, the data available shows very little improvement over the years in terms of sharing of technological growth between the Triad and Third World countries.

B. Policy Implications of Changes in International Technology Transfer

8. Dr. S. Radosevic in his presentation highlighted the changes in the macroeconomic and technology context in the 80s that have given rise to new and important policy issues for technology transfer in the 90s. In the macroeconomic context, these consist of: the changing nature of export

markets where markets are more segmented; user requirements play a much more important role and transaction costs in serving different markets are higher; the shift of focus from structural change in economies and diversification to new industries to competitiveness and efficiency; the inequality of access to investment, technologies and markets as a result of regional trading blocs; and the increasing importance of internalization due to adaptation to local market needs. On the other hand, certain changes in the character of technical change with particular reference to new technologies, have their implications on the process of technological learning and mastery. These consist of: the systemic character of new technologies making technology transfer more systemic-dependent; the knowledge base for new technologies whether it is predominantly based on tacit or formalized knowledge; the increasing importance of intangible investments (investments in information, training, organization) over physical investments (machinery and equipment); non-standardized character and high user specificity which reduces the ease of transfer in the form of "ready made" capital goods and blueprints and requires more localized technical change for efficient introduction; and the fact that knowledge of user needs has become as equally important as knowledge of production.

9. These changes in the macroeconomic and technology context have given rise to important policy issues for the 90s quite different from the policy issues of the 70s, among which are:

i) There is now the need for careful management of the complementarities and substitutability of importation vs. domestic generation of technology. While securing complementarity is an acknowledged principle, substitutability need not be totally disregarded particularly when proven foreign technologies are easily available through licensing or foreign direct investment (FDI). A more overriding consideration would be to link the acquisition of foreign technology to more intensive and strategic investments for adaptation and innovation.

ii) The relation between investments in actual transfer and investments in the implementation and use of technology where now the latter becomes more complex particularly with the impact of information technology requires that investments are made on building up absorptive capacities of enterprises and in restructuring organizations. Direct support for training, learning or R & D should be undertaken in association with acquisition of foreign technology.

iii) The need for emphasis on the role of business enterprises in generating technological dynamism in industry but not necessarily disregarding the role of infrastructure institutions which can support the specific needs particularly of latecomer firms which typically suffer from a lack of related support industries and a poorly developed technological infrastructure.

iv) Simultaneous access to technology and international markets is crucial for dynamic long term development. A variety of foreign channels of technology and marketing, channels that could serve the dual purpose of product marketing and technology acquisition such as foreign buyers and original equipment manufacturing (OEM) arrangements should be explored.

v) "Unpackaging" may not be that relevant under present conditions as the integrated nature of technological capability and production suggests dealing with a single supplier than sourcing from a variety of suppliers.

vi) Policies which differentiate or discriminate between specific channels of technology transfer (FDI, joint ventures and licensing) may not be justified. FDI led industrial growth will not by itself improve access to foreign technology. In actual practice, the choice of channels depends on the nature of technology, that is, whether mature or complex, and on its accessibility, whether proprietary or free. A more important issue is how to maximize the technological benefits from

the foreign technology which is in fact more dependent on how the method of transfer was effected rather than on which method was used.

10. In the context of the above policy issues, some tentative elements for deriving a new technology transfer policy framework for the '90s could consist of: technology transfer viewed more as a process of investment where the elements of transfer are inseparable from the elements of acquisition and assimilation; the crucial role of simultaneous access to technology and markets as necessary ingredients to achieving international competitiveness and long-term economic growth; local content requirements for foreign owned local companies as a possible approach to strengthening linkages between foreign owned enterprises and local suppliers and thereby maximizing benefits from FDI; informal or relational contracts, in addition to various channels such as R & D cooperative projects, distribution and marketing networks, additional training programs and marketing networks to be given attention as additional frameworks for maximizing the benefits of technology transfer; and implicit policies being more important than explicit technology transfer policies.

C. Foreign Direct Investments (FDI) and Technology Licensing

11. Dr. Nagesh Kumar of INTECH presented the highlights of his research as follows:

i) From the early post-war period to the mid-60s, FDI was the main mode of foreign production. From mid-60s to the mid 80s, the importance of licensing as an alternative to FDI increased. This was a result of several factors among which are: the maturity of a wide range of technologies; the widening of the market for technology; and host government restrictions on FDIs. From the mid-80s, FDI as a determinant of technology flows again showed increasing dominance as compared with technology licensing. In general, this is attributable to: liberalization of government policies towards FDI worldwide; the emergence of new technologies which are not yet widely available; the emergence of technology as a main tool for maintaining competitive edge between firms. The increasing technological protectionism resulted to decreasing trends in technology licensing and increase in more packaged forms of technology access which includes FDI, technology with equity, etc. Data shows that the volume of FDI flows increased dramatically from the late '80s up to the 90s and this has been specifically attributable to the globalization of production by MNCs; the accumulation of investible surpluses in Japan; the expansion of investment opportunities because of liberalization of foreign investment regimes and privatization programmes; debt-equity swaps in debt-ridden countries; the emergence of new sources of foreign investments in East Asia; and the fresh wave of tariff jumping investments arising from the formation of regional trading blocs. A dramatic decline was however experienced in the years, 1991 - 92 due to the recession in major industrial countries and the completion of worldwide restructuring of production led by the unification of EC markets.

ii) A review of trends in geographical and sectoral distribution of global FDI flows for the period 1960 - 92 reveal the following:

- share of developing countries in global flows has been decreasing up to 1990, i.e. 25% in the early 80s, 18% in the second half of the 80s and 15% in 1990; but increased in 1991 -92 when the global FDI flows started to decline. This increasing share is however concentrated only to a handful of developing countries such as Singapore, Mexico, China, Brazil, Malaysia, Hongkong, Argentina, Thailand, Egypt and Taiwan. The share as well as the absolute volume of flows to least developing countries has been declining.

- in sectoral terms, there is an increasing trend in the importance of services but this is concentrated in developed countries; within manufacturing, capital and technology-intensive sectors improved their share at the cost of natural resource and labor intensive sectors.

- the importance of minority-owned affiliates as an organizational form of FDI increased in the 70s and early 80s and declined thereafter.
- while the share of reinvested earnings in FDI inflows declined since the late 80s, they still constitute a considerable proportion of FDI flows in developing countries.

- strategic alliances is becoming of increasing importance as a means of inter-enterprise cooperation in the industrialized countries.

D. The New International Scenario for Technology Transfer

12. Referring to the Issue Paper entitled, *Prospects and New Dimensions of International Transfer of Technology* which he prepared as a discussion paper for the Meeting, Dr. Carlos Correa highlighted the following main points:

i) Technology is today a competitive asset for firms and it is recognized that economic growth is dependent not only on labor, capital and resources but also on education and technology. This implies that past and future investments in technology will be as important as investments in physical assets for the development of countries.

ii) Developed countries are paying a lot of attention to developing and controlling technology as indicated by the following:

- substantial increase in intangible investments, i.e., other investments linked to technological capabilities such as training, organization, market exploration, information technology, in OECD countries.

- R & D activities continued to increase during the '80s despite the recession exhibiting increasing participation of private enterprises from OECD countries (quite different from developing countries where R & D is performed by the State).

- the ongoing reenforcement of the international intellectual property system which is a component of the emerging technological protectionism among the industrialized countries. Two trends are noted; first, the strong demand by developed countries for the reform of the intellectual property system particularly in developing countries, e.g., protection of software, computer programs, pharmaceutical; and second, the negotiations in GATT for an Agreement on Trade-related Intellectual Property System (TRIPS). This agreement, if adopted will set universal standards for the protection of intellectual property independent of the state of development of countries. Among its main implications are: it will make all areas of technology patentable, that is, countries will not be able to exclude certain sectors for reasons of national welfare or public interest such as for instance, pharmaceutical; it will dilute or eliminate the "working" obligation of patent holders in the sense that mere importation will be considered as "working"; protection of seeds and plant varieties will be covered by patents and this will imply a substantial change in the agricultural systems of many countries; and for the first time, multilateral protection of knowhow, trade secrets, undisclosed information will be provided and this may have substantial implications on tacit knowledge and technology transfer based on FDI.

iii) The globalization of the world economy, the opening up of economies in developing countries and the increasing privatization of knowledge will have significant effects on the supply and demand for technology. On the supply side, firms which own technology will be more hesitant to transfer technology because of fear of creating competitors in a globalized market and also because given the liberal reforms in developing countries, owners need not invest or license to penetrate protected markets but instead can use trade. It is thus likely that the price of technology will increase. On the demand side, technology acquirers which traditionally can compensate for higher costs by working in protected markets are now operating in an environment where they have to compete with foreign companies in the domestic market. They will therefore need to become more efficient in the selection, use and assimilation of technology.

iv) Given these developments in the international scenario for technology transfer which are affecting the supply and demand for technology, certain elements are suggested for national technology policy formulation, inter alia, an adaption-oriented technology policy which emphasizes absorption of foreign technology rather than creation of new technology as in the examples of the Republic of Korea and Japan and here, the involvement of the private sector is crucial; more attention to the building up of domestic capability to take knowledge and undertake adaptive efforts; improved capacity to select and negotiate technology in the light of the expected difficulties in obtaining technology; and increased efforts to integrate importation with domestic technological efforts.

E. Briefing on the EC FAST (Forecasting and Assessment on Science and Technology) Research Programme on Transfer of Technology:

13. Dr. Georges Thill briefed the meeting on the activities of the FAST Programme of the EC and the results of the Theme C Programme on science and technology which aims to provide a vision and an approach towards a global perspective for science and technology in the year 2010. The programme is anchored on the philosophy that complex interactions of a social, cultural, economic, political, ethical and institutional nature encompass the discussions on S & T. In other words, technology assessment is promoted as an interdisciplinary approach where technology is viewed as a social process which requires understanding as to its nature, its value and social utility, in addition to an evaluation of its feasibility and economic utility. Its approach is a proactive research on sustainable development and the role of science and technology as an instrument for co-development and co-determination for a world population of 8 billion by the year 2010. The challenge of technological forecasting under this programme's approach is to go beyond the classical contrasts of developing country/developed country, producer/user, etc; to put into perspective economic, political, social, educational, ethical, ecological and environmental considerations; to increase the density and range of interaction among participants; and analyze the critical areas that will promote co-development and co-determination for the world economic system. In its research, the programme involves the collaborative efforts of many groups such as SPRU at Sussex University, the MERIT Programme in Maastricht, Ecotech, Centre for System Studies and PRELUDE, among others, as a way of learning from the diversity of opinions, experiences, visions and needs perceptions of various sectors.

14. The approach involves the following steps: identification of the desirable vision for the future of the global system/society among the many realistic possible scenarios; assessment of the contributions of S & T to enhance the capability of mankind to decide and take proper actions to achieve the desirable vision of the future by contributing to respond to the global prospects, problems and challenges at all levels; selection of the priority areas where a revisited S & T global agenda would better contribute to create stable conditions and mechanisms for now and the future which are instrumental to the satisfaction of the needs and aspirations of the 8 billion people;

identification of obstacles that now and in the future are preventing S & T to be designed, developed and diffused in the general interest of the world population and on which actions from the EC can have a determinant influence; assessment of the EC S & T agenda in comparison with the needed S & T and the S & T priorities "shortlist", and proposals for Protocols for Action in the short-term, mid-term and long-term. Four priority areas for S & T development have been identified as follows: shelter and human settlements; education; communications; and energy eco-efficient living.

15. The programme suggests that as borne out by many researches, the transfer of skills and hybridization i.e., the local creation and institutionalization of an innovative process, and interdisciplinary and intersectoral fertilization which takes into account the local knowhow, social and cultural reality and user needs, is not taking place. This situation is further aggravated by the growing "triadization" of technology and increasingly in the hands of multinational corporations. There is therefore the strong need to move from transfer to hybridization. Studies prepared by the programme provide empirical evidence on the role of associative networks as an appropriate instrument to cope with the need for interdisciplinary and intersectoral fertilization and hybridization. Associative networks, which consist of different human actors, social groups and institutions are open processes of communication, exchange, common decision and co-development. The associative network approach enables complex, highly heterogenous situations to be tackled in a systemic and global fashion under the condition that all involved actors and researchers are engaged.

16. The EC has also embarked on a Programme of Research and Liaison between Universities for Development otherwise known as PRELUDE. The programme involves more than 850 researchers in 63 countries involved in scientific coordination.

F. Acquisition and transfer of environmentally-sound technologies: Access, opportunities and barriers for developing countries

17. Dr. Fuchs of the Stamberg Institut of Germany presented to the meeting the preliminary results of ongoing research on the above subject, the highlights of which are as follows:

i) In a widely cited estimate made by the OECD in 1992, the global market for environmentally sound technology is projected at US$ 300 billion, the estimate largely comprising end-of-pipe technologies or those used to remove environmentally dangerous substances or recyclable materials from solid waste, wastewater, flue gas. These technologies are often inexpensive and available but the cost of building the processing facilities and installation of necessary equipment may be considerable. In addition, there is what is deemed as a practical unavailability of these technology arising from the lack of access to information on sourcing. In contrast, environmentally sound production processes, i.e., those used to avoid the emergence of environmentally dangerous substances and toxic waste and to save raw materials, energy and water, are generally expensive and access may be difficult as the technology is integrated into a complex production process, for instance, in the textiles industry.

ii) Apart from the problem of access and cost of clean technology, the transfer process itself has failed in many cases because of the lack of technical competence among potential users, which is a precondition to the efficient use of the technology.

iii) There is a high degree of concentration of patent applications and grants of patents for clean technologies nearly exclusively among OECD countries and among a limited number of firms in these countries particularly in areas which promise extraordinary profits for patent holders such as in the production of lacquers, dyestuffs and paints. Empirical data suggests that there exists a

positive correlation between the size of the firm, the number of patents and the profitability of the market to be exploited.

iv) In the textile industry, data collected implies that the whole dynamics of innovation is dominated by the leading manufacturers of textile machinery which often incorporates single aspects of clean technological processes to save on production costs, improve quality or to comply with governmental environmental laws. Access to clean technology in these cases is determined by the fact that the technology is part of a whole complex of production technology which may be embodied in machinery or a whole production process. The required clean technology cannot be separated from this package. Furthermore, the latest and most sophisticated form of clean technology is usually transferred if a completely new plant is built. These patterns seem to characterize the transfer of clean technology in general.

v) Apart from most end-of-pipe clean technologies on a turnkey basis, it is not always easy to estimate the real costs of clean technology as usually, it is supplied and transferred as part of a complex system.

vi) There is ample evidence pointing to the relocation of heavy polluting industries to developing countries to avoid environmental standards in the industrialized countries mainly due to less strict environmental laws and weaker enforcement in the former countries.

vii) Some suggested ways to improve transfer of environmentally sound technologies are: to establish a network which will facilitate exchange of information between companies, organizations and countries in the rapidly developing field of clean, input-efficient and waste-reducing technology, including an awareness campaign particularly for small and medium sized firms in developing countries; and subsidy for relevant R & D such as by public institutions, as well as for investment in clean technologies.

G. Trends in Technology Transfer Policy and Effects on Technological Capacity Building, the Case of the Republic of Korea

20. During the '60s, Korea adopted an outward looking strategy focusing on light consumer goods industries for import substitution and at the same time, expanding exports of industrial goods. During this period, technology flowed in primarily through turn-key arrangements. Importation of foreign capital goods was preferred over building up of domestic capital goods industry. At the same time, the government relied more on long-term foreign loans than on FDI. Acquisition of foreign technologies was primarily through informal rather than formal modes. Given this background, technology transfer policy in Korea in the '60s was biased in favor of informal technology acquisition through imports of turn-key plants and capital goods rather that formal modes, i.e., FDI or licensing. The restrictive policies placed on FDI and licensing in the mid-'60s as a result of the serious foreign exchange shortage had in fact very little effect on technology flows. Rather, it was the strong export-orientation of Korean industries which facilitated rapid technology acquisition through exposure to international competition and the opportunities of working with foreign firms through such arrangements as OEM manufacturing, technical training and consultancy provided by turn-key suppliers and turn-key arrangements, among others, and the capacity of existing manpower to undertake reverse engineering.

