Approaches for Technology Assessment and
Selection for Developing Countries- A ToT Model

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Abstract

Transfer of technology plays a pivotal role in the industrialization of developing countries. The challenge faced by these countries is the non-avail of Transfer of Technology (ToT) model that can depict the technology transfer process by involving the internal and external factors. As the technology assessment and selection is the main process in ToT, so this paper focuses on this area and propose two approaches for development of a ToT model. Also existing analytical approaches to technology evaluation and selection, such as engineering-economic analysis, cost benefit analysis and optimization techniques have limited applicability due to imprecise and non-quantifiable evaluation of variable and factors. This paper proposes approaches to assess technology on both quantitative and qualitative bases simultaneously, involving all internal and external factors (forces) that affect the entire ToT process.

1. Introduction

In the human history, technology has played a leading role for industrial development and on the progress of civilization. Today, it has invaded all aspect of human endeavor. From human life style to government operations, industrial growth and global corporations are highly dependent on technology for their successes. Technology is the knowledge, capabilities, products, process, tools, methods, and systems used for creation of products or services for human consumption and industrial use. It is a dynamic process, which is fundamental to any development and brings about social and economic change for the growth of knowledge database leading to further technological progress and new cycles of growth [1].

Categorized Technology can be into Six Main Forms [2] [3] [4]:
- General Know-How or
  Information
- Goods or Tools
- Processes, Methods &
  Techniques Personal Skills and
  Know How
- Management Systems
- Organizational Structures and
  Frame Works.

Technology in both developed and developing countries [5] brings benefits as well as detrimental effects [6]. Despite of its disadvantages, the technological change is vital to socio-economic growth. As the technological development in developing countries is also held responsible for destruction of ecological and environmental equilibrium, causing pollution, noise, dirt, hazards, ugliness, monotonous jobs, lowering social values, cultural disruption and many psychological distress [7], even then, this cannot justify ignoring the enormous benefits the technology brings to all aspects of technical, economic and social life. To overcome the technological gap between developed and developing countries, developing countries have to think about advance technologies and tools. To counterbalance these technological drawbacks, developing countries should apply proper models and approaches of technology acquisition, technology planning and transfer of technology [8] [9] [10].

Focusing on the essential role of technology in the development

processes of developing countries leads to an understanding of the processes, procedures and approaches by which technology might be imported and employed in a country's sociotech economic system. Transfer of Technology (TOT) is the process, by which technology (in any form) developed by one group or organization for a specific purpose, adopted and applied by another group or organization, sometimes for different purposes. So, it is a process of planned, rational movement of technology from one firm to another (in our case from developed to developing countries).

If a nation is unable to develop her indigenous technological capabilities sufficiently to compete, it can obtain technology through transfers from other sources. This technology transfer may be the minor changes or up gradation to the original technology, technology in unbundled form or package technology.

Achieving technological sustainability involves passing through a series of stages [1], including:
- Technology Assessment and Selection
- Technology Acquisition
- Technology Adaptation
- Technology Absorption and Assimilation
- Technology Diffusion
- Technology Development

The first stage of ToT process is the main objective of this paper, i.e. to develop a model or approach to technological assessment and selection. Many factors affect the

transfer of technology to developing countries. The lack of ade-quate financial and technological resources, low per capita income and Gross National Product (GNP) and unfair income distribution, inflation and lack of hard currency [11] are the major economic and financial factors influencing the process of transfer in most developing countries. Other problems are specific political conditions and rigid or ineffective bureaucracies, high rates of illiteracy, riots and other forms of social violence caused by differences in language, religion and caste, political instability and frequent labor strikes. Transportation, telecommunication, and communication systems are poor and cost oriented. Unmodernized educational systems result in poor research facilities and academic institutions [1].

ToT may experience a cyclical interaction between internal and external forces. Internal forces are represented by indigenous technological capabilities, which consist of the quality and quantity of resources (human resources, financial resources, availability and capability of existing R&D, effective organizations). External forces include the technoeconomic environment, the physical and natural environment (including energy resources and geographical conditions), social and cultural environment (represented by education, ethics of labor and entrepreneur, custom and tradition, natural consciousness and the preferences of consumers), & the policy system [1].

