

**Application of TQM Principles in the
International Technology Transfer Process of Industrial Production Plants:
An Analytical Framework**

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Abstract

This paper makes an attempt to illustrate the application of the Total Quality Management (TQM) philosophy in the International Technology Transfer (ITT) of the processes used in industrial production plants. Disaggregated analysis of the 'technology transformation' process is used to highlight the use of TQM. AT&T's 'Customer-Supplier' model of quality is introduced to highlight the interactive roles of the parties involved. It is argued that the existing literature does not deal with the issues discussed in this paper. Finally, a conceptual ITT-TQM model is suggested that should ensure proper assimilation of imported technology and continuous improvement of the processes leading to the satisfaction of the ultimate customers. It is suggested that the success of the model depends on the 'win-win-win' strategies of the supplier, the process owner and the customer. Examples from various case studies are presented to reinforce the argument. Some international standards such as the ISO series and a framework for total quality management such as the Malcolm Baldrige National Quality Award are necessary to ensure quality technology transfer.

Application of TQM Principles in the International Technology Transfer Process of Industrial Production Plants: A Conceptual Framework¹

1. Introduction

Modern technology has emerged as one of the primary sources of national power, prosperity and strategy. Advances in science and technology in one country are often critical to other countries' ability to attain national goals, including economic growth. Countries that lack the autonomous capability to generate, develop and diffuse new innovations must rely on the technology transfer process and eventual diffusion and assimilation of foreign technologies. Proper management of international technology transfer is, therefore, considered as one of the critical success factors for the importing nations. The transfer of inappropriate technology or inadequate assimilation and absorption of the imported technology may have serious consequences on the host economy.

The international transfer of technology involves a host of political, social, and economic issues. This paper does not attempt to address those issues. Neither does it address the issues related to the transfer of all types of technologies. It focuses instead only on the transfer of technology used in industrial production plants. The sole purpose of the paper is to demonstrate how the Total Quality Management (TQM) philosophy can be applied to the international technology transfer process to ensure satisfactory performance of the imported production technology. Literature indicates that the TQM philosophy has been applied successfully by many world class organizations and in many areas of business. Sharad (1992) made an attempt to demonstrate the application of this philosophy in construction related technology transfer projects. It is, however, noted that no attempt has yet been made to apply TQM philosophy to the transfer of industrial production technology.

2 Total Quality Management (TQM) Philosophy

Total Quality Management (TQM) is both a philosophy and a set of principles that represents the foundation of a continuously improving organization (Calingo: 1995). It involves everyone in the organization and extends to suppliers as well as to customers. In a TQM environment the customer is the focal point and customer satisfaction is the driving force (Stevenson: 1993). Customer focus, process improvement and total involvement are the three fundamental principles of TQM (Tenner and deToro:1992). These three principles are supported by leadership, education and training, structure, communications, reward and recognition, and measurement.

Sharad (1992) argues that the Management by Project (MBP) approach facilitates technology transfer (TT) and recommends a ten-point action plan for MBP oriented TQM. This action plan is general in nature and not specific to international technology transfer conditions. This paper attempts to show the TQM-TT connection more explicitly using the 'technology-transformation' process framework discussed below.

¹ An earlier version of this paper was presented at the 1995 IEEE Engineering Management Conference in Singapore

3. Customer Driven Approach to Quality

The quality policy of any organization should be to consistently provide products and services that meet or exceed the quality expectations of the customers. Customer expectations evolve and expand continuously. Continuous improvement of the business processes that produce these products and services is, therefore, critical to meeting the customers' expectations. This section examines the Customer-Supplier Model (AT&T:1988), which helps identify the roles of the various parties involved in the TT process (Fig. 1)

Insert Figure 1 here

The production system that is created through an international technology transfer process provides products and services that are expected to meet the quality expectations of the ultimate customers. If the technology transfer process is not managed properly, the impact on the customer satisfaction and the profitability of the organization will be enormous. Identification of the suppliers and the customers (both internal and external) is fundamental to the management of the process. This model illustrates how requirements and feedback drive the process as it converts supplier inputs into outputs that are delivered to customers. Customer requirements and timely measurement of customer satisfaction are key aspects in the process perspective represented by the model.