21. In the decade of the '70s, the focus was on technology-intensive heavy machinery and chemical industries. The strategy adopted was increased protection against imports in addition to providing incentives for local manufacture in industries considered to be strategic. This created an enormous demand for imported technologies. The Government responded by easing governmental approval

procedures on FDIs , encouraging joint ventures with higher technology transfer effects and liberalizing rules on technology importation. The liberalization on technology imports took a step-by-step approach: first, through the classification of technology imports into three categories, i.e., those subject to automatic approval, to quasi-automatic approval and to inspection prior to approval; second, the merging of the first two categories of approval; and third, the expansion of cases for automatic approval to include all technology imports with a contract period not exceeding 10 years and with a royalty within 10 per cent of sales. At the same time, FDI was also rapidly liberalized with the opening up of many new industries to foreign investors and simplification of approval procedures. In 1978 when the first of the series of liberalization measures was taken, technology imports increased by 26.8% and since then, at an annual rate of about 20%.

22. The period of the '80s saw the Korean economy facing severe structural difficulties as a result of both internal and external events. This led the government to introduce a series of institutional reforms to promote the role of the market and reduce government intervention. This involved liberalization of FDI regulations as well as those involving foreign licensing, in the latter case, involving complete liberalization such that by 1984, the approval system has been transformed into a mere notification system. The effect of this liberalization may be gleaned from the increased quantity of technology purchased for the period 1984-1990 as reflected in payments made. Of a total of 4,925.5 million dollar payments for the period 1962 - 90, 83.1% represented payments made in the period 1984 - 90.

H. The UNIDO Programme on Technology Acquisition and Negotiation

23. The Meeting was briefed by the Chief of the Technology Acquisition and Negotiation Section on UNIDO's programme on technology acquisition and negotiation consists of an integrated and mutually supportive package of programme elements consisting of:

- Policy and institutional component
- Human resource development activities
- Advisory services, and
- Empirical analyses and publications

24. The <u>policy and institutional component</u> involves assistance to developing countries in the formulation of technology transfer policies; and in the setting up of appropriate legal and institutional infrastructures in relation to technology acquisition and evaluation. The latter also involves establishing in existing institutions the capability to render technology advisory services to entrepreneurs and the business community in the choice, selection, evaluation, negotiation and implementation of technology transfer transactions and to promote technology development activities e.g., linking enterprises, associations and R & D institutions.

25. Under this component, UNIDO has been promoting a network of cooperation involving institutions in developing countries dealing with technology acquisition and evaluation activities. It was put in place at a time when developing countries in particular knew very little about technology transfer operations and therefore evolved around the exchange of information on contractual terms and conditions of technology transfer as a means of improving the leverage and enhancing the decision-making process for technology importers. It has since evolved into broader areas both in terms of scope of activities and the character of its networking. Linkages among institutions and organizations engaged in different aspects of technology transfer, adaptation, development and use is being promoted as a new feature of network. This would involve S & T agencies, technology promotion agencies, boards of investments, industrial associations and professional organizations and as is the idea behind the concept of associative networks under the

FAST programme, this networking is a facility which promotes dialogue and cooperation at regional and international levels among technology institutions of developing countries and between institutions representing technology buyers and technology suppliers. It is also an avenue for mutual learning as it draws upon the diversity of experiences, perspectives, visions and needs perceptions of various participants in the network. Cooperation takes place through institutional staff exchanges, exchange of experts, study visits and on-the-job training, exchange of information and sharing of experiences as a supportive approach to building or strengthening national capacities to acquire, to negotiate, to adapt and develop externally sourced technologies including the strengthening of the policy capacity. It is also a unique source of up-to-date data and information on technology transfer transactions at the national and international levels which facilitates the monitoring of technology transfer trends and developments and has provided an effective institutional basis for promoting cooperation and improving understanding between technology suppliers and recipients.

26. The **human resource development** component involves systematic educational activities aimed both at enhancing professional skills of developing country negotiators, e.g., government officials, entrepreneurs and professionals, and in creating self-sufficient training capabilities in the field of technology transfer negotiations. Activities are carried out through workshops and seminars on technology acquisition and technology transfer negotiations and the development of teaching materials which are now being consolidated into a manual on technology transfer negotiations.

27. The Manual is a product-service package which consolidates in an innovative way UNIDO's knowledge and experience in the training of technology transfer negotiators. It is so structured as to cover in a comprehensive way the range of subjects which entrepreneurs, government officials and decision-makers dealing with technology acquisition are likely to be confronted with during the various phases of the technology transfer process, not only from the buyers point of view but from that of the supplier as well. In its final form, it will consist of twenty-one modules grouped around thematic clusters surrounding the technology acquisition process, i.e., a cluster of general information on technology transfer and development, technology market characteristics, the role of intellectual property protection and success factors for transfer of technology; a second cluster giving more detailed and practical information on the legal environment in industrialized countries, the legal environment in developing countries, financing sources for technology transfer, sources of information, technology evaluation, bidding and procurement and the dynamics of the negotiation process; a third cluster containing core information on how to approach the contractual phase that is, information on basic legal notions in technology transfer, principles of contract drafting, general structure and types of agreements, training, payment and guarantee provision; and a final cluster dealing with the complex forms of technology transfer such as strategic partnering and joint ventures. In line with its product-service package concept, the Manual is supplemented by a collection of standard and normative documents including a glossary of terms, a trainer's set with instructions and notes for trainers and case studies.

28. In its entirety, the Manual is the instrument with which UNIDO is able to organize its capacity-building activities with more focus, develop its programme for training trainers and enable institutions in developing countries to conduct their own training programmes on the basis of UNIDO's methodologies and standards. The Manual is therefore meant not only for teaching negotiators but for developing skills of trainers as well.

29. The **advisory services component**, otherwise known as UNIDO's Technological Advisory Services (TAS) programme, provides assistance to government institutions or companies of developing countries at the time of negotiations with foreign suppliers and partners, thereby strengthening their negotiating position directly *in situ*. TAS offers assistance to negotiators in all matters related to the acquisition of technology through contracts, for example, preparing tender

documents; evaluating proposals and selecting suppliers; preparing for negotiations; drafting agreements; providing advice during negotiations and resolving problems which may arise during negotiations.

30. The empirical analyses and publications component is an ongoing activity which is intended to keep developing countries abreast with developments in the international technology transfer arena; informed sufficiently enough to be able to formulate national policies and strategies of dealing with the rapidly changing environment; and guided in their acquisition and negotiation processes. UNIDO disseminates studies and analyses of technology transfer trends and developments with particular attention to their implications to developing countries. Issues of technology acquisition in the field of new and emerging technologies such as environmentally sound technologies are also given focus.

31. In addition, supplementary programmes involve the development of an *Expert System on Contract Drafting and Negotiation* and a programme on Build-Operate-Transfer (BOT). The first is a response to the constantly increasing demand for assistance in the contracting and negotiation of technology transfer. This Expert System with its data bank of clauses and contractual structures relating to different types of agreements and different sectors, and information on the legal requirements of specific countries, will allow negotiators to draft contracts suitable to the kind of arrangement being envisioned, the sector and the legal environment where the contract is to be concluded. As such, it will facilitate negotiations, reduce the time and cost of contract drafting and improve the quality of contracts. The Expert System which can be used both by the recipient and the supplier will come as a package of the knowledge system, a software, advisory and training services.

32. UNIDO has also developed a programme on BOT consisting of the following elements: i) the establishment of guidelines and standard procedures for the negotiation and implementation of BOT arrangements; ii) the availability of an advisory task force that can service requests for assistance in connection with specific BOT projects; and iii) technical assistance at the enterprise, national or regional levels for capacity building and policy advice related to the implementation of the BOT scheme. The draft Guidelines for the Development, Negotiation and Contracting of BOT Projects is in the process of finalization.

33. UNIDO also publishes a quarterly TIES Newsletter containing information on technology transfer related developments worldwide including policy, legislative and institutional developments at the national level and articles covering recent trends and new and innovative forms of technology business.

IV. DISCUSSIONS

34. Summarized hereunder are the important points raised during the discussions:

35. The varied experience of countries bears out the absence of any single model or "formula" for technological growth and development. To cite an example, acquisition of foreign technology in the Republic of Korea in the '60s was predominantly through informal, i.e., turn-key arrangements, rather than formal modes such as licensing and FDI. There was also greater reliance on long-term foreign loans than FDIs. Technology transfer policy was therefore biased in favor of informal technology acquisition through imports of turn-key plants and capital goods. At some stage, protection from imports through tariffs was adopted as a way of supporting strategic industries which were being developed. Singapore, on the other hand, acquired technology through FDI

particularly from MNCs which were viewed by the Government as the most effective means of transferring technology and the fastest route to technology development. There was therefore a general economic openness to investments by MNCs through generous tax incentives, absence of restrictions on foreign equity investments, remittances of profits and technology transfer, plus minimal trade tariffs.

36. In short, one may say that countries, while following different macro-economic policies and strategies undoubtedly reflecting or influenced by national characteristics, may end up achieving the same goal. Both economies have seen a transformation that qualifies them as NICs. Similarly, one may not simply replicate or transplant one or the other approach to other developing countries with the same measure of success.

37. There are, however, some common denominators despite the differences in economic philosophies adopted by countries. Among the more explicit ones are the accumulation of technical skills and creation of indigenous technological competence through a policy of build-up of education in general and scientific and technical education in particular and the creation of strong scientific and technological systems, i.e., support for local R & D to adapt products and techniques to local conditions. In other words, what may differentiate success from failure, in the final analysis, is the availability of human capacity to make wise adaptations in consonance with the local environment, local conditions and objectives.

38. The example of Singapore is worth noting. During the '70s and '80s, Singapore promoted R & D institutes to carry out indigenous R & D of an applied nature and to provide resources of manpower, skills, technology, knowledge and products and processes to the private sector. At the same time, tertiary institutes were developed to provide a steady source of highly-trained scientists and engineers for research institutes and industry, conduct basic research and collaborate with industry in joint projects, consultancy and in-house courses. It was a definite and firm commitment to the development and promotion to S & T that led to the setting up of a National Science and Technology Board and the adoption of a National Technology Plan which identifies key technology areas where Singapore aims to develop technological competence. Added to these is the deliberate approach to promote R & D institute and private sector collaboration through collaborative R & D, licensing, joint venture arrangements, contract R & D and consultancy.

39. In general, policy and institutional approaches by governments of developing countries in the field of technology transfer have been evolving according to both internal and external factors. Regulatory regimes in the '60s and '70s were heavily focused on reducing the foreign exchange costs of technology imports and eliminating restrictive business clauses in contracts with very little attention to the building up of local technological capabilities with the exception of a few countries such as Korea and India. In many instances, technology development was treated separately under a different institutional set-up much divorced from the technology transfer institutions. The result was a lack of productive interaction between technology transfer and technology accumulation and development. Furthermore, the emphasis on costs, reducing royalty payments and eliminating business restrictions was a very static interpretation of the nature of technology markets and the motives of technology suppliers. Eventually, control of costs can deprive the economy of needed technology rather than improving the terms of its acquisition.

40. The decade of the '80s saw the gradual easing up of regulations on technology transfer in many countries for various reasons. In some cases, it was simply subsumed in the wave of liberalization and opening up of the economy in line with structural adjustments required by international or regional commitments and obligations. In others, regulations were either abolished or applied with great flexibility in line with a "market-friendly" approach to foreign investments. Technology

transfer institutions which were traditionally carrying out screening and regulatory functions started shifting their orientation towards the rendering of advisory services in the form of access to technological information, assistance in contract preparation and in contract negotiation and other business-oriented services. More importantly, here is now an emerging awareness of the need for a deliberate transformation from a policy of regulation to an "acquisition"-oriented policy, i.e., giving focus on strengthening domestic absorptive capabilities to support technological learning and accumulation from technology importation.

41. No doubt, there has to be a greater awareness on changes taking place in the international arena for technology transfer in the light of their potential repercussions for developing countries particularly as regards access to and transfer of technologies. Recent studies and researches reveal the following trends:

- on the aggregate, global R & D expenditures have been increasing despite the worldwide economic slowdown suggesting the importance of innovation-based advantages to production and international competitiveness;

- a high concentration of R & D activities in the developed economies, particularly in the Triad countries of USA, Japan and EC and an extremely small share by Third World countries;

- worldwide participation of the private sector in global R & D activities as a means of maintaining technological competence and competitive advantage has also markedly increased;

- in the face of mounting R & D expenditures, mergers, joint ventures and other types of strategic alliances have characterized the behavior of many firms manufacturing high-technology products. This type of collaboration has largely been concentrated within the Triad although some alliances have been established with NIC firms particularly in the sectors of microelectronics, telecommunications, consumer electronics and the automotive industry.

- core technologies, i.e., information technology, biotechnology and new materials, which constitute the basis of many future technological developments affecting manufacturing and services and consequently of competitive advantage, play a very important role in strategic technology partnerings.

42. A similar asymmetry is observed as regards direct foreign investment. Trends in geographical distribution reflect concentration of global investment flows in developed countries though recently, the participation of developing countries in inward FDI has started to grow. The distribution of FDI flows among developing countries is also characterized by a high degree of concentration and polarization. The bulk of the flows to developing countries are destined to a handful of newly industrializing countries and least developing countries as a group are being marginalized in the process. On another angle, increasing FDI trends and decreasing technology transfer of a disembodied nature particularly for the most dynamic sectors is a manifestation of the tendency by technology owners to protect and control technology.

43. These trends indicate that the policy issues have changed and developing countries have to put in place alternative strategies and policy instruments covering both public and corporate concerns which will enable effective response to these developments. Ensuring access to technologies at reasonable terms and conditions is still a key issue in this exercise. Awareness of the importance of indigenous technological capability to ensure that absorption takes place is another key element. It now becomes more crucial to enhance technological capability in all its dimensions in order for firms to compete both in the domestic and international markets. The ability to design and re-design

products and production processes is one key dimension as this capability paves the way for innovation and for adapting to targeted markets, whether domestic or international. Some governments may take a more active and direct role in concretizing this awareness particularly in certain strategic industries. Others may simply opt for lending strategic support, rather than intervention, as a more effective way of government participation in the process and allow local initiatives in technology cooperation and sharing to fuel domestic productive activities. Such support may come in the form of sustaining skill formation, encouraging collaboration between R & D institutes and business, developing advisory, consultancy and negotiation capabilities.

44. The essence is that there are definitely still important roles for governments with respect to the acquisition of human capabilities essential for the proper technology selection, negotiation and adaptation processes as well as the institutional devices needed to facilitate its diffusion within the country. There is indeed a whole area of influence on structural factors, e.g., absorptive capabilities of enterprises.

