

Management Aspects of Industrial Technology Transfer to Developing Countries

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Abstract

For the benefit of technology transfer managers in developing countries, the relationship between technology transfer and development projects is given. Awareness of the need for the control of technological developments is used to structure a paradigm for mapping impacts of technological developments. The different phases of technology transfer projects and the tasks and necessary conditions and resource requirements associated with these tasks, are also dealt with. Approaches to technology assessment, research trends and sources of information on technology transfer are identified. These management aspects are integrated and a model system flowchart for dealing with technology transfer projects is proposed. Finally, relevant conclusions are made and the necessary recommendations are given.

Keywords: Technology management; technology transfer; technological development projects

1- Introduction

The term development is used to cover the activities aiming at inducing growth in the gross domestic product (GDP). Development is implemented through programs. A development program is envisaged as the sum of development activities, relating to a given product family, within an economic sector. A development project is seen as all the activities associated with setting up a production capacity for a given product mix, with a given production technology, location and a target commissioning time. Technology transfer is always effected through projects which introduce technological developments as a result of research and development, transfer across borders, or diffusion of existing technologies. Technology transfer does not only take place from the well developed countries to the less developed. It takes place between well developed countries and within these countries as well. In all cases technology evolves at a place where research and development capabilities exist and spreads through deliberate efforts to other locations. It initially spreads mostly as a substitution to old technologies, then further diffuses through the effects of the objective conditions governing the technological, economic and social set up of society. In developing countries [1, 2] new technologies are invariably transferred for the first time across national borders in highly aggregated packages such as the so called "Turn Key Project". Depending on the mobility of personnel and development of the national capabilities, the same technologies, when successful and where market conditions permit, further proliferate through continuing the transfer across national borders with rising levels of indigenous inputs. The question of acquisition from one company to another remains a rare phenomenon.

Technology transfer to developing countries is associated with big successes as well as big failures. Public awareness of the need for the control of technology is common place. It is at the focus of attention of thinkers, business leaders, professional organizations, technology transfer managers and even politicians [3-6]. International organizations are also concerned. The UNIDO, UNCTAD and the World Bank had been most concerned with technology transfer to developing countries. In the seventies of the past century the UNIDO sponsored and published many papers, reports and/or guidelines on the general aspects of the subject [7]. Later on, the UNCTAD and the World Bank sponsored and published several working and research papers on the subject [2, 8].

Recently, on the basis of their experiences, authors from various developing countries contributed to the discussion emphasizing the significance of key issues like the necessity of formulating national strategies [9], continuous assessment of strengths and weaknesses [10], supplementation of national know how capabilities [11], and the need for securing cooperation between the parties involved in the technology transfer project [12].

In connection with the significant aspects of the management of industrial technology transfer to developing countries, the understanding of the process of technology transfer and its relevant

implications are of paramount importance. This, as dealt with in this paper, is attempted through mapping the impacts of technological developments and the proper treatment of the management issues relevant to these developments. These issues include technology assessment approaches, understanding the phases of technology transfer and knowledge of research trends and sources of information relevant to technology management. The exposition and integration of these aspects in one attempt as well as the proposal of a system flowchart that relates these aspects to each other as a guide for dealing with technology transfer projects is the objective of this investigation.

2- Mapping the impacts of technological developments

For a societal assessment of technological developments, technological impacts should be valued in terms of the costs and benefits they reflect on societies. The USA was the leading society that became aware of the impacts of technology. In 1969, the "Committee on Science and Public policy" of the "National Academy of Science" presented a detailed report to the "Committee on Science and Astronautics" of the "US House of Representatives" elaborating the impacts of technology. Hetman [13] also highlighted some of the impacts and so did Bulfin Jr. [1] and the UNIDO [14]. Perhaps one of the most significant and comprehensive models for mapping technology impacts was presented by MITRE to the "Office of Science and Technology" in the "US Executive Office of the President" [15]. A more recent quantitative treatment is given by the "Hickling, Arthurs, Low- Technology Impact Model" [16]. In spite of the various ways the impact areas were identified and the differences in structuring and dealing with these impacts, a general common understanding of the impact areas and the nature of these impacts is quite evident. To sum up the various experiences and treatments, it is possible to structure the impact areas as follows in table 1 below:

Table1: Societal impacts of technology

2.1- Impacts on the individual These involve the impacts on the: - Child development and socialization - Work experience of the adult including: . Occupational mobility . Leisure and recreational aspects . Job satisfaction and motivation . Professionalization process . Work involvement and alienation . Participation in decision making . Health and safety 2.3- Impacts on the environment These involve the impacts on: - The aesthetic aspects - The ecosystems - Environmental health and safety	2.2- Impacts on society These involve the following: - Economic impacts including . Perpetuated economic growth . Standard of living . Efficiency in resource utilization . Security against risks - Social impacts including . Management trends . Industrial relations . The education system and social norms . Family life . Polity
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For a successful technology transfer, these impacts must be properly mapped. The negative aspects must be removed by making technological developments conform to societal norms against a remedial cost that should be considered as part of the overall development costs.

3- Technology assessment approaches

Having mapped the impacts of technologies and having made technologies conform to societal norms, the key to the successful implementation of technology transfer projects is using proper assessment procedures. Assessment procedures can be specific models tailor made for specific technologies [17] or general procedures as shall be explained herein after. Technology assessment involves multidisciplinary efforts cutting across the areas of technological forecasting, economic analysis, decision analysis, systems engineering/analysis, information technology, technical performance assessment, impact analysis, and risk analysis [18]. The assessment can be problem induced, project induced or technology induced. As such the assessment should be based on a sound study involving problem definition, description of the technology and prediction of future

developments. It should relate to the relevant society and social sections affected. The technical, political and social consequences should be carefully analyzed. As technology transfer projects inevitably involve negative aspects, these aspects must be dealt with and made conform to valid environmental, social and perhaps individual norms. The cost of achieving conformity must be included in the overall costs of technological projects. Several approaches [18] borrowed from economic analysis, operational research and/or other fields, have been used for the assessment of technologies. Some approaches use the criterion of cost-benefit analysis; others use cost effectiveness. Quantitative models based on these approaches have been developed. Some are simple isolated single stage optimization models; others involve a hierarchy of sub-models that identify long term societal values of resources, optimize the definition of long term development programme in terms of overall capacities and timing and optimize the breakdown of the programme into individual projects defined in terms of capacities, locations, technological processes and patterns of market distribution. Some approaches use simulation modeling while others develop heuristic models that, in the light of some assumptions, make multistage assessment decisions following a hierarchy of adopted criteria. Still an interesting approach, gaining popularity, is based on the intuitive development of several feasible solutions and attempting to choose the best on the basis of paired comparisons in the light of a set of criteria.

In addition to the classical technology assessment approaches, some, nationally and internationally recognized, models are well known. These include the "OTA Model" used by the "US Office of Technology Assessment" where, in addition to involving experts, stakeholders are also involved in advisory and review capacities. The Dutch "Rathenau Institute Model" and the Danish "Technology Council Participatory Model" extend technology assessment to involve stakeholders and the public, in addition to experts, in the decision making process [19].

4- Phases of technology transfer and relevant implications

Having mapped and assessed the impacts of technologies and internalized conformity costs, technology transfer projects can be formulated and implemented. An understanding of the phases of development projects and their implications contributes to the successful management of these projects. The existence of a national technology transfer strategy [9] and the continuous assessment of own strengths and weaknesses contribute to the success of the technology transfer project [10]. The supplementation of national capabilities with external support, when necessary, helps provide the necessary balance of power and risk sharing between the technology vendor and recipient [11]. The significance of the cooperation between the parties involved can not be overemphasized [12].

Technological developments have been categorized under three broad phases [20, 21]. Each phase can be broken down to stages that can be executed in several alternative ways involving the full spectrums of resources and management functions. Each of these phases, as they pertain to the relevant projects, is examined separately here in below.

4.1- Acquisition phase

This phase involves the activities connected with the selection, acquisition and setting up of the industrial technology project.