4. Technology Transformation Process

An investment project incorporates a wide range of technical knowledge that is drawn into the process in different ways. Part of this knowledge is embodied in capital goods required for the production process. Another portion appears as drawings, specifications, diagrams, and manuals. The remainder is directly delivered as various services provided by the engineers, managers and technicians who participate in the design and execution of the project (Kamenetsky:1979). The technological dimension of such a project involves a process that incorporates an interconnected series of activities. Different kinds of technology in different forms are drawn in at different stages, and from different sources. Disaggregated analysis of the 'technology transformation' process is necessary to identify the appropriate processes for the application of TQM philosophy. Such analysis is provided in the following paragraphs.

Previous studies have used various kinds of disaggregated frameworks for the analysis of 'technology transformation' processes (see Teece:1975, Cortes:1976 and Bell and Hoffman: 1981). Among these, Bell and Hoffman suggest the following four generic groups of activities:

- (i) Pre-investment and feasibility studies: Involves examination of general proposals for possible investment, identification and evaluation of options,
- (ii) Design and engineering activities: Involves development of the detailed specifications for the proposed production system,
- (iii) Capital goods production: Involves the transformation of the specifications of the hardware components of the system into the realities of machinery, equipment, buildings and the related infrastructure; and,

(iv) Installation and testing: Involves the assembling of the various components of the system into a functioning operational facility and the training of the operatives and the like.

In addition to the above mentioned technological activities that occur during almost any investment process, there exists a stream of overall decision making and management activities. The main function of this stream of activities is to control the technology transformation process. These activities have been labeled as 'techno-managerial' activities. There are at least four categories of such techno-managerial activities which are described below:

(a) *Defining the terms of reference for any particular stage in the transformation process* : What is done in each stage in the process will be determined by the output of the preceding stages. In fact, what is actually done will depend in large part on the terms of reference set by those who have overall responsibility for the project.

(b) *Identifying and deciding upon the agents*: This task is concerned with the search for, and the selection of the suppliers of the relevant knowledge, service or goods. There is wide range of possible agents for each technological activity in the investment process. Capabilities of these agents as well as the terms for undertaking these activities may vary widely. The execution of this set of techno-managerial activities is critically important for the outcome of the project.

(c) *Negotiation and acceptance of the terms*: The terms upon which the technological inputs are provided usually cover far more than the financial price to be paid for the knowledge, service and goods. Negotiation over the nature of these packages of conditions can often be complex, and the decision to accept a given set of terms can have major implications.

(d) *Monitoring each stage of the process and the evaluation of its output*: Ensuring that implementation actually matches requirements will usually involve a distinctive set of techno-managerial activities. It may also involve detailed evaluation of the output of particular stages in the process. Thus, key techno-managerial decisions about the outputs from the particular stages in the transformation process may constitute critical links between such stages. The links can only be made by those with overall techno-managerial responsibility for the project as a whole.

All of these steps of techno-managerial activities will usually be necessary in the main stream of the 'technology transformation' process within a particular investment project. They, therefore, constitute a parallel stream of tasks within the projects. This stream of 'techno-managerial' activities will be critically important in determining the nature of the transformation process. It is also equally critical in determining the nature of the ultimate consequences for the user of the final system and for the economy within which that system is located.