Each of these factors (forces) affects the process of technology assessment and selection. To cope with these factors, there is a need for a proper assessment and selection model or approach. Existing analytical approaches to technology evaluation and selection, such as engineering-economic analysis, costbenefit analysis and optimization techniques have limited applicability to real technology evaluation, where many of the variable and factors that need to be evaluated are imprecise, illdefined and nonquantifiable. Consequently, there is a need for development or integration of appropriate technique [1].

To fulfill the need to develop an assessment model enabling decision makers to assess technology on both quantitative and qualitative bases simultaneously, some approaches are proposed for development of a 'ToT Model', through which developing countries can easily assess the need and level of technology requirements.

1. Hypotheses

Proper technology assessment and selection is vital for successful transfer of technology process, which is possible only by utilization of all internal and external factors that are related to technology transfer.

2. Research Methodology

Two approaches are proposed for development of ToT model. These approaches cover technology assessment and selection process, which is the key and first most

important stage of overall ToT process. The success and failure of ToT process depends on this stage. These approaches are based upon the internal and external factors that affect the ToT process and contribute in its success or failure to a large extent.

First approach is the quantitative approach, in which the factor analysis is performed and using ToT curve method assesses the best suitable level of imported technology for developing country.

Second approach is the qualitative approach for assessment and selection of technology process. The ToT matrix is utilized for developing strategies that can more fit between in-ternal and external factors (forces) of ToT.

Quantitative approach was applied on a real ToT project 'X' in Pakistan. ToT curve was drawn for assessing the suitable level of ToT of project 'X', to support the approach.

3. Proposed Quantitative Approach

This model has horizontal and vertical dimensions. The horizontal dimension has three ba-sic levels:
- Receiver Level (Developing Country)
- Donor Level (Developed Country)
- Technology Level (Receiver Technology Level with Respect to Imported Technology)

The vertical dimension refers to the factors and sub factors related to receiver, donor and technology being transferred. The horizontal and vertical dimensions of approach are as follow:

3.1. Receiver Level (Developing Country)
- Technical (research facilities, & academic institutions)
- Social and cultural (customs, ethics, violence due to religion caste & language)
- Political and legal (political stability, labor strikes & policy systems)
- Economic (market size, level of personal income, market and information distortions & inflation)
- Environmental (energy resources & geographical conditions)

3.2 Donor Level (Developed Country)
- Technical (research facilities, academic institutions)
- Social and cultural (customs, ethics, violence due to religion, caste, language)
- Political and legal (political stability, labor strikes, policy systems)
- Economic (market size, level of personal income, market and information distortions, inflation)
- Environmental (energy resources, geographical conditions)

4. Technology Level (Receiver Technology Level with respect to Imported Technology)
- Know-how (usage)
- Skill level (maintenance capabilities)
- R&D base (upgradation capability, development facility/capability in similar field)
- Organizational systems (labor intensive, partially/fully automated)
- Management approaches (HR policies, customer satisfaction etc)

Step 1:
Technology Breakdown Structure

For proper analysis of above factors (internal and external), this approach needs a technology breakdown structure. This structure comprises of recourses, expertise, time, legal and expenditure requirements may be needed for development of particular imported technology.

Step 2:
ToT Factor Analysis

This includes the factor analysis of all the factors and sub factors relating to threecategories / levels (i.e. receiver level, donor level, and technology level) in the scale of low (stagnant), low (improving), medium, high, and advance. Example of factor analysis is shown in Table1.

Step 3:
ToT curve
Case 1

Figure 1 represents suitable and economical level of ToT. If the technology level improve and other factors remain the same (in actual receiver level will also increased), the suitable level may be the lower technology, because the country has the ability to feasibly build the advance technologies.

Case 2

If receiver technology level decreases, and other level remains the same (technology level may be lowered), than the suitable technology may be the lower one. As country has less capability to adapt and diffuse the higher technology. (Figure 1)

Case 3

If the technology line and donor versus receiver line meets at left,

i.e. technology level above the donor and receiver level, then suitable technology level is obtained as shown in the Figure 2.