The selection stage involves the decisions relating to the choice of the candidate product mix, specifications, capacities and timing of commissioning. It also involves the identification of the candidate technological packages from the possible alternatives. These alternatives pertain to the nature of the technology, the scope of technological operations and the depth of involvement in the way of different levels of indigenous participation. Several thoughts have been advanced in connection with the treatment of this stage. Some simplistically advocated concentrating on satisfying the basic physical and security requirements of societies or the achievement of discrete general objectives like employment. Others [7, 14, 22] advocated the selection of technologies that bridge the technological gap in adequate doses. This phase also involves concluding the agreements and contracts, placing the orders, and establishing the enterprise. Several alternatives are available in this respect. Foreign investment, joint ventures and native acquisition in various arrangements involving in house participation, licensing, patent rights and trade marks and intellectual property rights, up to the turn key project, are some of the issues pertinent to this objective. Cox [23], though talking about university technology transfer, dealt extensively with the legal aspects of technology transfer in general.

The proper assessment of technological options is very important. Revisions and updating are common in this phase. Quality control during the setup activities is very important. Two issues are highly significant in respect of this stage. These are the commissioning procedure, involving trial runs and performance testing, and that of the management of the warranty period. Successful implementation of this phase requires a sound overall knowledge of available technologies, their economic and societal impacts and assessment techniques. Also it requires effective skills in locating sources of technologies and negotiating the details of the agreements, contracts and relevant deals. The setting up requires well developed knowledge and skills in project management. The services of national and/or international consultants and extension agencies may be deemed necessary [22, 24].

4.2- Assimilation phase

This phase involves the running of technological processes, carrying out adequate measures of maintenance and, perhaps, executing some limited design activities. This phase aims at putting to application the project systems, facilities and resources for the purpose of achieving the objectives of the technology transfer project. While the previous phase involves the critical decisions and expenditure, the ultimate viability of the enterprise rests with the proper management of this phase.

Training and instilling the necessary levels of industrial discipline is crucial to the successful implementation of this phase. Operational technological skills and management know how in the areas of production planning and control, materials management, quality control, personnel management, costing and other aspects of operations management are very important. Supplementing the in-house capabilities with technical and managerial support may become quite relevant. Local and international extension services, technical aid, and contract agreements with indigenous and/or foreign organizations are some of the means of handling the problems relevant to this phase [22, 24]. The employment of experts, advisors and/or on call consultancy services is quite relevant too.

4.3- Mastering the technology

This phase involves the evolution of interests and development of capabilities in the fields of product design, tool design, process planning, as well as the execution of research and development in these areas [25, 27]. Although the material infrastructure and resource requirements are very expensive, the development of the human resource is the key to the success of this phase. Execution of this phase requires extensive expenditure in capital investment and training. Integration of national capabilities available in established organizations, universities, research and development centers and human resource development establishment is of paramount significance. As the development of the human resource provides the key to the success of this phase, the management of the recruitment, selection, training and motivation of this resource plays a great role in this respect.

As progress in this phase is achieved, the local diffusion of technologies becomes possible through the mobility of personnel, contract work and/or local partnerships.

5- Research trends in the management of technology transfer

Research in the management of technology transfer has been active all over the world. Research centers and universities in developed and developing countries are continuously searching for new means and ways of optimizing the planning and monitoring of the application. Knowledge of these research areas can contribute to the proper management of technology transfer projects. The following are some of the research areas that have been investigated:

- Management of technology and technology transfer as a whole complex as well as the detailed management of the different phases of technology transfer [21, 28] including:
 - . Identification of the special aspects of the phases of technology transfer and the proper handling of these aspects
 - . Demand, supply, and price relationships in technology transfer
 - . Resource management in technology generation and technology transfer
 - . Multilevel technology transfer implications, namely on the national, district, Sub district and unit levels
- Examination of the factors relevant to the management of technology transfer [29] including:
 - . Roles of the patterns of learning, training and management