5 International Technology Transfer Process

International technology transfer will be involved when the new production plant is located in one country and some of the technological and techno-managerial inputs to the investment process are imported from suppliers in another country. The various possible combinations of relocation and transformation can give rise to several forms of technology transfer and hence to different degrees and types of dependence on technology imports; Fig. 2(a) depicts the case in which the process of international technology transfer involves country B drawing almost all the technological and techno-managerial inputs from country A. The whole process of transfer is, therefore, 'exogenous'

to the economy. Fig 2(b), on the other hand, shows the process where only the basic and very general system-related knowledge is imported into country B. The imported knowledge is then transformed by drawing on the services of country B's technological and techno-managerial resources.

In between these two extreme cases, there is a large number of options in which technology may be transferred across international boundaries. This analytical framework will be used to examine the possibility of using TQM principles in the international technology transfer process.

Insert Figures 2(a) and 2(b) here

In the following paragraphs the various elements of the technology transfer process discussed earlier are examined to identify the areas where TQM principles can be applied.

6. Elements of Technology Transfer Process

a) *Management of R&D.* According to the technology transformation model, R&D activity is performed by the supplier of the technology. The literature shows that TQM has been applied successfully in the R&D environments of some leading organizations. For example, Taylor and Pearson (1994) report the application of TQM principles in a large R&D lab of a major multinational organization. The study concludes that the likelihood of successful implementation of TQM in R&D is significantly improved through organization analysis. Collin and Pearson(1993) report that in the UK, many R&D departments have started practicing TQM on their own initiative. Collin and Pearson argue that many quality problems may be caused by factors that are not unique to R&D and quality tools and techniques can be applicable to the R&D process if used flexibly.

b) *Management of pre-investment and feasibility study.* This task is performed either by the technology importer or by consulting firm(s) hired by the importer. The major requirement for the execution of this task is the clear understanding of the needs of the customers. This allows the planners to identify the correct operations strategy, which in turn, allows them to choose the right process, technology, layout, and location for the proposed facility. TQM is customer focused and it includes various ways to listen to the voice of the customers. Quality Function Deployment (QFD) is one of the tools that is used to translate customers' requirements to a appropriate technical specifications. Uselac (1993) defines QFD as follows:

“QFD is a practice for designing your processes in response to customer needs. QFD translates what the customer wants into what the organization produces. It enables an organization to prioritize customer needs, find innovative responses to those needs, and improve processes to maximize effectiveness. QFD is a practice that leads to process improvements that enable an organization to exceed the expectations of the customers.”

The most widely used analogy for explaining how QFD is structured is the QFDhouse. Fig. 3 shows how a basic QFDhouse is put together. Fig 4 shows the flow and focus of one complete cycle of the QFD process.²

Insert Figures 3 and 4 here

The QFD process ensures that all resources are being optimally utilized in ways that maximize the organization's chances of meeting and exceeding customer requirements. QFD is customer focused

² For a detailed discussion refer to Goetsch, D. and Davis, S. (1994), pp. 465-470.

and time efficient, and teamwork and documentation oriented. (Goetsch and Davis: 1994). It can, therefore, be suggested that the application of the QFD approach facilitates the identification of the appropriate technology and the manufacturing processes at this stage.

This dimension of the technology transformation process (i.e. management of R&D) is usually carried out by a group of individuals having expertise in the various related fields. TQM fits well into such a situation as it also advocates group work.

c) *Management of design and engineering service.* These services are usually performed by the technology supplier. Participation of the buyer's representatives in the process is not uncommon. This stage of the technology transformation process can best be performed jointly by the two groups as partners. The AT&T's Customer-Supplier Model suggests such joint activities. A very successful example of such a joint activity is ICI of UK. ICI adopted this approach with excellent outcome (Quazi: 1984) while building their fourth ammonia plant in the late 1970s. The Saturn and Boeing 777 projects are two of the many successful examples where teamwork was the critical element of success. In such projects, engineers worked in cross functional team structures and solved design and manufacturing problems before production started (Schermerhorn:1993). Empowerment was used among other things to keep group members motivated. TQM philosophy encompasses both teamwork and empowerment.