45. There was consensus that the emerging global environment and its implications for developing countries require a fresh response in terms of new forms of international cooperation and the new role of international organizations such as UNIDO. The global changes require an approach that would respond to new and emerging needs of developing countries such as those arising from opening up of economies to competition, including the economies-in-transition which need not only to adopt to the world economy but to link their technological potentials and capabilities within the context of a global economy. Policy analysis and advice in a liberal environment is an area where presently an enormous gap exists and where UNIDO is in a good position to assist in. Aside from improving terms and conditions of acquisition of technology through contracts, new issues and ideas which could be the subject of policy analysis and advice are: improving absorptive capabilities or maximizing technological learning; maximizing technological benefits from formal and informal channels of technology transfer, for instance, OEM arrangements, subcontracting and exports; how to efficiently use existing technology including reference to such issues as intangible investments; organizational technology ; new forms of technology business such as strategic alliances; attention to improving on existing technologies through quality, productivity and environmental programmes. In addition, it was suggested that policy prescriptions should be qualified according to different groups of developing countries, for instance, for the least developed, the medium group and those in the catching-up stage, as the needs of these groups could vary significantly.

46. The view was also expressed that new approaches to international cooperation should be derived taking into account the increasing role of the private sector and MNCs in particular in the globalized economy, the re-emerging role of FDIs as a channel for technology transfer and the growing asymmetric development in relevant international intervention, i.e. increasing protection and control over technology by developed countries as manifested in the TRIPs negotiations under GATT and the absence of any international instrument for regulating misuse of monopoly power. In this connection, the importance of information for overcoming insufficiencies was highlighted; for instance, information on the range of alternatives available and technology market opportunities.

47. The view was expressed that the UNIDO efforts for a systematic approach to training of technology transfer negotiators amidst this climate of change is commendable and its outreach should be expanded. The increasing difficulties in obtaining technology by developing countries including increasing costs of acquisition make it imperative for developing countries to become very efficient in the selection, acquisition and negotiation of technology. Enhancement of professional skills in this field is a very important service. Likewise, access to commercial and legal information is deemed to be very crucial as well as direct advisory assistance at the negotiation stage. The improvement of the policy capacity at the firm level should be incorporated in the

negotiation framework, i.e., the corporate policy approach in addition to the public policy, as well as the integration of the transfer process with local capabilities. This, together with inclusion of topics on management and financial issues, will enhance the business orientation of the training programme while at the same time strengthening hold on enterprise-oriented clientele. Indeed, access to technology and enhancement of negot ..i capabilities have to be considered in the context of the new competitive environment to which developing country enterprises are now a part of. The view was further expressed that the Manual on Technology Transfer Negotiations is an excellent instrument for such training and experts from developing countries should be trained in the proper use of the Manual.

48. Another area of international collaboration is among international organizations themselves where complementarities and opportunities for cooperation exist. Networking and operational relationships should be promoted between international organizations including international research groups working in the field of S & T, for synergistic effect as well as to avoid duplication of efforts. Joint researches may be undertaken or exchange of studies, research results and working materials as well as joint sponsorships of seminars and workshops. Needless to say, such collaboration could greatly enrich the delivery of services and technical assistance by these organizations.

49. The Meeting welcomed the multidisciplinary approach of the EC FAST Programme in elaborating on the role of S & T in world development, its expressed concern over the increasing "Triadization" of the world economy and towards increasing the access of and eventually the contribution from developing countries to the world S & T. The view was expressed that there is now the need to transform this programme into a policy agenda with the appropriate recommendations for bringing developing countries into the mainstream of this programme such as for instance through joint work in R & D and technical cooperation programs.

50. In discussing the preliminary results of the study on environmentally sound technologies, the question was raised on the possibility of coming up with a finite categorization of environmentally sound technologies that will enable the identification of issues specific to each category. The view was expressed that such a categorization will enable an examination of the extent to which environmentally sound technologies represent issues of their own vis-a-vis new and emerging technologies technologies or technologies in general.

51. In reply, it was expressed that to a certain extent, environmentally sound technologies are a special case, one reason being, because it represents a political issue for which governmental legislations are becoming the response. Because of its political sensitivity, concern for clean technologies is also becoming an issue of image.

52. To the first question, the expert replied that a categorization has in fact been undertaken including a differentiation of conditions of transferability, i.e., end-of-pipe technologies being often inexpensive and easily available except that knowledge is dispersed; clean technologies relating to whole production processes which may be expensive and access difficult because it concerns the whole process of production; environmentally sound inputs which may be more easily transferred through machinery and equipment; and environmentally sound outputs where market differentiation through trademarks is an important characteristic.

53. The Meeting was informed of the conclusions reached by some researches that the main obstacle to transfer of environmentally sound technologies is not so much the supply but the demand due to lack of awareness and lack of knowledge by potential users. In this connection, the same researches reveal that technologies which are clean are also efficient. The cost problem is also another obstacle as the introduction of these technologies often require huge investments.

54. The Meeting was also informed of a project being undertaken by the Centre for the Promotion of Imports from Developing Countries (CBI) of Netherlands on reverse transfer of technology, i.e., the flow of technology from the South to the North. This has its basis on the results of preliminary investigations which indicated that there are a number of institutions in developing countries which can assist Netherlands industry, say, in consultancies, civil engineering and other services. On the demand side, however, a perceived obstacle to entry is the lack of awareness on the expertise and possibilities available. The view was expressed that the topic of reverse transfer of technology needs to be promoted and there is a need to gather and disseminate information on good examples, case studies and success stories on the subject.

V. CONCLUSIONS AND RECOMMENDATIONS:

55. Emerging trends in the international technology transfer arena, with their potential implications on developing countries in terms of access to and cost of technology, highlight the need for the adoption of certain policy measures that would enable developing countries still to catch-up and participate in a globalized economy. Such measures should take into account the following:

- a comprehensive view of technology transfer where the elements of transfer are inseparable from the elements of assimilation and integration with local technological capabilities. This becomes particularly crucial due to the increasing knowledge-intensity of production and the required availability of local competence to ensure maximization of users benefits.

- a dual approach of harnessing technology from external sources and developing and adapting technologies indigenously through an assimilation-oriented R & D strategy, with a major commitment to education and training with special emphasis on managerial and commercial training.

- promoting a more efficient process of selecting, acquiring, negotiating and assimilating transferred technologies in order to meet the new competitive challenges emerging from the globalization of the world market and liberalization of developing countries' economies;

- adequate integration between technology transfer and investment policies taking into account the growing importance brought about by the globalization of the world economy;

- mobilization of local research and development facilities for technology development and for establishing linkages with the various components in the technology system, for instance, the users of technology;

- establishing a simultaneous access to technology and markets such as through the promotion of exports as a means of creating markets or through OEM arrangements as a means of accessing technologies;

- maximizing technological benefits from both formal and informal channels of technology acquisition.

56. The growing technological protectionism among the developed economies as reflected in the current reform of the international intellectual property system and the move towards an Agreement on Trade-Related Intellectual Property Rights (TRIPS) under GATT meant to harmonize and establish the same standards of protection for patents, copyrights, trademarks, industrial designs, geographical indications, integrated circuits and undisclosed information also require that developing countries establish awareness about the issues arising from this Agreement and the implications as

well as the opportunities relating to the negotiation and implementation of technology transfer transactions.

57. Trends in the global scenario likewise indicate that FDI is again becoming an increasingly more important channel of technology transfer. This is a result of the liberalization of government policies towards FDI worldwide and the importance of technology as a tool for establishing and maintaining competitive edge between and among firms. Developing countries should try to maximize technological effects from FDI such as by developing and/or strengthening linkages with local design and R & D activities.

58. The role of institutions which have traditionally been dealing with technology transfer activities in a regulatory way and of the State in the process of transfer of technology need to be reassessed as well. In the context of the current opening up and liberalization of economies, institutions should serve as promoters of technology acquisition, transfer and development to industry. While the trend has emerged for the dismantling of explicit controls over technology importation, the re-orientation of institutions have to be based on a solid understanding of the needs of industry in terms of R & D activities, particularly adaptation of technologies; manpower training and human resource development; advisory support in information sourcing, technology sourcing, partnering, contract negotiation, etc.

59. It was noted that some common elements contributing to economic and technological growth can be identified namely indigenous R & D, a focused manpower development and a deliberate technology absorption policy. These elements for success seem to be largely independent of the very different macro-economic policies pursued by countries.

60. In discussing the possible new dimensions of the UNIDO programme for facilitating greater access to technologies by developing countries and strengthening the domestic technological learning and accumulation process particularly in the context of the new global scenario, it was indicated that on the whole, the existing programme instruments consisting of policy advice, human resource development, advisory services and information dissemination are adequate tools for programme implementation. What is needed is a sharpening of focus in terms of responding to specific demands of specific target groups and the introduction of new elements in the content of the programme instruments.

61. In the area of policy advice there was a call for the formulation of a new agenda which will take into account the need of developing countries for policies and strategies aimed at catching-up and participating in a globalized economy. Integral to the technology acquisition and assimilation process is the element of the efficient USE of technology which brings about the concepts of intangible investments, organizational technology, and the business perspective of technology transfer, e.g., management and financing issues. In this connection, there is a need to analyze and study how developing countries could maximize technological benefits from both formal and informal channels of technology transfer, e.g., OEM manufacturing, subcontracting and exports. UNIDO is in a good position to undertake this study as it has the advantage of access to information and sources of information on successful cases which could be the basis for such analysis. Business encounters and exchange of practical experience within the country should be promoted as separate and valuable instruments for economic growth. UNIDO can help develop these instruments.

62. Policy advice on the above issues may also be extended at the enterprise level where focus should be given to the integration of imported technologies with local capabilities and the development of innovative capacities as highlights of a firm's corporate strategy.

63. In the context of the current trend for opening up of economies, developing countries in general and LDCs in particular would need assistance on how to cope with the effects of liberalization moves as far as ensuring access to suitable technologies at reasonable terms and conditions is concerned.

64. Furthermore, the specific problems and needs of the economies in transition need attention. UNIDO must be able to provide advice to these countries to facilitate their participation in the world economic system taking into account their technological needs as well as their technological potentials. In this context, it is important to envisage how the significant R & D capacities can be linked to import and absorption of foreign technologies as well as to the export of domestic embodied and disembodied technologies.

65. In the area of human resource development, UNIDO has established a strong foothold in the market through the range and quality of services it has been extending which are at par with those of private-oriented organizations. The UNIDO approach and methodology for training technology transfer negotiators as documented in the Manual on Technology Transfer Negotiations have a clear private sector orientation and appeal that make the Manual a highly marketable product. Possibilities of self-financing should be explored in order to expand the outreach of this programme to the many countries who have already expressed a desire to benefit from it.

66. However, further enhancement of the training programme may be made in the following areas: inclusion of modules on strengthening the policy-making capacity of developing country negotiators, be it public policy or corporate policy; enrichment of existing modules or inclusion of additional modules on specific topics related to the business perspective of technology transfer. This will give the programme an enhanced private sector focus which will then enable UNIDO to further build on its established relations with private business organizations.

67. The extension of advisory services should continue to be based on the specificities of country needs, priorities and aspirations; for instance, the priority for improving on existing products and technologies; concern for global quality; environmental concerns and technology management issues; the need for a sectoral and a production cluster approach. On the other hand, some countries may still need assistance at the institutional level such as in reviewing or in strengthening existing technology transfer mechanisms.

68. In the field of environmentally sound technology, a pilot study commissioned by UNIDO on access and barriers for developing countries to environmentally sound technologies show evidence that the process of acquisition and transfer follow the same pattern observed for new technologies associated with increasing productivity and competitiveness. A strong participation of private sector, specially transnational enterprises, in the innovation process, increasing costs for development and licensing, increasing tendency to locate in less regulated environment and selective sourcing of partners are main features of this pattern. Some specific characteristics are also to be noted, particularly the high political sensitivity determining the development and application of cleaner technologies, both in developed as well as in developing countries and the participation of dynamic non governmental organizations promoting the introduction of cleaner industrial process and products. The meeting recommended that the analytical efforts and assistance of UNIDO should classify the different forms of clean technologies and develop appropriate strategies to promote transfer of each cluster of clean technologies. UNIDO should also focus on the promotion of an enabling environment for the introduction of cleaner technologies in developing countries, through awareness building and assistance in designing the necessary policies and incentives to promote their utilization.

69. UNIDO, with its varied clientele and counterparts representing government institutions, business and industrial associations and professional organizations; its links with associated international agencies; and its established relations with academic and research institutions including its roster of high calibre experts and consultants, has in fact a unique network of collaborators which it can tap as a source of knowledge, information, skills and expertise in the field of technology acquisition, transfer and development. This networking, which may be expanded to include users' organizations, should be maintained as a broad-based international cooperative effort which may be tapped to serve the changing needs of developing countries in the area of technology transfer and development, be it in the field of information, knowledge or expertise.

70. The existing information dissemination methods, e.g., the TIES Newsletter, monograph series, guidelines, and training should be continued and periodically re-evaluated according to the increasing sources of knowledge and information available.

71. One specific area of need which has been identified is increased awareness on the present asymmetric regulatory framework concerning technology transfer issues particularly between developed and developing countries. UNIDO should also intensify its promotional efforts to increase awareness on the mechanisms of assistance available to developing countries under its technology programme.

72. UNIDO should support efforts for promoting technical cooperation among developing countries (TCDC) as another avenue for improving access to technologies by developing countries and explore more dynamic approaches to encourage greater utilization of this mechanism. Since awareness that developing countries can also be a supplier of technological knowledge (reverse transfer of technology) is low, UNIDO should pay attention to this new phenomena and document cases to promote acceptance, so that the position of developing countries in this respect is strengthened.

73. Coordination and collaboration with other international organizations dealing with technology transfer and development should be intensified as a way of optimizing on resources available such as in the form of information, knowledge, knowhow and technical assistance activities. Complementarities exist and present opportunities for conducting joint programs, for instance, linking certain elements of the EC FAST Theme C programme and future researches of global problems with the UNIDO training activities on technology transfer and acquisition; and similarly with the marketing promotion programmes of the ITC, including joint technical workshops, cross-participation in seminars, etc. and with relevant initiatives at the national level.

Annex A

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Annex B

EXPERTS MEETING ON TECHNOLOGY TRANSFER TRENDS
11 - 14 October 1993
Conference Room VII, C Building
Vienna International Centre
Vienna, Austria

PROGRAMME OF MEETING

MONDAY, 11 OCTOBER 1993

0830 Registration

0900 **Opening Address by Deputy Director-General of UNIDO**

0915 Business Arrangements

0930 **Globalization of Technology** by Prof. J. Hagedoorn
Discussion will cover the characteristics and features of technology development nowadays; new patterns in technology development and its reflection on the international technology market (as compared with traditional patterns); how new developments impact on technology flows and access to technology by developing countries.

1045 Coffee Break

1100 **Policy Issues on Technology Transfer** by Dr. Slavo Radosevic
Discussion on the evolution of technology transfer policy over the years and recent Breakemerging policy issues for developing countries.

1230 Lunch Break

1430 **Foreign Direct Investment and Technology Licensing**
by Dr. Nagesh Kumar
Discussion on trends and patterns in FDI flows and their increasing importance as a channel of technology transfer; results of recent quantitative studies on determinants of FDI flows across different countries and sectors; and identification of main factors that determine the direction and pattern of FDI flows.

1545 Coffee Break

1600 **The New International Scenario for Technology Transfer**
by Dr. Carlos M. Correa
Discussion on technology as a key factor of economic development and international competitiveness; the increasing privatization of knowledge and protectionism by industrialized countries; liberalization trends in developing countries; implications and policy responses or options.

1730 Summary of Issues and Conclusions

TUESDAY, 12 OCTOBER 1993

0900 **Results of FAST Research on Global Perspective 2010, with a particular focus on transfer of technology** by Mr. Georges Thill

Discussion will also include the main objectives and guidelines of the 4th frame programme which was approved for scientific and technological actions of the European Community Commission for 1994-1998; and possible future collaboration between the EEC and other international organizations.