- . Effects of accessibility, mobility and receptivity
- . Effects of factors like the relevance of the technology, the agents ability and the quality of the communication on the transfer effectiveness
- Management of some novel technology transfer arrangements [20] such as the incubators, pilot plants, develop/sell establishments, and supplier/recipient partnerships
- Modelling the transfer process [31] in the way of simple linear deterministic models and/or holistic models taking the problem in its complexity
- Investigation of the dynamics of technology transfer [32- 34] such as:
 - . Interaction between the different participants like the innovator, the regulator, the linker and the receiver
 - . Interaction between the extent of technological progressiveness and the conservative role of safety and security requirements.
 - . Interaction between leaders and followers in technology transfer
- Participatory involvement of stakeholders and the public in technology assessment [17]
- Reporting of interesting cases of success in various parts of the world. Example are:
 - . IBM experience in technology transfer
 - . Technology transfer in Asia
 - . Technology transfer between the Americas
 - . Technology transfer to Thailand.

6- Sources of information on the management of technology

Knowledge of the sources of information can also contribute to technology management. The UNIDO, UNDP, UNCTAD and the World Bank are the international organizations most relevant to the management of technology transfer. The internet can furnish valuable information leads on the management of the subject. Journals, universities, institutes and centers are some of the sources that can be consulted for any serious investigation. Some journals are specialized in one type of technology each, while others are general. Amongst the specialized are: "Aerospace Technology Innovations", (USA), "Federal Aviation Administration Technology Talk", (USA) and "Department of Energy Pulse", (USA). Amongst the general are: "International Journal of Technology Management", Geneva, Switzerland, "Journal of Technology Transfer", Chicago, (USA), "International Journal of Technology Transfer and Commercialization", Geneva, Switzerland, and "Research-Technology Management", Washington, (USA).

Short courses, bachelor degree courses and MSc and PhD programs are organized by many universities. These programs follow step-by-step tuition in the form of lectures, workshops, projects and case studies. They invariably cover the subjects of technology assessment, securing intellectual rights, marketing technologies, processes of technology transfer, information systems of technology transfer, and technology transfer modeling. Manchester Business School in the UK, British Colombia University in Canada and Washington University in the USA are some of the leading institutions in this field.

Technology transfer centers are spread all over the world. Many universities have their own technology transfer centres. Amongst others are MIT, LaSalle, North Carolina, Florida and Washington, in the USA. On a national level, the American "Technology Transfer Information Center" is the best known. Worldwide, there are the "World Association of Technology Transfer Organizations" and the "International Association for Management of Technology".

7- Discussions, conclusions and recommendations

Technological development projects have always been desirable, feasible and underway, accounting for a large share of the progress achieved on national and international levels. The impacts of technology transfer, and the approaches to and models of technology assessment, as well as the phases of the implementation of technological developments, are well understood and developed. While recent investigations dealt with the operational and tactical aspects of technology transfer, old references were the superior in providing most of the strategic conclusions and recommendations. To the best of the author's knowledge, such a comprehensive overview of the information requirement for managers in the area of industrial technology transfer to developing countries has been contributed, in this paper, for the first time. Also a model system flowchart, as shown in Figure 1 below, is contributed as a guide for dealing with technology transfer projects. This overview is very essential as a primer for pursuing and/or shaping actual timely attitudes, investigations, plans, models and actions relevant to technology transfer projects.

As technological developments are invariably implemented in the way of development projects, decision making, with view to technology assessment, in the area of project management is continuously and progressively warranted. As such decision making should be made within an overall national development assessment framework that observes the following conditions:

- Technological development projects, whether belonging to the public or private sectors should conform, or be made conform (through the internalization of the costs of undesirable features) to societal norms through the adoption of a well defined and well discussed set of national criteria.
- All development projects should be assessed, in terms of costs and benefits, making full impact scenarios.
- Technological development projects should compete against each other, for national resources, using a suitable quantitative assessment paradigm.

The exchange of knowledge and experiences amongst developing countries is highly recommended as it can save problems and costs and can lead to development of interests in research, development and design. Also the use of national and/or international consultancy services and technical aid should be considered, as it may offer significant advantages, especially when dealing with the transfer of technology for the first time.

As this is a general overview, it only provides a management primer that has to be specifically developed when dealing with specific technology transfer cases. The elaboration of this framework to cater for specific technology transfer case can be subjects for further research.