d) *Management of capital goods production.* Two TQM principles (process improvement and total involvement of the employees) are directly applicable to this phase. Here again, if the supplier and the purchaser work as partners, a better outcome is expected as the purchaser has better knowledge of the local conditions and the needs and expectations of the ultimate customers. Many developing countries depend solely on the supplier for this stage of the process as they do not have the technological and techno-managerial capacities to participate effectively. Studies show that in many cases, the post-transfer performance of the production system has been unsatisfactory because of the lack of proper participation and too much dependence on hired consultants (Quazi: 1984, Malawa: 1983).

e) *Management of installation and commissioning service.* Leadership, effective communication, education and training, supportive structure and process control are the critical success factors in this stage of technology transformation process. Sharad's (1992) study supports this claim. He reports that the lack of most of these factors is the source of quality related problems in the construction industry. It is, therefore, argued that these supporting elements of TQM are appropriately applicable in this stage of the technology transformation process.

7. Assimilation of Imported Technology and TQM

Besides the transfer of technology transforming and techno-managerial activities (as shown in Fig. 2 a), international technology transfer projects may also incorporate the transfer of skills, knowledge and experience. This adds to the technological capacity of the importing nation. Fig. 5 illustrates the international flows of different technological components. Flow A corresponds to the technology transformation and techno-managerial activities shown in Fig. 2 (a). Flow B includes skills and knowledge required only to operate and maintain the production system being established. Flow C includes the skills, knowledge and experience required to modify and change the production system (Quazi: 1984) and the knowledge required to supply the 'core' technology. Farrel (1979) labeled Flow B as *static* technology. This is because the operating skills required simply to carry out routine procedures and practices are not enough to ensure continuous improvement of the process. He labeled Flow C as *dynamic* technology because it includes the necessary skills, knowledge and experience needed for continuous productivity and quality improvement through technical change. He argues that Flow C provides the key to proper assimilation of the imported technology that helps achieve continuous improvement of the production process. Discussions of technological self reliance have focused on the transfer of the kind of technologies included in Flow C. Studies suggest that many technology importing countries have experienced inadequate assimilation due to restricted transfer of skills and knowledge that are included in Flow C (Quazi :1984, Malawa: 1983).

Continuous improvement of the production system is necessary to improve the quality and productivity of the products and to reduce the cost of production. This can be achieved using the three principles and six supporting elements of TQM named earlier. However, process improvement may be difficult to achieve without the proper skills and knowledge to deal with it. Therefore, the importance of managing different types of technology flows (Fig. 5) becomes obvious when the issues of process improvement and ultimate customer satisfaction are discussed.

8. The Proposed Model

There is a complex set of variables that may influence the ultimate success of the transferred technology. Robinson (1988) has identified a large number of factors and sub-factors that are relevant to the international technology transfer process. He does not, however, provide any prescription for successful transfer. Keller and Chintas' (1990) integrative model provides some strategic guidelines for this purpose, but it does not include the issues related to the post transfer performance of the technology.

Proper understanding of the international technology transfer process and the TQM philosophy is critical to the success of the proposed model. The model assumes that both the parties (i.e., the technology supplier and the technology importer) have the right kind of attitude for long-term benefits. This should include a 'win-win-win' strategy (i.e., a 'win' strategy for the technology supplier, a 'win' strategy for the technology importer and a 'win' strategy for the ultimate customers). The proposed model shown in Fig. 6 recognizes the need for the transfer of those technologies that are included in Flow C for proper assimilation. The model shows where the TQM principles are to be applied to ensure continuous improvement of the related processes.