Case 4

If the technology line and donor vs. receiver line meets at right, i.e. technology level is below the donor and receiver level, than suitable technology level is obtained as shown in the Figure 3.

5. Proposed Qualitative Approach (ToT Matrix)

As successful ToT process depends on creating a match between the resources available to developing countries and the opportunities present in its environment. Identification of internal factors of goods and bads and the external factors of goods and bads can be an important approach for ToT process. ToT matrix [12], Table 2 may be a very useful tool for this purpose. The following approach was proposed for construction of ToT matrix:

a) List the external factors to developing country that depend upon import of new technology. List down all the good and bad factors.

b) List the internal factors that affect the import and level of new technology. Separate the goods and bad.

The matrix cells for G-g, B-g, G-b and B-b contain lists of feasible strategies, alternative technologies and suitable technological level

Table 1. Factor Analysis

| Scale	Low – stagnant	Low – improve	Medium	High	Advance
	1	2	3	4	5
Receiver level					
Technical					
Research facilities		2			
Academic institutions			3		
Technical = (2 + 3) / 2 = 2.5					
Social & cultural					
Customs		2			
Ethics				4	
Social and culture = (2 + 4) / 2 = 3					
Political and legal					
Political stability		2			
Policy system		2			
Labor strikes		2			
Political and legal = (2+2+2) /3 = 2					
Economic					
Market size				4	
Level of personal income			3		
Inflation		2			
Economic = (2+3+4) / 3=3					
Environmental					
Energy resources			3		
Geographical conditions		2			
Environmental = (3 + 2) / 2 = 2.5					
Receiver level = (2.5 + 3 + 2+ 3 +2.5) / 5=2.6					
Donor level					
Technical				4	
Society and culture			3		
Political & Legal				4	
Economic				4	
Environmental			3		
Donor level = (4+3+4+4+3) / 5 =3.6					
Technology level					
Know how				4	
Capability to use new technology				4	
Skills			3		
Maintenance capabilities			3		
R&D base = (3+2) /2 = 2.5					
Up gradation capabilities			3		
New development (in similar field)		2			
Organizational system		2			
Automation		2			
Management system = (3+2) /2 = 2.5					
HR policies		2			
Customer satisfaction			3		
Technology Level = (4+3+2.5+2+2.5) / 5 = 2.8					
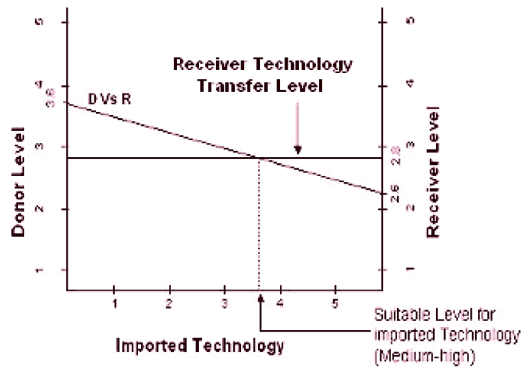
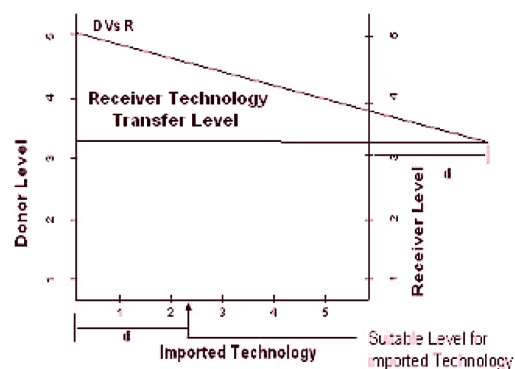Figure 1. ToT Curve (Case 1)
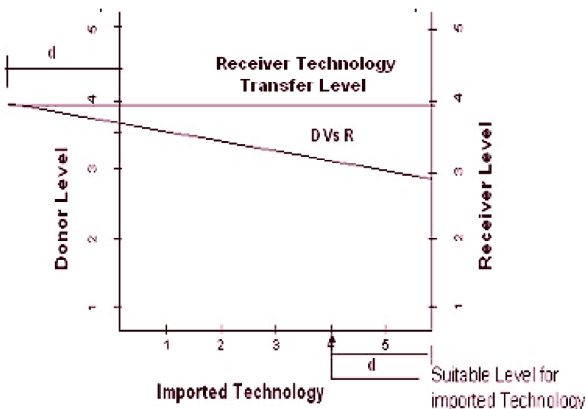
Figure 2. ToT Curve (Case 3)