1045 Coffee Break

1100 **New and Emerging Technologies, a Focus on Environmentally-Sound Technologies** Discussion will focus on issues of access, barriers and opportunities; characteristics of technology flows of environmentally-sound technologies and recommendations to increase access and share by developing countries in applying these technologies by Dr. Manfred Fuchs

1230 Lunch Break

1430 Continuation of morning session

1545 Coffee Break

1600 **Presentation of Country Experiences on Liberalization Trends and their Impact on Technology Flows.** A review of the evolution of technology transfer policy citing various regimes and features; trends in technology flows attributable to such regimes; present situation in terms of policy orientations; effects of technology transfer policies on technological performance of industry and accumulation of technological capabilities.

A. **Republic of Korea** by Dr. Sung Chul Chung
B. Other Country Presentations

1730 Summary of Issues and Conclusions

WEDNESDAY, 13 OCTOBER 1993

0900 Continuation of Country Presentations

1045 Coffee Break

1100 **The UNIDO Technology Programme**

1230 Lunch Break

1430 **Brief Presentations** by other International Organizations

1530 Coffee Break

1545 **Discussion on New Approaches to International Cooperation**

1730 Summary of Issues and Conclusions

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PROSPECTS AND NEW DIMENSIONS OF INTERNATIONAL TRANSFER OF TECHNOLOGY:

*AN ISSUE PAPER**

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* *This document has not been edited.*

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INTRODUCTION

Technology transfer (by direct and indirect forms)[1] play a crucial role in the innovation process and, particularly, in technology diffusion. The scope and relative importance of the different modes of technology transfer vary over time and as a result of multiple factors affecting the supply and the demand of technology. Recent literature on economic development and technology transfer have identified and characterized the determinants of technology flows and of the differing capabilities -at the firm and country level- to absorb and operationalize acquired technologies.

This paper discusses a number of issues that are likely to influence the patterns of technology transfer to developing countries. Issues to be examined relate to qualitative changes in production and trade that have taken place over the last two decades and that may substantially affect the supply and demand of technology. The globalization of the world economy clearly is a major element for understanding the evolution of technology flows among firms and countries. This is an overriding factor that, coupled with recent policy changes in many developing countries, may help to explain current trends and future scenarios for technology transfer.

Section I concentrates on a number of issues that affect the supply and demand of technology and that determine a rapidly changing scenario for technology transfer. First, it considers the role of technology in trade and economic growth (section I.1), the trends in respect of intangible investments and, particularly, research and development (R&D) (section I.2) and the likely impact of shorter product life-cycles in a context of globalization of the world economy (section I.3). Second, it deals with trends towards the privatization of science and growing technological protectionism (section I.4). Third, a special section is included in order to discuss the implications for technology transfer of environmental concerns (section I.5). The relationship between technology transfer and various stages of industrialization is considered in section I.6. In the light of this latter discussion, the role of different formal modalities of technology transfer -including trends on foreign direct investment towards developing countries-(section I.7) and changes in the bargaining power of technology recipients are considered.

Section II focuses on a set of international regulatory issues that are likely to affect the demand of technology in developing countries. Section II.1 describes the emerging international intellectual property system as framed by international negotiations in course, particularly within GATT. Section II.2 briefly considers international conventions and principles relating to the transfer of environmentally sound technologies and to biodiversity.

Finally, section III contains the main conclusions of the study and suggests some policy options and issues for further consideration in the area of technology transfer.

I. CHANGES IN THE INTERNATIONAL SCENARIO FOR TECHNOLOGY TRANSFER

1. Technology as a key competitive asset

It is generally accepted today that technology has become a key asset for firms' competitiveness and countries' economic growth. This perception is based on a number of factual trends and new theoretical developments.

First, production is increasingly knowledge intensive, as a combined result of the emergence and expansion of information-and-knowledge based industries and the diffusion of new process technologies (Drucker, 1986, p. 779). On the one side, there is a structural shift in OECD countries to industries which are innovation and skill intensive, such as electronics, electrical, non-electrical and transport equipment[2] as well as to service industries. On the other, new information-based technologies have not only affected high-tech sectors but also find significant applications that enhance productivity and quality in many industries where technologies are mature and well diffused.

Second, the accumulation of innovative-based advantages is a prerequisite for international competitiveness. The firm's technological capabilities and the characteristics of the national system of innovation in which it operates seem to determine relative and absolute trade advantages (OECD, 1992a, Chapter 11). The pattern of trade in relatively high-technology intensive industries is primarily affected by countries' advantages in product innovation. The ability to raise efficiency through new process technologies (including flexible automation) and organizational changes is, in turn, critical for international competitiveness in low and medium technology intensive industries (Goglio, 1991, p. 23). 'Technology is, in short, a key explanatory factor in international trade[3]

Third, economic theory has formally incorporated technology as one of the distinct engines of economic growth[4]. Knowledge is regarded now as a factor of production, like capital and labour. In accordance with this approach, past investments and accumulated knowledge open the possibility of a virtuous cycle in which investment spurs knowledge and knowledge spurs investment. Lack of human capital rather than lack of investment in physical capital, would be, thus, the most significant barrier for catching up by underdeveloped countries.

In sum, technology is a critical asset for production, competitiveness and long term growth. Greater and explicit efforts are made by firms and governments, particularly in OECD countries, to build up and preserve technological advantages. Those efforts reflect themselves in several indicators on intangible investments and on science and technology, as well as in firms' and governments' attitudes towards technology transfer and diffusion, which are considered below.

2. Intangible investments and R&D expenditures

Innovative activities are difficult to define and measure[5]. Expenditures on innovative efforts include investments in physical assets (machinery and equipment) and on intangible investments, which cover all long-term outlays by firms aiming at increasing future performance other than by the purchase of fixed assets. A major part of intangible investments are related to technology, either to develop the knowledge and competence base acquisition via licenses, etc., design, engineering and search activities) or to adequately exploit physical and other intangible investments (training, information and organization).

Evidence on several OECD countries, though still limited, clearly indicates that intangible investment is growing rapidly and that, by some measures, it now exceeds physical investment, driven by the recognition of the role of technology, skills and organization in competitiveness. Of particular importance is the growth of R&D, which has outstripped the growth in machinery and equipment (OECDa, 1992, p. 123). The analysis of recent trends in R&D in major industrialized countries is useful to understand perceptions and attitudes on technology transfer as well as future prospects in the matter.

First, as indicated by Figure 1, R&D expenditures have steadily grew since the 1970s. Their growth has been relatively unaffected by economic slowdown; growth rates have been higher than average GDP growth rates. These figures point to an increase in the rate of innovation, notwithstanding the limitation of R&D expenditures as an indicator on innovative efforts. While the unit cost of performing R&D specific tasks may have declined over the course of the past thirty years, in many areas of basic science and industrial R&D fixed costs have escalated and strain the financial resources of even large corporations (David, 1992, p. 12-13). In technology-intensive industries, economies of scale in R&D are high and give large firms an absolute cost advantage. Thus, the development of a new drug costs an estimated US$ 200 million, the largest portion of which is accounted for by development expenditures. An average of U$S 200 million to U$S 1 billion is required for each generation of process technology in the semiconductor industry (Ferguson, 1990). The development of Ford's Mondeo car cost U$S 6 billion, General Motor's Saturn U$S 5 billion, and Chrysler's Neon U$S 1,2 billion (Business Week, 3.5.93).

Second, the participation of the private sector in total R&D expenditures has also markedly increased (see Figure 2). This does not mean a retreat by the State in science and technology. In fact, the enactment of the Competitiveness Act in the United States and recent policy announcements by the Clinton Administration indicate a strengthened public role in R&D for civil applications[6]. The growing private involvement in R&D reflects the vital importance of technology competence to survive and grow in a globalized market. US corporations expenditures on R&D grew at 7,5% a year through the early 1980 (Fortune, 19.10.92) They spent U$S 74 billion on R&D in 1991, up 6,8% the previous year (Business Week, 29.6.92).

Third, R&D expenditures widely differ according to the sectors involved. Table 1 points out the intensity of R&D expenditure in the OECD area by industries. The marked differences in the expenditure/output ratio have been largely recognized by innovation studies (Dosi, Pavitt and Soete, 1990). While some sectors are essentially innovation users and receive innovations embodied in producer goods (e.g. textiles), others (scale intensive sectors, such as automobiles) are predominantly innovation producers; a third group, finally, also is a source of innovations for other sectors (typically, electronics and chemicals).

TABLE 1

Intensity of R & D expenditure in the OECD area

Weighing of 11 countries[1] - R & D expenditure/output ratio

1970		1980	
HIGH		HIGH	
1. Aerospace	25.6	1. Aerospace	22.7
2. Office machines, computers	13.4	2. Office machines, computers	17.5
3. Electronics & components	8.4	3. Electronics & components	10.4
4. Drugs	6.4	4. Drugs	8.7
5. Scientific instruments	4.5	5. Scientific instruments	4.8
6. Electrical machinery	4.5	6. Electrical machinery	4.4
MEDIUM		MEDIUM	
7. Chemicals	3.0	7. Chemicals	2.7
8. Automobiles	2.5	8. Automobiles	2.7
9. Other manufacturing industries	1.6	9. Other manufacturing industries	1.8
10. Petroleum refineries	1.2	10. Non-electrical machinery	1.6
11. Non-electrical machinery	1.1	11. Rubber, plastics	1.2
12. Rubber, plastics	1.1	12. Non-ferrous metals	1.0
LOW		LOW	
13. Non-ferrous metals	0.8	13. Stone, clay, glass	0.9
14. Stone, clay, glass	0.7	14. Food, Beverages, tobacco	0.8
15. Shipbuilding	0.7	15. Shipbuilding	0.6
16. Ferrous metals	0.5	16. Petrol refineries	0.6
17. Fabricated metal products	0.3	17. Ferrous metals	0.6
18. Wood, cork, furniture	0.2	18. Fabricated metal products	0.4
19. Food, beverages, tobacco	0.2	19. Paper, printing	0.3
20. Textiles, footwear, leather	0.1	20. Wood, cork, furniture	0.3
21. Paper, printing	0.1	21. Textiles, footwear, leather	0.2

[1] Australia, Belgium. Canada, Germany, Italy, Japan, Netherlands, Sweden, United Kingdom and United States.

Source: OECD

Fourth, there is an overwhelming geographical concentration of R&D. Developing countries on the most generous estimates accounts for only about 6 per cent and without China, probably less than 4 per cent of global R&D (Freeman & Hagedoorn, 1992, p. 10)[7]. Even within OECD the concentration is important. In 1989, seven countries accounted for 91% of total OECD expenditures. United States alone concentrated 47% of the total (30% of which was accounted for by defence activities), Japan 17,6% and the EC countries 28% (OECD, 1992b, p. 113)

Private R&D activities are also concentrated in terms of the firms that undertake them. Transnational corporations play a significant and increasing role in R&D . In the United States, for instance, 28 corporations account for about half the total private R&D expenditures[8]. Notwithstanding this concentration, a trend towards an international dispersal of R&D activities has been observed. Large firms are decentralizing part of those activities to foreign subsidiaries and branches mainly in other OECD countries. R&D spending by foreign sources reach high levels in Canada (26% of national expenditures), United Kingdom (16,9%) and Italy (9,6%). U.S. companies and their subsidiaries account for a large part of the total R&D spending by foreign firms in other countries (OECD, 1992b, p. 83-84).

The transfer of R&D activities to subsidiaries in developing countries has been made on a very limited scale, basically in relation to adaptive tasks (UN/TCDM, 1992, p.136). There are a few examples (mainly in India and Brazil) of transnational corporations establishing R&D activities, which indicate that such corporations may be attracted to build up R&D facilities but in rather exceptional cases where an adequate infrastructure and high quality personnel is available.

Fifth, as a result of the increased R&D budgets, the risks involved in high-tech research and the exacerbation of competition, in a context of slow economic growth, agreements for joint research have proliferated. On the one side, a number of public-supported programs have promoted joint undertakings either on precompetitive or competitive technologies. EC programs -such as ESPRIT- fall within the latter category, while Eureka aims at more short term marketable results. SEMATECH in the United States is a good -apparently successful- example of government support[9] for interfirm cooperation in a strategic field, not to mention the various cooperative programs launched by MITI in Japan.

On the other side, a large number of "strategic alliances" have been established in order to face growing technological and competitive challenges, particularly in the field of information technologies and biotechnology[10]. IBM alone joined over 400 strategic alliances; notably among them is the partnership with Toshiba and Siemens to develop a new generation of DRAM chips. Though many of such alliances seem to have met partners' expectations (examples of these include alliances between Corning and Dow Chemical; Merck and Astra; Ford and Mazda; Microsoft and Apple), according to one source the rate of failure is also high (one third of 49 alliances tracked), particularly when the alliances were focused on short term rather than on long term objectives (Fortune, 21.9.92). With the exception of some cases where firms from NICs are involved, strategic partnering has been limited to firms from industrialized countries. The reason is simple: "the key to being able to enter such relationships appears to be the possession by the NIE (New Industrializing Economy) of a key technology or some other complementary asset required by the OECD partner" (Ernst and O'Connor, 1989). Few firms in developing countries are in a position to offer such assets[11].

Finally, the organization of R&D activities is also changing from isolated units in corporate structures to a more interactive approach whereunder researchers work together with production, engineering and marketing personnel in the design and execution of new projects. As depicted by the interactive model of innovation at the firm level (Kline and Rosenberg, 1986), R&D tends today to be an integrated process characterized by continuing interaction and feedback. In this model, a close

contact between production and R&D is promoted, leaving little room for laboratories working in isolation within the corporation[12]. Another feature of new R&D is, according to Kodama, the combination of the traditional "breakthrough" approach by a "fusion" approach, i.e. the joint use of existing technologies (new materials, informatics, biotechnology) in order to reach "hybrid" technologies (e.g. mechatronics and optoelectronics). Big conglomerates with a wide range of product lines are the most likely to benefit from this approach where the old maxim "one technology-one industry" no longer applies (Kodama, 1992, p. 70).

In conclusion, several simultaneous trends are discernable in the field of innovation and R&D in industrialized countries. The increase of intangible investments and of R&D budgets suggests, on the one side, the growing importance of knowledge and skills in production and, on the other, the escalating costs that innovative firms (and countries) are due to pay in order to remain competitive. Private sector share of R&D outlays is growing and with it the appropriation of knowledge and most likely, the barriers to its diffusion (see section I.4 below). Despite the decentralization of some R&D from parent companies, the bulk of R&D continues to be concentrated in (a few) industrialized countries.

3. Product life-cycle and open economies

The shortening of the life-cycle of products, particularly in knowledge intensive industries, is a well known feature of the current innovation-led type of competition: "The fierce competition is shortening product life cycles in every generation. Every competitor has to hire more engineers to develop, manufacture and market new products as quickly as possible" (Uenohara, 1991, p.17).

The life-cycle of products theory has provided a convincing explanation for the behaviour of technology holders over the curve of maturity of a product.The emergence, maturity and decline of a product (or cluster of products) offer different opportunities of entry to potential competitors. At an earlier phase, investment costs and experience requirements are low, but technological and entrepreneurial competence must be high. At the maturity stage, knowledge requirements are low (it is largely embodied in machinery and codified skills) but physical investments are higher than in the early phase. Capital barriers and labour costs are then significant[13].

Said theory has also been useful to understand the dynamics of international technology transfer, which will generally take place at the mature stage, as a transferor's means to obtain extra-income through royalties from licensees or profits generated by foreign subsidiaries. Many large industrial firms systematically exploited their licensing potential during the 1960s and 1970s via transferring mature technologies to developing countries. Negotiations with licensees usually occurred only after the R&D effort was completed and the product or process standardized (Contractor, 1981, p. 40).