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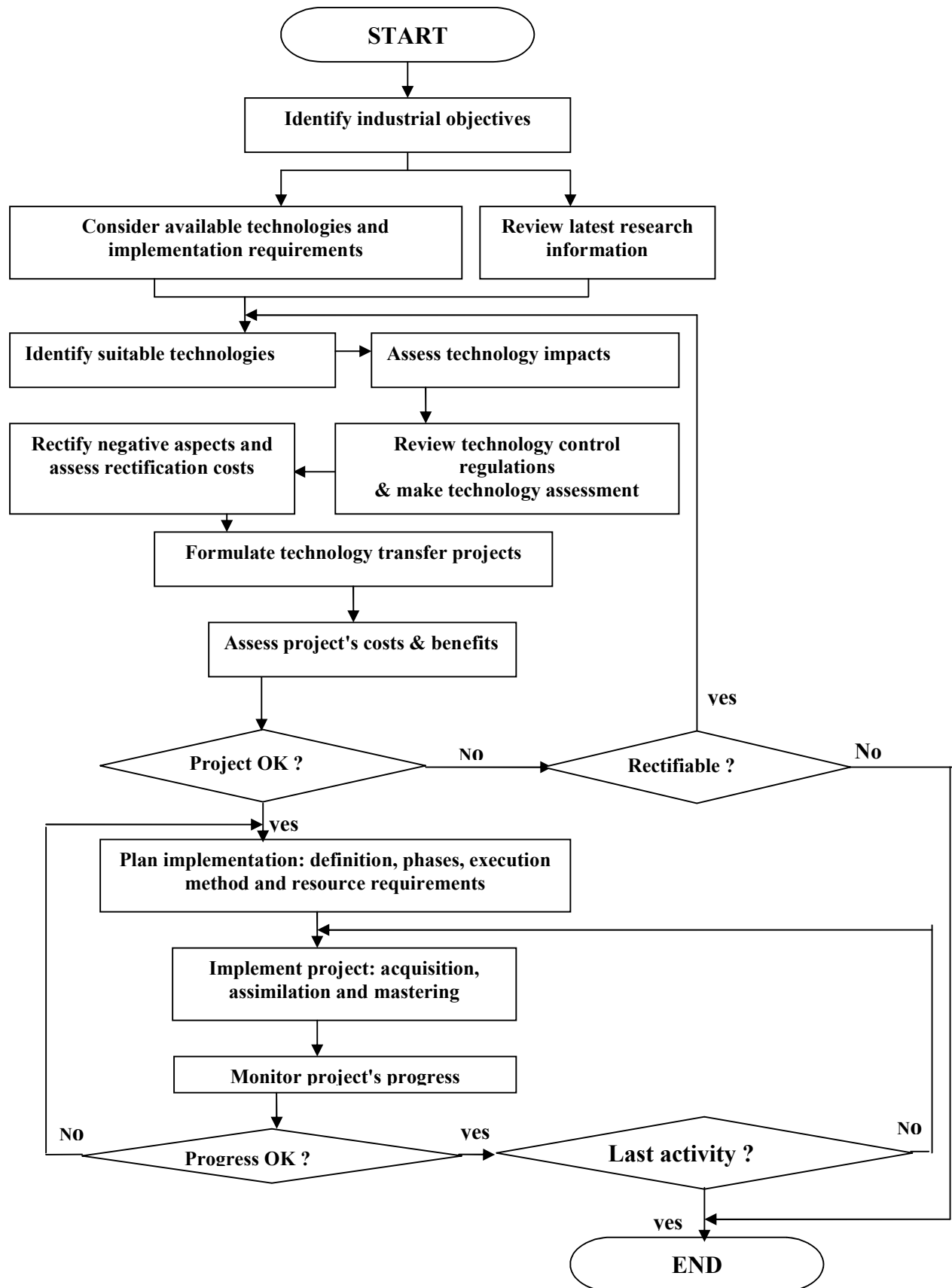


Figure 1: A model system flowchart for managing technology transfer projects