Figure 3. ToT curve (Case 4)

that can more fit between internal and external forces to ToT. The best model can be achieved by minimizing/focusing on bad lists of internal and external factors by strengthening the good lists.

6. ToT in Pakistan

Pakistan's track record on ToT is modest. Despite the passion for advancement in sciences and technologies and welfare of the society, inadequate resources are spared for the slow progress over the years is attributed to:
- Lack of Adequate Government Support for ToT
- No Comprehensive or Consistent Polices
- Indiscriminate Imports of Foreign Goods
- Poor Taxation System, Vague Procedures, Weak Industrial Infrastructure and Serious Financial Limitations.

Now the government is taking concrete measures to institutionalize science and technology system, so as to perpetuate a self sustained growth process. Many of ToT projects relating to defense, private, education, and biological sciences, have been successfully completed.

For the validation of the proposed approach of technology assessment and selection, this approach was applied on one of ToT project 'X' of defense organization.

The following options were avail for ToT.
- Full package engine (Include manufacturing of all parts) scale-5
- Compressor and turbine (Critical portion as blades can wear off with time) scale-4
- Starter system, combustion chamber and body scale-3
- Oil and fuel system, exhaust system scale-2
- Maintenance scale-1

After performing analysis, the following ToT curve was obtained as shown in Figure 4.

From ToT curve, it was found that, ToT of compressor and turbine is suitable for Pakistan keeping in view the technology level and other internal and external factors (forces).

7. Conclusion

Transfer of technology has a vital importance in the industrialization and growth of developing countries. The technology gap between the developed and developing countries can decrease by adopting successful ToT process. So by proper technology assessment and selection process, developing countries

Table 2. ToT Matrix

ToT Matrix		External Factors	
		List of Goods	List of Bads
Internal Factors	List of goods	G-g Strategies: use strength of internal and external factors for more advance & economical ToT	B-g Strategies: overcome bads by advantage of goods for successful ToT
	List of bads	G-b Strategies: use goods to avoid bads, for proper technology selection	B-b Strategies: minimize internal bads and avoid external bads.

not only utilize their resources properly but also develop R&D environment for minimizing the need for ToT.

The development of developing countries depends on many internal and external factors, like social and technoeconomic growth, which in turn is achieved by extensive industrial growth. This industrial growth depends on technological development, which is achieved through ToT mainly from developed countries.

There are failures and success stories in ToT process in developing countries. The aim of this paper is to develop a model

(approach) for technology assessment and selection process under the circumstances of social, cultural, technical, environment, economic, and political and legal framework of the developing countries.

There is still much room of refinement in the proposed approaches for technology assessment and selection for development of a mature ToT model. But main objective of paper was to develop a method to highlight the internal and external factors of ToT, which can be utilized for successful ToT process.

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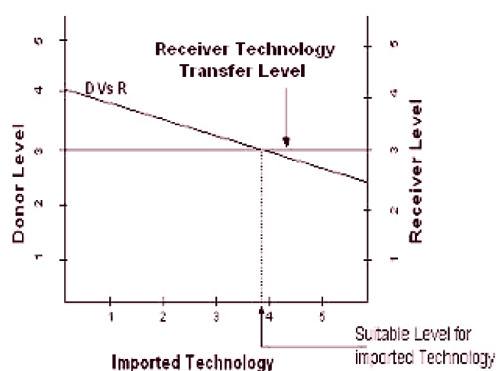
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Figure 4. ToT Curve for Project 'X'