One implication of the life-cycle model is that the transfer of mature technology provides advantages to both the supplier and the recipient of technology. Given the age of the technology transferred, however, the recipient firms need to find "compensating advantages" to meet the competitive disadvantages arising from time lags in the transfer of technology. In Cooper's view "the existence of these compensating advantages in import- substituting economies is all too obvious: they take the form of effectively captive markets" (Cooper, 1991, p. 14). Many developing countries have undertaken since last decade drastic reforms aimed at liberalizing and opening their economies to foreign products, technologies and investments. In this new context, recipient firms will find more difficult, if it is possible at all, to compensate the referred competitive disadvantages, not only because they would have to compete with foreign products on the domestic market but also because they will often need to export in order to make their operations profitable.

Shorter life-cycles might induce technology holders to transfer their technologies at an earlier stage of the cycle, in order to recover more quickly R&D and other costs incurred in their development. Nevertheless, three considerations are likely to lead to a different behaviour. Firstly, the problems of appropriability of technology are crucial, particularly in high-tech sectors (see next section) and technology holders do not want to create new competitors. The success of Korean firms in learning transferred technologies and building up export capabilities was not an unnoticed phenomenon, as mentioned below. Secondly, with a more liberalized world economy, innovating firms may directly exploit their technologies on a world scale through trade: to the extent that tariff and other barriers have been reduced or eliminated, they need not to look for licensing or FDI to enter a given market. Thirdly, rapid substitution of products in a globalized market imply that old products become unprofitable soon and its transfer to third parties does not offer enough advantages neither to the technology owner (which might prefer to rely on its newest versions) nor to potential recipients.

A globalized economy with an exacerbated competition is likely to change, in sum, the patterns of technology transfer and, in particular, the relative importance of licensing. Open economies are likely to have a greater reliance on informal transfers of technology, i.e. those taking place through the import of equipment and capital goods, since neither the producers of said equipment nor those that may provide supportive services (engineering and consultancy firms) compete in the markets where the eventual recipients operate, and therefore they are not interested in delaying said transfers[14].

4. The privatization of science and technological protectionism

The knowledge created or improved by an innovative agent can be imperfectly appropriated by it. Imitation will take place at different rates depending, inter alia, on the kind of innovation, the firm's strategies, and the legal framework. Lead times are crucial in some sectors (e.g. microelectronics) for innovators to keep their technology-based competitive advantages; in others (e.g. pharmaceuticals), intellectual property rights are a key instrument to avoid imitation.

Appropriability problems differ among sectors. They have become most tangible in the high-tech areas where R&D costs are high and products are often easy to copy or imitate. A software product may be easily copied, at an insignificant cost. Personal computers, the driving force in the informatics market, can be "cloned" by reverse engineering their basic operating system (Basic Input/Output System). Biotechnology-based products can be soon imitated, once the gene sequence is known. Engineering techniques have become trivial and within the reach of most average skilled professionals in the field. Appropriability is particularly difficult where the products are just clones of substances existing in nature, like in the case of interferon, TPA and other human proteins now marketed as bio-pharmaceuticals (Correa, 1991, p. 55).

The close linkage between science and technology is one outstanding factor behind the appropriability problems in high-tech areas. Some biotechnology patents "are using current science just about as quickly as it emerges from research labs..." (Narin and Noma, 1985, p. 3). Notwithstanding the increase in R&D expenditures, a significant reduction in the number of scientific publications has been observed in the United States (La Recherche, 1989, p. 429). Moreover certain limitations have been imposed on foreign researchers and students to participate in high level courses and scientific meetings (Bifani, 1987, p. 13). As indicated by an OECD report,

"because of weakened government support and its increasingly close relationship with industry, science, considered as an independent institution with a code of professional rules, has come under great and ever increasing pressure. In particular, the norm of rapid and total disclosure of new knowledge has been subjected to extraordinary strains. Great financial awards can be earned by

keeping certain vital scientific knowledge secret and by moving with it to the business enterprise sector, which can reward the production of knowledge through participation in the flow of profits which result from it" (OECD, 1992a, p. 35)

Attitudes and strategies on transfer of technology are likely to be influenced by perceptions of and limitations on the appropriability of technological advances. Thus, leading computer firms (such as IBM) have systematically avoided licensing agreements and secured transnational activities almost exclusively via wholly-owned subsidiaries. Similarly, large software producers generally enter into distribution agreements in developing countries, which do not entail the communication of source-programs or other trade secrets. Exceptions to these attitudes are found in the framework of "strategic alliances", mostly entered into between partners from industrialized countries, as mentioned above. Such alliances seem to offer enough guarantees of fair play on technology property issues, which are in fact one of the key aspects in negotiations and contract drafting[15].

A growing trend towards technological protectionism has emerged in industrialized countries. In addition to the just described factors, an important cause of that trend has been the relative loss of technological leadership by the United States in certain areas[16]. Such a deterioration has been perceived by U.S. government and industry as associated not only to the proliferation of counterfeiting and piracy, but also to the existence of a too open scientific and technological system and of outward unbalanced flows between the United States and other countries (Office of Technology Assessment, 1985, p. 6).

Technological protectionism does not seem restricted, however, to one country or group of countries. European Economic Community technological programs as well as Eureka, while allowing the participation of some U.S. firms, are clearly targeted to enhance the technological competence of European firms at the pre-competitive and competitive level. Restrictive practices on the export of civil technology have also been reported in South Korea. According to one source, Japan prohibited the transfer of know-how for 200 major components and materials, most of which were of keen interest to Korean manufacturers, such as semiconductor materials, numerical controllers for robots, and laser printers (Lee International Newsletter, March 1991).

South Korean firms in fact faced increasing difficulties as they approached the frontiers in some industries:

"Korean firms developed dynamic memory chips in the past under the design assistance of relatively small-sized foreign firms. Work on the next generation chips, however, meant exploring the frontiers of semiconductor technology and also competing neck-in-neck with Japanese and American companies. As the stakes have risen in the chip game, the field of players has grown smaller worldwide, meaning that few, if any, of those left in the game can be counted on to sell state-of-art chip design technology to Korean firms. So, Korean had to tackle the 4M DRAM design alone. To avoid duplicate research and investment, the government stepped in and designated the R&D of the 4M DRAM as a national project. A consortium was organized with a public R&D institute playing the coordinating role of cooperative research activities with three private firms" (Kim, 1993, p.13).

The examined attitudes and trends are likely to reduce the possibility of a successful and rapid "catching up" process by developing countries mainly based on the acquisition and imitation of foreign technologies. If access to scientific knowledge is also more problematic[17], the need to integrate technology transfer with deliberate and endogenous technological efforts seems indispensable[18] . In other words, the opportunities that are opened by various channels of technology transfer and diffusion will be more and more confined to those countries and firms that are prepared and able to develop their own technological capabilities. Even the scientific cooperation may be affected to the extent that

"the growing economic relevance of research...increases pressures to limit the free dissemination of research results and to constrain the traditional openness of university laboratories where most basic research is performed in western countries" (Skolnikoff, 1993, p. 118).

5. Transfer of technology and the environment

Environmental problems have become a central issue in the international agenda and in policy actions in a growing number of countries. The global nature of environmental problems and their implications for a long term sustainable development, have prompted several national, regional and international initiatives.

A key -and still open- question is to what extent environmental concerns may and should shift the course of technological development in order to induce technological trajectories consistent with a sustainable development. This implies, in particular, that technology development should shift from end-of-pipe to process integrated concepts, involving both the design of process and products. Public R&D efforts devoted today to environmental issues in developed countries seem quite limited, and have not significantly grown during the past decade, despite a greater preoccupation on the matter. Environmental protection only represented 0,6% of total government R&D appropriations in United Sates in 1990, 1,4% in United Kingdom and 1,8% in Canada. Efforts are higher in New Zealand (4,8%), Germany (4,2%) and The Netherlands (4,0%). The so-called "environmental industry" (a still undefined industrial branch) would invest, in contrast, about 8-10% of its turnover estimated at around US$ 185 billion annually (OECD, 1992b, table 10 and p. 52).

An issue of particular relevance is the transfer of environmentally sound technologies. Given the present North-South asymmetries in innovation capabilities and the global reach of environmental problems, the access to such technologies by developing countries emerges as a crucial issue for any effective global action in this field. Improving the access to said technologies has been the focus of recent international negotiations, where diverging North and South positions have arisen.

Southern position has stressed the need to secure access to the latest available technology, and the importance of concessional transfers and of appropriate funding. Along these lines, the Tlateloco Platform on Environment and Development, adopted in Mexico in March 1991, stated that "the promotion of sustainable development is incompatible ... with restricted access to technology", and that developing countries should be guaranteed access to environmentally sound technologies "on a non-commercial basis", with the largest share of the costs of transfer borne by the industrialized countries. The document further recommended that a special international fund be set up to ensure that the developing countries receive access to and transfer of environmentally sound technologies and to strengthen their endogenous capacity. Similarly, the Beijing Ministerial Declaration on Environment and Development (June 1991) stressed the need "to ensure the transfer of environmentally sound technologies to the developing countries on preferential, most favourable, concessional and no-commercial terms". Northern position has advocated, in exchange, the need to ensure adequate compensation for innovators under non-concessional (commercial terms), and to limit the range of technologies under consideration, particularly to those concerning global warming.

Notwithstanding the referred divergences, some progress has been made towards expanding international cooperation in technology transfer in particular areas (see section II.2 below). This process has been facilitated[19] where a) the relevant technologies are not patent protected: in many cases solutions involve public-domain technologies or "soft" technologies (e.g. managerial expertise); b) problems and technological alternatives may be limited and hence the costs of possible actions can be estimated more precisely; and c) the causes of environmental strains are scientifically verified.

6. The industrialization process and changes in technology demand

Studies on innovation and industrialization undertaken in developed and some developing countries, have shed light on the sectoral differences in the process of technical change, and on the impact of varying stages of industrial development on the modalities and content of technology transfer.

On the one side, work by Dosi, Pavitt and Soete (1990, p. 92-98), provides a taxonomy that is useful to explain the main channels of technology transfer and diffusion in different sectors. "Supplier dominated sectors" are basically recipients of technology under informal channels (e.g. machinery and equipment), and may accede to state-of-the-art technology provided that financing and operating skills are available. In contrast, "scale-intensive sectors" and "science-intensive sectors", where R&D strengths are critical, are dependent upon transfers under more formalized ways (licensing, joint ventures), and subject to the opportunities and constraints that emerge from the trends described in the previous section.

On the other, such studies demonstrate that technology demand varies as the firms and the industry evolve through different technological stages[20]. At the initiation stage, mostly "mature" technologies are incorporated by firms in developing countries. The main means of non-equity transfer at this stage are:

- informal channels such as machinery and equipment;
- imitation through reverse engineering and other;
- technical assistance provided by Original Equipment Suppliers (OEM) (Kim and Dahlman, 1992, p. 439).

Though informal mechanisms predominate at this stage, technologies need to be acquired through more formal channels, including turn-key agreements and licenses, in cases relating to large scale industries (e.g. steel, petrochemicals) where complex processes and plant lay-outs are difficult to imitate.

FDI, on its side, is an usual channel of technology transfer at an early development stage, when local absorptive capabilities for unbundled technologies are limited. Latin American countries have heavily relied on this form of transfer during their import-substitution period. FDI has also been a dominant transfer channel in "second-tier" Asian countries (Malaysia, Thailand, Philippines)[21].

As the industrialization process advances, and firms move along technology learning curves, the utilization of formal channels grows. At the "internalization" stage, since firms "have already mastered the operation technology, the focus of technological efforts changes from the mastery of operation and low-level design technology in the initiation stage to the mastery of production-related technology such as manufacturing equipment, plant engineering, etc. and high level design technology" (Lee, Bae and Choi, 1988, p. 242). At this stage licensing and foreign direct investments become more important sources of technology transfer.

South Korean industrialization process illustrates changes in technology demand associated with different development stages. As indicated by Table 2, capital goods imports surpassed other means of technology transfer during the whole period considered, while FDI and licensing only became significant sources during the 1980s. In order to appropriately interpret these data it should be borne in mind that the Korean government promoted technology transfer at the early stage through the procurement of turnkey plants and capital goods, and that only liberalized FDI and licensing controls at the beginning of the 1980s (Lee, 1990).

TABLE 2
Foreign technology transfer to Korea
(US$ millions)

Source	62-66	67-71	72-76	77-81	82-86	87-89
Direct foreign investment	4.4	218.6	879.4	720.6	1,766.5	3,433.2
Foreign licensing	0.8	16.3	96.5	451.4	1,184.9	2,130.3
Technical consultancy	-	16.8	18.5	54.7	332.3	679.0
Capital goods imports	316	2,541	8,841	27,978	44,705	52,155

Source: Ministry of Finance for data on direct foreign investment and foreign licensing; Ministry of Science and Technology for technical consultancy data; and Korean Society for Advancement of Machinery industry for capital goods data. (Kim, 1991,Table 1)

The advances in the industrialization process of Asian countries and, to some extent, of some Latin American countries has led -in the light of the previous analysis- to changes in the content and modalities of technology demand during the last twenty years. As new industrializing countries reach higher levels of technological development, developed countries' firms face a more sophisticated demand, relating to products and technologies which have not yet reached the "maturity" stage. Unlike mature technologies, which are relatively easy to acquire, technology which is still changing and profitable is more difficult to be obtained, as mentioned above.

Innovation and industrial economic studies provide, in sum, a basis to understand diverging technology demands by firms and industries, in terms of formal and informal channels. A more detailed analysis and empirical evidence may further allow to identify the role of different modalities of technology transfer, as indicated in next section.

7. The role of different modalities of formal technology transfer

a) Trends in foreign direct investments

Foreign direct investment (FDI) constitute a vital channel for international technology and trade. During the second half of last decade, the growth rate of FDI has substantially increased vis-à-vis the period 1980-1985 (see table 3). Two aspects of this trend are relevant for our analysis.

TABLE 3

Inflows and outflows of foreign direct investment, 1986-1990

Country group	1986	1987	1988	1989	1990	1980-1985	1986-1990	1980-1985	1986-1990
	(billion of dollars)					Share in total (Percentage)		Growth rate (Percentage)	
Developed countries									
Inflows	64	108	129	165	152	75	83	-3	24
Outflows	86	135	161	201	217	98	97	-2	26
Developing countries									
Inflows	14	25	30	30	32	25	17	4	22
Outflows	2	2	6	10	8	2	3	1	47
All countries									
Inflows	78	133	158	195	184	100	100	-1	24
Outflows	88	137	167	211	225	100	100	-2	26

Source: UN/TCMD, Table I.1.

First, the growth of inflow FDI to developing countries has only been slightly lower in 1986-1990 than inflows to developed countries. However, developing countries' share in total FDI inflows has drastically fallen over the decade, from 25% to 17%. This means that developing countries, as a whole, are today a less attractive target for developed countries' investors. A few countries provide a noticeable exception to this trend, as mentioned below.

Second, it is worth noting the substantial increase of FDI outflows from developing countries. The Asian new industrializing economies (notably South Korea and Taiwan Province of China), are the leading source of such investments. Once those countries reached a certain level of industrial sophistication and became competitive in international markets, they have started to shift production facilities to other less industrialized developing countries, looking mainly for lower labour costs. Outward FDI by developing countries has also taken place in developed countries (in the case of Taiwan Province of China, up to 64% of its total outward stock), to a great extent in order to respond to protectionists threats and secure access to foreign markets (UN/TCMD, 1992, p. 22).

The analysis of FDI trends by developing countries' regions, confirms the growing weight of East, South and South-East Asian countries as suppliers and recipients of FDI. Thus, while the share in total FDI inflows of Latin American countries fell from 13% to 6% between 1970-1979 and 1986-1990, the respective share of said Asian countries increased from 6% to 9%. Singapore, Thailand, India and China have been among the main destinations of U.S. FDI in Asia[22]. Mexico and Jamaica are, in turn, two of the main recipients of investments in Latin America and the Caribbean. A substantial increase of FDI is expected in Mexico, as result of the North American Free Trade Agreement (NAFTA), if finally approved.

The main reasons for a higher growth rate of FDI flows to developing countries since the second part of the 1980s seem to be associated to:

a) the rapid economic growth of several Asian countries, such as South Korea, Taiwan Province of China, Singapore, China, and to a lesser extent of a few Latin American countries (Chile, Mexico) which offer expanding market opportunities;

b) the availability of low cost and skilled labour, mainly to undertake assembly and other low value added tasks for exportable goods. Hourly compensation for workers in manufacturing, according to one estimate, is almost sixty times lower in China than in the United States, forty times in India, seven times in Mexico and twenty three times in Thailand (Fortune, 14.12.93)[23].

c) changes in FDI legislation which eased or suppressed restrictions and controls.

Reasons described in b) above seem to be of particular importance for FDI taking place since last decade: "increasingly, companies began investing overseas as part of an integrated global production strategy which relies on significant cross-national transfers of intermediate and final products " (Wint, 1992, p. 1516). In some cases, such strategies go beyond setting up factories to take advantage of low-cost labour. Foreign companies are also looking to benefit from design and engineering by locals, such as in the case of Motorola in Singapore and Malaysia (and more recently, China), and IBM in India (in the software area). Under this new integrated approach by multinationals, FDI would tend to involve manufacturing, sales as well as research and development (Business Week, 17.5.93).

b) Foreign direct investment and licensing

Foreign direct investment (FDI) may be regarded as a modality of transfer of technology alternative to licenses and other non-equity forms[24]. The trends explained in section I and existing evidence seem to suggest a relative increase in the use of the former vis-à-vis the latter.

First, according to data in table 4, FDI inflows to developing countries have grown, during 1985-1990, faster than any other indicator of technology transfer (royalties and fees, capital goods imports and technical cooperation grants).

TABLE 4

Foreign direct investment and technology inflows for developing countries, 1990, and growth rates for 1980-1984 and 1985-1990.

(Billion of dollars and percentages)

Indicator	Values of flows,1990 (current prices in billions of dollars)	Average annual growth rates (percentage) 1980-1984	1985-1990
FDI inflows	32	3	19
Royalty and fees payments	2	5	12
Capital goods imports	155	-2	11
Technical cooperation grants	13	1	12

-Source: UN/TCMD, 1992, p.321

Second, internalized forms of technology transfer (i.e. those taking place intrafirm) are more likely to be preferred by technology holders when the technology changes rapidly and when potential recipients may pose competitive threats in world markets as future competitors (Lall, 1992, p.4-6). Several other factors seem to reduce transnational corporations choice for externalized modes of transfer:

"For one, recent developments in information technologies tend to increase the internationalization advantages of Transnational Corporations (TNCs). Those developments facilitate and cheapen the cost of intra-firm communication, coordination and control. The high costs of development and rapid obsolescence are likely to reinforce efforts of TNCs to secure a quicker pay-back through internationalization. Furthermore, the internationalization of the R&D expenditure noted earlier and the trend towards strategic alliances among TNCs in respect of the development and transfer of technologies limit the plurality of sources in the technology market. The deceleration in the growth of external resource inflows through official development assistance and private flows other than FDI would limit the ability of developing countries to acquire unpackaged technology. Finally, recent policy changes in developing countries in favour of FDI tend to reduce the cost of internationalization. Those factors are likely to increase the importance of FDI as an instrument of technology transfer" (UN/TCMD, 1992, p. 154-155)

Third, relying on licensing alone (from the point of view of the recipient) in order to obtain advanced technologies may limit access to state-of-the-art technologies. On the one side, financial constraints make technology transfer without capital investment less feasible for developing countries. On the other, technology suppliers' concern with confidentiality issues and intellectual property has increased significantly, as discussed above. FDI ensures a tighter control over critical technology assets "which OECD firms are increasingly reluctant to license" (Ernst and O'Oconnor, 1989, p. 107).

Fourth, not all relevant technological knowledge is appropriately codified and, hence, easily transferable. A good part of technology in use is of "tacit" nature, such as many details and materials specifications and expertise at the floor level. The transfer of "tacit" knowledge may eventually be secured through well drafted contracts; but the direct involvement of the technology supplier may be crucial where there is great technological distance between supplier and recipient.

In conclusion, FDI not only plays an important role as a means of technology transfer at earlier stages of development; it is also likely to increasingly become a substitute for unbundled licenses as far as state-of-the-art technologies are involved.

On its side, licenses will always provide an economical way of transfer -from the transferor viewpoint- of standardized, relatively simple and mature, technologies to recipients having absorptive capabilities. Licensing will also be the first option for small and medium enterprises lacking the financial resources to enter into equity ventures or FDI[25]. Licensing is also likely to be used in transactions between large industrial groups with comparable technological levels (Unctad, 1990a, p. 13).

c) Joint-ventures

Joint-ventures are another well-known option for technology transfer in many instances. An increase in the use of this modality has been reported (Unctad, 1988, p. 8). It has been particularly favoured in former socialist countries of Eastern Europe, as an entry device for foreign firms. At the beginning of 1989, there were over 1.200 companies with foreign capital participation located in said countries (Unctad, 1990a, p. 12). It has also been employed in developing countries, to a varying extent. In Malaysia, 175 joint-venture agreements were approved by the government between 1970

and 1987 (Jegathesan, 1990, p. 101). In Philippines, out of 821 agreements, 422 were accounted for by purely technical collaboration agreements, while 133 involved subsidiaries and 266 joint-ventures (Bautista, 1990, p 133).

In accordance with a generally accepted view, joint-ventures offer greater opportunities for the transfer of technology than other modalities, since domestic partners share in the ownership and management of the enterprise. Though a systematic assessment of the comparative advantages and disadvantages of this modality has not been conducted, it seems to lead to mixed results depending, among other factors, upon the terms of the particular agreements. The equity participation of the technology holder does not necessarily mean that he is actually committed to the success of the venture and to the transfer of know-how. Anecdotal evidence suggests that through royalties-plus-profits formulae and the capitalization of technological assets (or trademarks) and equipment, foreign parties may share little risks and offset any costs incurred to establish a joint operation. Thus, dissatisfaction has been reported in the Soviet Union with some joint ventures due, inter alia, to their concentration in trading, consultancy and services, the non-transfer of advanced technologies and the low start-up rate (Financial Times, 1.2.90).

d) New modalities

Strategic alliances provide an increasingly important channel for the acquisition and exchange of technology. In order to become a partner to these agreements, however, a party must possess technological or other assets, including access to large markets, efficient manufacturing capacity, speed of delivery and/or large cash reserves (Ernst and O'Connor, 1989, p. 198).

Strategic alliances are premised on and respond to specific characteristics of present competition and technological change (for a comprehensive analysis, see Mytelka, 1992). They are not a substitute for licensing and other forms of technology transfer between partners of unequal technological level. In fact, developing countries firms have only rarely been able to participate in such agreements. Noticeable exceptions are provided by South Korean firms in the semiconductor field (see table 5).

TABLE 5

South Korea: Technology Tie-Ups with Foreign Firms

Companies	Year	Foreign Partner	Content	Major Field
	1983	Excel	TT	
Samsung		DITTI	TT	
Semiconductor&		Micron Technology	TT	Memory IC's
Telecom		Sharp	TT	Logic IC's
	1984	DITTI	TT	Custom IC's
	1985	Intel	TC	
		National Semicon	TT	
	1986	IXYS	TJ	
	1981	AT&T	JV	
Goldstar	1982	AT&T	TT	TTL
	1983	Zilog	TT	Gate Array
	1984	LSI Logic	TT	

		AMD	TT	
	1985	LSI Logic	TT	
		Fairchild	TT	
	1986	United Microtek	TJ	
	1987	Toshiba	TT	TR's
Korea	1983	Toshiba	TT	Bipolar IC's
Electronics	1984	Toshiba	TT	Linear IC's
	1984	Inmos	TT	
Hyundai		TI	TT	
Electronics		Int'I CMOS	TC	Memory IC's
	1986	MOS Electric	TT	Custom IC's
	1987	Alto Corp.	TT	
Daewoo Telecom	1986	Zymos	TJ	ASICs

Note: TT: technology transfer TC: technological cooperation
TJ: technological joint venture JV: joint venture
Source: B.K. Electronics, Dec. 1987.

Some firms in new industrializing countries have looked for other means to obtain state-of-the-art know-how in high-tech fields. The straightforward acquisition of small and medium technologically advanced firms in industrialized countries is one of them. For instance, U$S 270 million were invested by a consortium made up of the Taiwan government and five private companies to acquire WYSE Technology Inc. of San José, California. This buy-out gave said consortium the control of nearly 50 percent of the U.S. market for PC screens. Other deals, including Acer Inc. US$100-million acquisition of computer system manufacturer Altos and US$4.4 million takeover of Counterpoint Computers. along with the US$100-million takeover of the former USX Corp.subsidiary American Bridge by continental Engineering, have reinforced the campaign to tap into U.S. technology as well as manufacturing and marketing techniques (Herald Tribune, 25.11.91).

These new forms[26] for ensuring access to technology is certainly beyond the reach of most firms in developing countries. But they indicate that, as the process of technological development proceeds, new channels emerge which may permit latecomers to compete in areas of rapid technological change and strategic importance. As suggested above, the forms of technology transfer and the degree of technological development appear again here as strongly interrelated.

8. Bargaining power of technology recipients

Technological development essentially is a learning process. Adoption of a new technology presupposes some absorptive capability, which in turn is enhanced by the adoption of a new technology. The ease of learning in a firm is generally related to the level of deliberate innovative efforts, particularly in R&D (OECD, 1992a, p. 51). The more technologically capable a firm, better positioned is it to select, negotiate and assimilate technologies. The content, including the contractual

clauses, of a technology transfer transaction will in general associated with the technological competencies the recipient firm has developed and with the innovative environment in which it operates.

Pérez has vividly depicted the typical attitudes of firms operating under highly protective conditions in Latin America:

"Under the Import Substitution Industrialization (ISI) regime, the attitude towards foreign technology was generally located at the extremes: either total dependency or total mistrust. On the one hand, technologically passive firms were naturally dependent on the suppliers, they bought technology as a sort of capital good and purchased technical assistance as a regular input. Complex negotiations to assure learning were rarely considered; suppliers were not seen as potential strategic partners, neither was technology understood as a strategic tool in competition with others or eventually even with the original supplier (as some of the Asians saw it). The gap between the local firm and the foreign supplier of technology was taken as natural and the link between them usually as permanent."(Pérez, 1992, p. 12).

Scattered evidence suggests, however, that an increase in the bargaining power, parallel to the development of endogenous capabilities, has taken place even under relative isolation form external competition. A learning process on how to negotiate licensing agreements was reported, for instance, as resulting from the process of technical learning in the Brazilian industrial machinery industry, as well as in a number of Indian firms which ably searched for and selected their technology suppliers (Chudnovsky, 1990, p. 14). In a comparative study on Argentina, Brazil and Mexico on petrochemicals and capital goods it was also found that the Brazilian firms were the most successful in the assimilation process,in the reduction of restrictive clauses and in unpackaging the received technologies. State policy that promoted R&D and prohibited restrictive clauses in technology transfer contracts was allegedly partly responsible for such a performance (Chudnovsky et al, 1993, p. 24).

The precedent paragraph suggests that, as the firms improve technologically, they strengthen their bargaining position to obtain required technologies. Such a bargaining position may also be strengthen by a close relationship with R&D institutes. In the case of South Korea, for instance, they "played an important role in strengthening bargaining power in acquiring foreign technology. Joint research with the firm provided opportunities for the latter to acquire enough prior knowledge about technology to import. Such prior knowledge enabled the firm to identify prospective technology suppliers and to have bargaining power in negotiation technology transfer. Once imported, such joint research provided a basis on which the firm could assimilate and adapt technology rapidly. In other words, during the maturity stage the private enterprise entered a joint research not so much to gain a significant research outcome as to gain initial knowledge about technology it was interested in acquiring. For example, when RCA asked for an unreasonable high royalty for its color TV technology, Korean consumer electronic firms entered a joint research with the local R&D institute. The outcome of the joint research strengthened the local firm's bargaining power to bring the royalty rate significantly down. When Corning Glass refused to transfer optical fiber production technology to Korea in 1977, the large cooper cable producers in Korea entered a joint R&D project with a public R&D institute. After 7 years of R&D, the locally developed optical cable was tested successfully on a 35-Km route in 1983. Although this local effort eventually grounded to a halt due mainly to slow progress in R&D, it nonetheless helped local firms gain bargaining power in acquiring foreign technology on favorable terms. Four firms entered licensing agreements with multinational enterprises in 1984." (Kim, 1993, p. 8, 9, 11 and 12).

An important issue for further research is how a new and more competitive scenario in open economies may affect the bargaining position of potential recipients in developing countries. On the

one side, firms need to pay more attention to quality, productivity and other implications of technologies acquired. The market shall not any longer bear any cost or product deficiencies. The efficiency in transfer of technology becomes a more relevant consideration and up-to-date technology is necessary to compete. The range of potential suppliers is, hence, likely to become more limited.

On the other side, the strengthening of intellectual property regimes is likely to push royalty rates upwards. Evidence in this sense already exists in the United States (Dwyer, 1989). Anecdotal information also suggests an increase in particular areas, such as in pharmaceuticals and the electronics sector. South Korean firms, for instance, have reported that when they can obtain licenses (what is increasingly difficult) royalty rates being demanded are much higher than ever before. About 10% of the cost of producing electronics goods in Korea goes to royalties (Lee International Newsletter, March 1991). Texas Instruments demanded Samsung a 3% royalty on gross sales in order to allow Samsung to continue using patented technology in personal computers (ibidem). IBM requested clone makers to pay a 3% royalty on sales value for entry into PS/2 microcomputers and 1% on original IMB-PC clones sold since 1982 (Jun, 1989. p. 55).

If the analysis made in the previous sections is correct, the new global scenario and the growing reluctance to transfer critical technological assets will most probably increase technology prices, despite the observed improvement in bargaining capabilities of potential recipients firms.

II. NEW REGULATORY FRAMEWORK

1. Changes in the intellectual property system[27]

a) Protection and enforcement of intellectual property rights within GATT

After almost five years of negotiations, a draft Agreement on Trade-Related Intellectual Property Rights (TRIPs) has been submitted by GATT Director General in December 1991 as part of a proposed "Final Agreement" of the Uruguay Round. If finally adopted, the TRIPs Agreement will be one of the most far reaching international instruments ever subscribed on intellectual property rights (IPRs). It covers all types of IPRs, with the sole exception of breeders' rights (only incidentally referred to) and of utility models (or "petty patents").

The TRIPs Agreement will establish minimum universal standards on patents, copyrights, trademarks, industrial designs, geographical indications, integrated circuits and undisclosed information (know-how). It will supplement with additional obligations the Paris, Berne and Washington Conventions in their respective fields. Though freedom shall still remain to legislate on various aspects at the national level, the Agreement shall harmonize to a great extent the substantive (and some procedural rules) on IPRs.

In addition to the well established principle of "national treatment", the commented draft extends to IPRs the "most-favoured-nation-clause". These principles tend to ensure non-discrimination, on the one side, between foreigners and nationals and, on the other, between nationals from different countries. This latter type of discrimination has arisen out in intellectual property as a result of unilateral actions that led to concessions only benefitting the nationals of the country that pressed for the reforms.

In the copyright area, the Agreement explicitly stipulates the protection of software as a literary creation and provides -for the first time in an international agreement- for rental rights in respect of phonograms, films and computer programs as well as for the protection of compilations of data. It establishes a minimum term of protection for works not belonging to natural persons: fifty years from publication or from creation (if publication was not made within fifty years from the making of the work)[28]. Enforcement rules are considerably strengthened by the obligation to establish criminal procedures and penalties against copyright piracy on a commercial scale.

Trademarks protection is also harmonized and reinforced by establishing a minimum permissible period of non-use and the possibility of justifying it by "valid reasons based on the existence of obstacles" (article 19). It also supplements the Paris Convention with regard to the protection of "well-known" trademarks, among other norms.

A crucial chapter of the TRIPs draft Agreement relates to patents. It neatly reflects the above-mentioned trends relating to patentability, limitation of working obligations and extension of duration. Patents should be granted without discrimination as to the place of the invention and the field of technology. The draft Agreement thus settles the so far conflicting issue of pharmaceutical product patents, which under the TRIPs Agreement should be fully recognized. For biotechnological inventions, however, and as a reflection of the complexity and still unresolved differences on the issue, the draft only provides for a transitional solution (to be reviewed within four years)[29].

The draft text states the rights to be conferred under a patent, including the protection of a product directly made with a patented process, and an exclusive right to produce, sale and import the protected

product. Though no explicit rule was finally introduced, article 6 allows member countries to legislate on exhaustion of rights and, therefore, to admit parallel imports if they wish to do so. The reversal of burden of proof is stipulated for process patents in order to strengthen the patentee's position in case of infringement. The minimum patent lifetime is determined as twenty years counted from the filing date.

Additionally, detailed norms are provided for to limit the conditions under which compulsory licenses may be granted. National laws could not discriminate in this regard on the basis of whether the patented product is locally produced or imported. Compulsory licenses should be non-exclusive and terminate when the circumstances that originated their granting cease to exist. There is no specification on the grounds under which such licenses can be granted, but particular reference is made to the cases of dependency of patents, licenses for governmental non commercial use and to remedy anti-competitive practices. The text is also open on the rights that can be exercised by the licensee, which may hence include production or importation.

In the area of "undisclosed information", trade secrets are deemed protectable under the rules of unfair competition and article 6 bis of the Paris Convention. In addition, obligations are imposed in relation to test results and other data submitted to governments to obtain approvals of pharmaceutical or agrochemical products. Such tests and data should be protected against disclosure and unfair commercial use.

As far as integrated circuits are concerned, the TRIPs draft Agreement requires compliance with the still unratified Washington Convention on the Protection of Intellectual Property in respect of Integrated Circuits, with a few -but important- additional obligations in connection with the protection of industrial products containing chips, innocent infringement, compulsory licenses and the term of protection.

The GATT proposal on TRIPs also contains detailed provisions on judicial and administrative procedures and other measures related to the enforcement of rights, as well as specific rules to combat counterfeiting.

The draft Agreement includes transitional provisions that would allow developing countries to delay its implementation up to ten years. However, GATT member countries would be obliged to recognize "exclusive marketing rights" during that transitional period in relation to pharmaceutical and agrochemical products that have been patented and approved for commercialization abroad and in the country in question.

Non-compliance with the new rules, once adopted, can be the basis of a dispute settlement procedure under the GATT rules and, eventually, of commercial retaliatory measures in any field (and not only in IPRs) by the country whose nationals are affected by such non-compliance. Since the respect for the new universal standards becomes within GATT a quid pro quo in the commercial arena, the likelihood of deviations from those standards is drastically reduced, unless a country is prepared to absorb the costs of trade restrictions that may be imposed against it.

b) Restrictive practices in licensing agreements

i) General Principle

Section 8 of the draft Agreement contains a set of rules aimed at the control of "anti-competitive practices" in voluntary licenses. These rules may be regarded as one of the concrete applications in said Agreement of the general principle stated in article 8.2, according to which "appropriate measures,

provided that they are consistent with the provisions of this Agreement, may be needed to prevent the abuse of intellectual property rights by right holders or the result to practices which unreasonably restrain trade or adversely affect the international transfer of technology".

The text in article 40.1 recognizes that some licensing practices pertaining to intellectual property rights which restrain competition "may have adverse effects on trade and impede the transfer and dissemination of technology".

ii) National legislation

Article 40.2 expressly allows countries to adopt measures to control or prevent certain licensing practices, but while doing so establishes limits for national action. The test to judge the practices to be controlled or prevented should be based on three elements:
a)the judgement of practices should be made in particular cases;
b)practices should constitute an "abuse" of intellectual property rights, a concept which will probably vary among different countries;
c)they should have an "adverse effect on competition in the relevant market". What the "relevant market" is remains open to interpretation. Thus, while applying this provision, Parties may look at the market of the products or services produced with a licensed technology, but also to the market of the technology itself.

Based on the referred elements, article 40.2 clearly adopts the competition test and the rule of reason to assess anti-competitiveness, and thus settles a debate that divided developed and developing countries during the long and unsuccessful negotiations on an International Code of Conduct on Transfer of Technology. For many participants and observers, this clause would achieve what the proposed Code attempted to obtain, and even more. In one sense this is correct. If the draft Agreement is adopted, for the first time there will be some rules on restrictive practices in licensing contracts in a binding international instrument. The Code of Conduct had been conceived, instead, as based on merely voluntary compliance. Article 40.2 of the TRIPs draft Agreement, however, falls short in respect of the Code objectives in many aspects. Most important among them are, on the one side, the fact that said article only allows national legislation to adopt measures, but (with the exception of a few examples considered below) does not contain internationally agreed rules on the practices that may be deemed anti-competitive. On the other, the proposed Code included other substantive chapters on obligations and responsibilities of parties engaged in technology transfer transactions, international cooperation and settlement of disputes. The GATT draft Agreement is silent on these issues.

iii) Practices that may be deemed abusive

Article 40.2 provides a few examples of practices which may be deemed restrictive. They include:
a) exclusive grant back provisions, i.e. those that oblige the licensee to transfer the improvements made on the licensed technology exclusively to the licensor;
b) obligations imposed on the licensee not to challenge the validity of licensed rights;
c) coercive package licensing, i.e. the obligation for the licensee to acquire from the licensor other technologies or inputs he does not need or desire.

It would be interesting to clarify the reasons that the drafters of the commented proposal had to select the three mentioned examples. Previous versions of the document included a significantly longer list where restrictions on research and on use of personnel, price fixing, exclusive sales or representation agreements, tying agreements, exports restrictions and other practices were mentioned[30]. One possible explanation is that there may exist some consensus to consider the clauses used as examples, subject to certain conditions, as anti-competitive. One problem is, however, that section 8

applies to all types of intellectual property and certain practices which may be generally deemed as condemnable for some titles may not be equally viewed when related to other types of intellectual property[31]. In any case, an advantage of the provision is that any restrictive clause could be subject to scrutiny, provided of course, that the stipulated test is applied.

iv) Consultation system

One peculiar feature of section 8 is that it establishes a consultation system applicable for cases where a Party (Party A) considers that a national or domiciliary of other Party (Party B) is undertaking practices in violation of the former s laws and regulations on anti-competitive practices. In this situation, Party A may request for consultations with Party B and the latter "shall accord full and sympathetic consideration to, and shall afford adequate opportunity" for such consultations. In addition Party B is obliged to cooperate "through the supply of publicly available non-confidential information of relevance to the matter in question and of other information available to the Party, subject to domestic law and to the conclusion of mutually satisfactory agreements concerning the safeguarding of its confidentiality by the requesting Party" (article 40.4).

In other words, Party B may be request to supply publicly available as well as confidential information, but in the case of the latter its supply only refers to information which is "available to that Party", what would exclude trade secrets except if in possession of the government (for instance, as a result of a submission for marketing approval of a product). The transfer of such information, in addition, is conditional upon national legislation of Party B and the establishment of confidentiality agreements with Party A. It may be expected that, under these conditions, the actual access to confidential information will be quite limited, if possible at all.

Consultations may also be requested by a Party whose nationals or domiciliaries are subject to proceedings in another Party concerning alleged violations of the latter's legislation on anti-competitive practices. In this case, the requesting Party "shall be granted an opportunity for consultations" (article 40.4) with the other Party under the same conditions as in the case presented above.

In the two referred situations, consultations will be without prejudice to any action under the relevant national law and "to the full freedom of an ultimate decision of either Party" (article 40.3), that is, judicial or administrative authorities will be free to decide in accordance with their own judgement of facts under the applicable law.

c) Developments within WIPO and UPOV

Various negotiations have taken place in the framework of the World Intellectual Property Organization (WIPO) during the last decade, in addition to the work of experts groups on several important issues such as counterfeiting and biotechnological inventions[32]. Such negotiations have included the revision of the Paris Convention, the harmonization of patent law and the establishment of a treaty on layout designs of integrated circuits.

The negotiations for the revision of the Paris Convention were prompted by developing countries during the 1970's and in a completely different international scenario. After more than a decade, those countries' efforts proved unsuccessful and were bound to failure since intellectual property was incorporated into the Uruguay Round, in 1986, as one of the "new issues". Developing countries demands for special treatment and other measures to strengthen compulsory licenses were completely overridden by changes, precisely in the opposite direction, more effectively articulated by industrialized countries within GATT.

The far-reaching proposal to harmonize patent legislation launched by WIPO has still an uncertain outcome[33]. The proposal -as contained in the WIPO's Director General draft text to The Hague Diplomatic Conference- touches upon various technical and procedural aspects (disclosure, claims, unity of invention, filing date, right to a patent, amendment and publication of applications). Among these issues, one has been (and continues to be) particularly controversial: while almost all countries in the world confer patents on the "first to file" principle, United States do it according to the "first to invent" rule.

The patent harmonization proposal also refers to several substantive issues such as the rights conferred under a patent, the duration and the fields of technology where patents should be granted. These issues have not yet been tackled by the Diplomatic Conference; in exchange, they have been addressed within TRIPs negotiations in GATT, as indicated above.

A third area where WIPO has been active in the development of international rules, is the protection of the layout designs of integrated circuits. Based on the sui generis approach first adopted by the U.S. legislation in 1984, a Treaty was negotiated and finally adopted by a Diplomatic Conference held in Washington in 1990. The Treaty provides for minimum standards relating to such designs whether fixed or not, for at least eight years. It authorizes reverse engineering and the granting of compulsory licenses.

The Washington Treaty has not yet entered into force. Paradoxically, United States, the country originally most interested in its adoption rejected the text finally adopted by the Conference. Japan also joined this position. Nevertheless, the TRIPs Agreement would supplement the Washington Treaty precisely in respect of the points that caused the U.S reluctance to sign and ratify the latter.

WIPO has also launched an initiative to negotiate an additional protocol to the Berne Convention, in order to supplement its provisions particularly in connection with computer programs, data bases, works made with a computer, and monograms. It is unclear yet whether this initiative will find enough support, in view of the agreements already reached on those matters in TRIPs negotiations.

The contents of plant varieties protection is, as noted before, one of the few areas not specifically dealt with in the TRIPs draft Agreement, which would only oblige member countries to protect such varieties via breeders' rights, patents or a combination of both.

While TRIPs negotiations were in course, the Union for the Protection of Plant Varieties (UPOV) convened, after thorough preparatory work, a diplomatic conference to revise the UPOV Convention. The new version, finally adopted in 1991, introduce a number of significant changes with respect to the 1978 text (Correa,1992).

d)Implications for technology transfer

The just described changes are likely to have implications on different aspects of the creation, diffusion and transfer of technology in and to developing countries. Those implications, however, will considerably vary in accordance with the level of development of the countries concerned and with the firms and sectors involved. A stronger or wider protection of IPRs may stimulate local innovation, provided that a certain level of technological development has been achieved. Transfer of technology may be affected in several ways.

On the one side, the existence or reinforcement of protection may be perceived by potential technology suppliers as a condition for transferring certain technologies. On the other, such a protection is likely to reinforce their bargaining power to determine royalty rates and other contractual conditions. If -as proposed in TRIPs- the working obligation of patents is diluted or eliminated, foreign

patents may be exploited just by importing the respective products into the country of registration. Given the globalization of the economy, the continued importance of economies of scale in various sectors and the reduction of tariff protection in many developing countries, it is likely that innovating firms in the North tend to increasingly exploit their inventions through trade -rather that through licenses or FDI- in the South. This explains why GATT -a trade related negotiating forum- has played such a significant role in the development of international rules on IPRs.

2. International rules on the environment and biodiversity

The review of environment-related conventions indicates a trend towards increasingly precise commitments regarding technical assistance and technology transfer in certain well defined areas. The Long-Range Transboundary Air Pollution (LTRAP) Convention (1979), called for technical cooperation in general terms among signatory countries. Its Protocol on nitrous oxide (1988) required parties to "facilitate the exchange of technology to reduce emissions" (on a commercial basis). The Basel Convention (1989) went a little farther and obliged parties to "employ appropriate means to cooperate in order to assist developing countries in the implementation" of the Convention and to "cooperate in developing the technical capacity among Parties, especially those which may need and request technical assistance in this field". Far more concrete was the Montreal Protocol on Substances that Deplete the Ozone Layer (as amended in London, in June 1990). It established a multilateral fund to meet, on a concessional basis, incremental costs of developing countries's compliance with the Protocol obligations and to finance "clearing-house" functions. In particular, article 10.A states that:

"Each party shall take every practicable step, consistent with the programmes supported by the financial mechanism, to ensure:

a. that the best available, environmentally safe substitutes and related technologies are expeditiously transferred to [developing country] Parties ...; and,

b. that the transfers referred to in subparagraph (a) occur under fair and most favourable conditions".

An interesting example of international cooperation in the transfer of technology, has taken place with the setting up of an association of large industrial users of chlorofluorocarbons CFCs, the Industry Cooperative for Ozone Layer Protection (ICOLP). ICOLP, as an intermediary institution has participated, for instance, jointly with Northern Telecom, the U.S Environmental Protection Agency and the Mexican state environmental agency, in a training and demonstration project on CFC solvent conservation and elimination in the Mexican electronics industry. Northern Telecom supplied a spray misting technology proven to be environmentally sound as well as feasible and efficient.

A major effort to set out an international framework for the transfer of environmentally sound technology reflected itself in the negotiation of Chapter 34 of Agenda 21 at the UNCED Plenary in Rio de Janeiro, in June 1992. The adopted text recognizes the need of a favourable access to and transfer of environmentally sound technologies, in particular to developing countries (art. 34.4) and that "proprietary technology is available through commercial channels, and international business is an important vehicle for technology transfer" (art. 34.11). Among the Objectives, the Plenary proposed

"To promote, facilitate, and finance, as appropriate, the access to and the transfer of environmentally sound technologies and corresponding know-how, in particular to developing countries, on favourable terms, including on concessional and preferential terms, as mutually agreed, taking into account the need to protect intellectual property rights as well as the special needs of developing countries for the implementation of Agenda 21" (article 34.14).

The referred Chapter also contains a detailed provision on activities for the "support and promotion of access to transfer of technology", including measures to prevent the abuse of intellectual property rights and compulsory licenses. The relevant text reads as follows:

"Governments and international organizations should promote, and encourage the private sector to promote, effective modalities for the access and transfer in particular to developing countries of environmentally sound technologies by activities, including the following:

a) Formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain;

b) Creation of favourable conditions to encourage the private and public sectors to innovate, market and use environmentally sound technologies;

c) Examination by Governments and, where appropriate, by relevant organizations of existing policies, including subsidies and tax policies, and regulations to determine whether they encourage or impede the access to, transfer of and introduction of environmentally sound technology;

d) Addressing, in a framework which fully integrates environment and development, barriers to the transfer of privately owned environmentally sound technologies and adoption of appropriate general measures to reduce such barriers while creating specific incentives, fiscal or otherwise, for the transfer of such technologies;

e) In compliance with and under the specific circumstances recognized by the relevant international conventions adhered to by States, undertaking measures to prevent the abuse of intellectual property rights, including rules with respect to their acquisition trough compulsory licensing, with the provision of equitable and adequate compensation:...

f) Develop mechanisms for the access to and transfer of environmentally sound technologies, in particular to developing countries, while taking into account developments in the process of negotiating an international code of conduct on transfer of technology, as decided by UNCTAD at its eighth session in Cartagena" (article 34.18).

Discussions and recent studies on the transfer of environmentally sound technology have helped to clarify various issues.

First, like in the case of the transfer of other technologies, the capability of the recipient party to select and effectively absorb the concerned technology is a decisive factor. Therefore, the building up of "institutional capacity within developing countries is of crucial importance (e.g. technical training, increased awareness of existing environmental problems, access to information about preferable alternatives)" (World Resources Institute, 1993, p.3).

Second, shifting away from old, environmentally unfriendly technologies, may not only have positive environmental effects but increase at the same time efficiency in production.

Third, the problems of access to environmentally sound technology is not necessarily a purely supply problem: a major constraint is likely to rely on the demand side, due to the lack of economic incentives to introduce changes and improvements (which often are costly), limited information on available alternatives and absence of effective public policies. In order to encourage, hence, the transfer and adoption of environmentally sound technologies new instruments may need to be devised such as taxes and incentives, financial mechanisms and improved information systems.

The Biological Biodiversity Convention is another outcome of the Rio Conference which contains significant provisions on technology transfer. Article 16 of the Convention states that each Party undertakes to provide and/or facilitate other Parties the access to technologies relevant the conservation and sustainable use of biodiversity or which make use of genetic resources and do not cause significant harm to the environment. Such an access shall be provided and/or facilitated under fair and most favourable terms, including mutually agreed preferential and concessional conditions. The adequate protection of intellectual property rights should be taken into account, wherever protected technology is involved.

Two other important provisions in article 16 establish that each Party shall take measures a) to ensure other Parties, particularly developing countries, that provide genetic resources, access to the technologies that use such resources and the transfer of said technologies on mutually agreed conditions; and b)for the private sector to facilitate access to technology, its joint development and its transfer to governments and the private sector of developing countries. Finally, a financial mechanism, eventually applicable to technology transfer transactions, will be established (articles 20 and 21).

The referred provisions represent a considerable step forward to the extent that they set out basic principles and define some obligations of the signatory countries. They need, however, to be implemented adequately and to be further developed in order to deal with particularly complex cases[34]. The United States, while ratifying the Convention, has announced an interpretive statement in order to make clear that agreements concerning access to and transfer of technology must be voluntary and consistent with an adequate protection of IPRs, thus excluding the eventual application of compulsory licenses.

Environmental concerns as well as the new international rules on biodiversity may, in sum, constitute a new and important factor influencing the transfer of technology, both in terms of the contents of the techno.ogical "packages" transferred as well as of the new initiatives that, at the national and international level, may be adopted to stimulate the demand and implementation of environmentally sound technologies.

III. CONCLUSIONS AND POLICY OPTIONS

The previous sections have described a number of trends which have changed the scenario for cooperation in the field of transfer of technology. Of course, the analysis is not exhaustive, but it provides some elements that may be helpful for policy formulation at the government and firm level. The main conclusions of said analysis are summarized below.

Technology plays today a key role in the development process and in the creation of competitive advantages. Intangible investments are growing in industrialized countries as a proportion of total investment. R&D, which accounts for a growing share of GNP, is highly concentrated in said countries, despite recent trends towards decentralization of R&D activities by large firms. The increased costs of R&D -which significantly differ by industry- have given raise to new modalities of cooperation, both government supported (e.g. European research programs) and directly established by interested enterprises.

The main implications for developing countries of the before mentioned trends are twofold:

a) entry barriers posed by intangible investments and, in particular, R&D costs continue to grow and further consolidate the market power of the major firms of industrialized countries;

b) changes in the access to and transfer of technology are likely to occur, given the strategic character of innovation and its increasing cost. As discussed below, the impact of these trends is accentuated by the shortening of the life-cycle of products and by the globalization of the economy.

Pari passu with the described trends, the globalization of the world economy, the liberalization of developing countries' economies, the shortening of the product life-cycle and the exacerbation of competition, are modifying the patterns of technology transfer. Potential technology recipients that can not enjoy any more compensating advantages to apply mature technologies in sheltered markets, need to become more efficient and qualified in order to obtain and exploit licensed technologies.

A general problem is, however, that in the new international scenario, strong pressures exist towards the privatization of scientific knowledge and protectionism of technology. This trend may not only affect scientific international cooperation -essential for the development of science worldwide- but also limit the access to the most modern and competitive technologies. Signs of said protectionism have been evident in the most advanced developing countries and also manifest themselves in the present initiatives for strengthening IPRs.

Environmental issues still receive little attention in terms of R&D resources devoted by industrialized countries, but are likely to constitute an important factor in innovation and technology transfer. Notwithstanding marked North-South differences on these issues, progress has been made in concrete cases of transfer of technology sound technologies as well as in the development of a number of international conventions and principles.

Technology demand changes as a country reaches different levels of technological and economic development. Formal channels of technology transfer prevail as the industrialization process advances, where FDI and licenses become more important than the purchase of machinery and other informal modalities of transfer. FDI inflows to developing countries have grown during 1985-1990 -attracted by a few fast growing developing countries, mainly in Asia- but said countries' participation in total FDI inflows has fallen 8% during the last decade.

FDI does play an important role as a means of technology transfer at early stages of technological development, when domestic absorptive capabilities are weak. Given the key importance of technology as a competitive asset and the protectionist trend pointed out above, it is also likely to increasingly become a substitute for unbundled licensing whenever state-of-the-art technologies are involved.

While joint-ventures have not fully delivered yet their promise as appropriate vehicles for technology transfer, new forms of technological cooperation have emerged. The latter -most notably strategic alliances- offer new ways of acceding to technologies, but are mostly confined to enterprises from industrialized countries or from the most advanced developing countries.

The bargaining power of technology recipients has not been substantially improved, according to the available evidence, by regulations on technology transfer applied in many developing countries. The bargaining power seems to improve as the recipient's technological capabilities increase, either in-house or based on cooperation with public laboratories and research centers. The new global scenario and the reluctance of innovative firms to part with their technology suggest that trade in technology may be subject in the future to increasingly hard terms and conditions for the recipient party.

Finally, the study has reviewed in some detail a number of regulatory trends at the international level. Most relevant for technology transfer issues are the developments within GATT and other fora, which tend to increase the levels of IPRs protection. It is too early to assess the likely impact of these

changes, particularly on IPRs, but they are undoubtedly giving potential technology suppliers more freedom to select the ways of internationalization of their operations and, in particular, to use trade as a main means of exploitation of innovations.

Based on the precedent analysis, a number of policy options may be indicated:

Technology and development policy

The growing importance of intangible investments, including R&D, is a clear indicator of the key role played by technology in global competition and economic growth. Access to and mastery of technology are to be viewed today as a main target of any development policy.

A new focus for transfer of technology

Evidence referred to above indicates that the regulation of contractual aspects of technology transfer transactions may improve the negotiating position of potential recipients. The building up of absorptive capabilities seems to be, however, the essential strategy at the country and firm level. This is a complex and time-consuming process which requires the supplier cooperation but, above all, an innovation-inducive environment and deliberate efforts by recipient firms. Technology transfer policy should strongly focus on the creation of conditions for such a process to take place.

On the other side, the opening of previously sheltered economies is forcing firms in many developing countries to compete with more technologically advanced firms. Lacking factors that may compensate the age of technologies acquired and other comparative disadvantages, recipient firms need to become more efficient in the process of selecting and absorbing transferred technologies. Policies should assist recipients to meet these new requirements.

The role of foreign direct investment

In the current competitive scenario, as mentioned, FDI is likely to play an increasingly important role as a channel for technology transfer both for mature technologies where the recipient's technological capabilities are low and for high technologies that innovating firms are reluctant to license to unrelated parties. Since FDI may be, in this new scenario, a substitute for licensing in many situations, technology transfer policies should be adequately integrated with investment policies, taking into account the changes brought about by the globalization of the world market in respect of FDI patterns.

New and old approaches to technology transfer

Strategic alliances as well as the acquisition of technology-intensive firms in industrialized countries, offer the most advanced developing countries new approaches to get access to modern technologies, but are not available to most firms in developing countries. The latter may, however, expand the utilization of modalities that have been extensively used in some Asian countries, such as subcontracting and OEM arrangements. These may lead to a substantial technological learning and job creation. Rather than a single channel of technology transfer, developing countries should endeavor to combine new and old modalities, depending on their degree of development and the sectors involved.

Technology and competition

The possession of technological advantages, particularly if protected by intellectual property rights, creates a considerable market power. Adequate measures are necessary at the national level in order to avoid abuses that unreasonably affect competition. Technology policy should therefore be associated to a sound competition policy able to stimulate innovation and fair deals in technology transfer. Action aiming at reinforcing legislation on anti-competitive practices should be encouraged.

Technology and the environment

The development of environmentally sound technologies may be in the years to come one important source of technological change. Developing countries' access to such technologies (as well as to those that preserve biodiversity) should be stimulated acting on the supply as well as on the demand side. Policies should eventually incorporate incentives and compensations for firms adopting technologies better suited to the environment.

Research on technology transfer issues

Notwithstanding the extensive literature on technology transfer produced since the 1970s, a fragmented theory and little evidence are available on various issues referred to in this paper. Further research is needed, in particular, on the impact of intellectual property rights on technology flows, and on the implications of the emerging scientific and technological protectionism for the access to and pricing of technology.

Action by international organizations

Programs on technology transfer of international organizations should take the new realities and trends in developed and developing countries into account. Specific issues to be addressed at the policy level may include:

- linkages between technology transfer and building up of absorptive and innovative capabilities at different stages of development;
- relationship between transfer of technology and competition policies and legislation;
- the role of investments, particularly, of FDI, in the transfer of high-technologies;
- implications of subcontracting and OEM arrangements for technological learning.
- implementation of the Biodiversity Convention and of UNCED Agenda 21 in respect of transfer of technology issues.

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Footnotes

1. For the purposes of this paper "formal" modes include foreign direct investments, the purchase of turn-key plants, patent licenses, transfer of know-how, the supply of technical assistance and the like; "informal" mechanisms refer to imports of machinery and other forms of disembodied technology diffusion such as reverse engineering. Innovation studies have often referred to these different modes of technology transfer as "indirect" and "direct" (Cooper, 1991, p. 13).
2. These industries increased their share of total manufacturing investmnent from 25-30 per cent in major OECD countries in the mid- 1970s to around 50 per cent by the late 1980s (OECDa, 1992, p. 122).
3. "Technology gap/product cycle" theory, in particular, has shed light on North-South asimmetries and on the impact of technology capabilities on international trade.
4. See in this regard the "new" growth theories which emphasize the role of expenditures on R&D, human capital formation and investments in the diffusion and promotion of technical change (Romer, 1989).
5. For useful guidelines on the matter, see the "OECD Proposed Guidelines for Collecting and Interpreting Innovation Data-Oslo Manual" (1990).
6. The U.S federal budget proposal for 1993 earmarked U$S 803 millions for high performance computing and networking, U$S 1,8 billion for advanced materials and processing research, and U$S 4 billion for biotechnology, among other expenditures on R&D.
7. The North-South asimmetry in this respect is ilustrated by the fact that the U.S. top firm by its expenditure on R&D (General Motors) spends more than all Latin American countries in all areas of science and technology.
8. Author's calculation based on UN/TCMD, 1992, p. 136.
9. SEMATECH, established in 1987 with the aim of restoring U.S. competitiveness in chipmaking technology, had received U$S 500 million in federal funds untill 1992.
10. For a comprehensive analysis of those alliances, see Mytelka, 1992.
11. The South Korean firms that entered into strategic alliances are large chaebol. See section I.7.d) below.
12. In parallel to the referred trend, a growing externalization (and fragmentation) of R&D has been identified (Whittington, 1990).
13. For stylised presentations of the theory, see bibliography in Goglio, 1991.
14. This hypothesis is suggested by Cooper, 1991, p. 14.
15. Frequently, the parties will grant exclusive rights to one of the partners within one particular application, vertical market or geographic market, while the other retaining all other rights (Daunt and von Gehr, 1992, p. 99).
16. Microelectronics has been perhaps the best example, in the light of the impressive performance of Japanese firms. The process seems, however, to be reversing in favour again of American firms. Electronics and capital goods and robotics are other areas where United States has evidenced weaknesses both in the domestic and world markets (Cohen and Zysman, 1987).
17. If this conclusion is correct, little room would be left for "leapfrogging" strategies. For a discussion on this issue, see Ernst and O'Connor (1989), p. 91.
18. South Korea, for instance, increased its R&D expenditures from Won 10,67 billion in 1971 to Won 3.210,5 billion in 1990 (Kim, 1993, p. 7).
19. This paragraph and the two following ones are based on the comprehensive study by Rath and Brent-Copley, 1992.
20. Lee, Bae and Choi, 1988, p. 242 identify in this respect three stages of industrial development: initiation, internalization and generation.
21. South Korea -like Japan- deliberately restricted FDI at its early stage of industrialization, in order to enhance the development of local technological capabilities.
22. FDI inflows to China are growing at an unprecedented rate. FDI commitments will reach near U$S 60 billion in 1993 (Business Week, 17.5.93).

23. These estimates should, however, be cautiously considered since costs of training and productivity differentials -to mention just two factors- are not taken into account.
24. The relative advantages of both forms have been extensively examined by economic literature. See a review of this topic in Chudnovsky, 1990.
25. According to one IDRC sponsored international research project, most small and medium technology supplier firms (the survey included 106 firms) showed a preference for arms-length transactions, presumably because of the greater transaction costs involved in direct investment (Rath and Herbert-Copley, 1992, p. 32).
26. Other types of technology cooperation between firms include "codevelopment", "coproduction", and "offset agreements", among others (see Farr and Fischer, 1992).
27. This section is partially based on Correa, 1993.
28. One of the main areas of application of this minimum term will be computer programs for which Brazil and France have established a shorter term of protection (the same applicable to works of applied arts).
29. The draft Agreement authorizes Parties to exclude patentability of plants and animals other than microorganisms and of essentially biological processes for their production (other than non-biological and microbiological processes). However, plant varieties should be protected under patents, a sui generis regime or any combination thereof.
30. See the text of 22 November 1990, which was discussed at the Montreal Mid-Term Review of December 1990. See also the list of practices as negotiated by the U.N Conference on a Code of Conduct on Transfer of Technology (Unctad TD/CODE TOT/47).
31. This may the case of example b) which has been commonly accepted for the patents but not for trademarks.
32. Although these groups do not enter into actual negotiations, their conclusions are often influential. One example are the suggestions on the extent and modalities of protection of biotechnological inventions.
33. A "First Part" of a Diplomatic Conference for the Conclusion of a Treaty Supplementing the Paris Convention as far as Patents are Concerned was held in The Hague in June 1991. The dates for the second part of the Conference, where the most substantive issues should be dealt with, have not been determined yet.
34. See in this regard Menon, 1992.