9. Discussion:

A critical factor for success in the global market is the ability of a firm to transfer technology effectively and quickly across national boundaries. In order to do this, strategic planning and implementation must be geared to the special nature of international technology transfer. Firms can use several factors to facilitate the transfer of technology across organizational and international boundaries. In the case of an intra-firm transfer, redeployment strategies of existing products or processes can be implemented in a parallel, delayed or sequential manner (Keller and Chinta: 1990). In a *parallel* transfer situation, the technology supplier simultaneously introduces the new technology in both the home and host country. In a *delayed* transfer situation, a new technology is first introduced in the home country. Later, after experience is gained and improvement made, the technology is transferred to a foreign country. In a *sequential* transfer, a technology is transferred to a foreign country only after the technology in question is completely through its life cycle in the home country. There are both advantages and disadvantages to these strategies. Since these transfers are internal to the organization, implementation of TQM philosophy and principles discussed in this paper should be easier.

Joint ventures, licensing, and technology sharing are some of the commonly used modes in the case of inter-firm transfers. It is argued that the proposed model can also be applied effectively in a joint venture situation. In joint venture projects both parties pursue the same goal increased market share through satisfied customers.

By incorporating the TQM approach the proposed model goes one step beyond the integrative framework of Technology transfer proposed by Keller and Chinta (1990). The intra-firm and inter-firm bonds of Keller and Chinta are reinforced by the inclusion of the TQM philosophy and principles.

It is argued that a quality management system for international technology transfer be developed by an organization such as the International Organization for Standardization. International awards such as the Malcolm Baldrige National Quality Award could also be designed to encourage high quality technology transfer across international boundaries.

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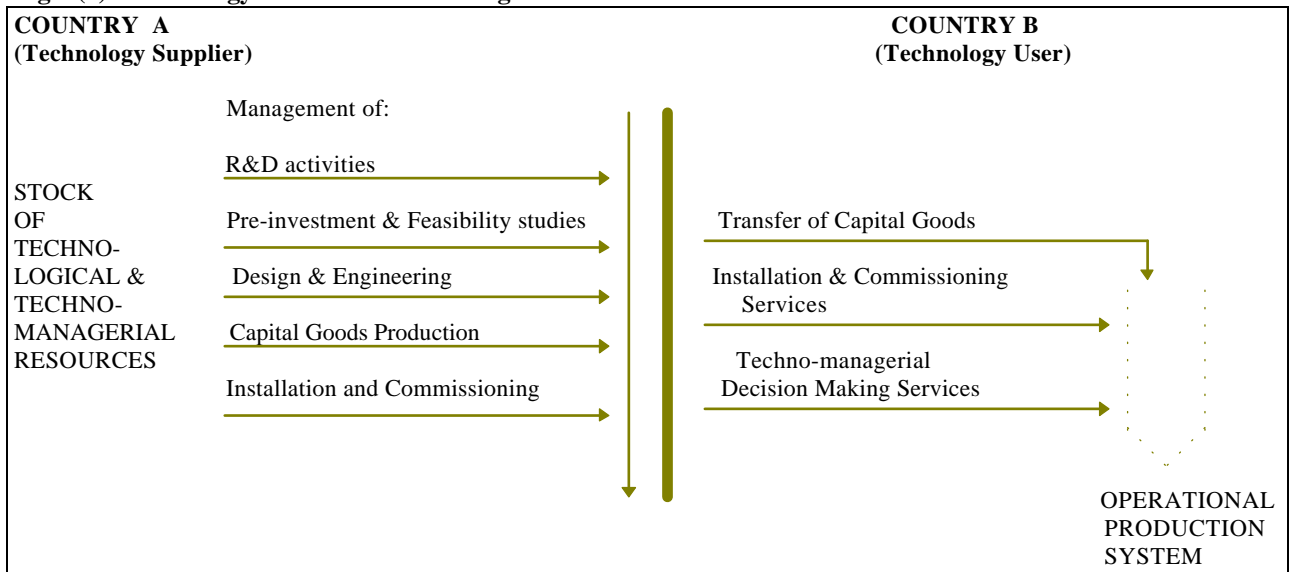
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Fig. 1: Customer-Supplier Model



Source: AT&T (1988)

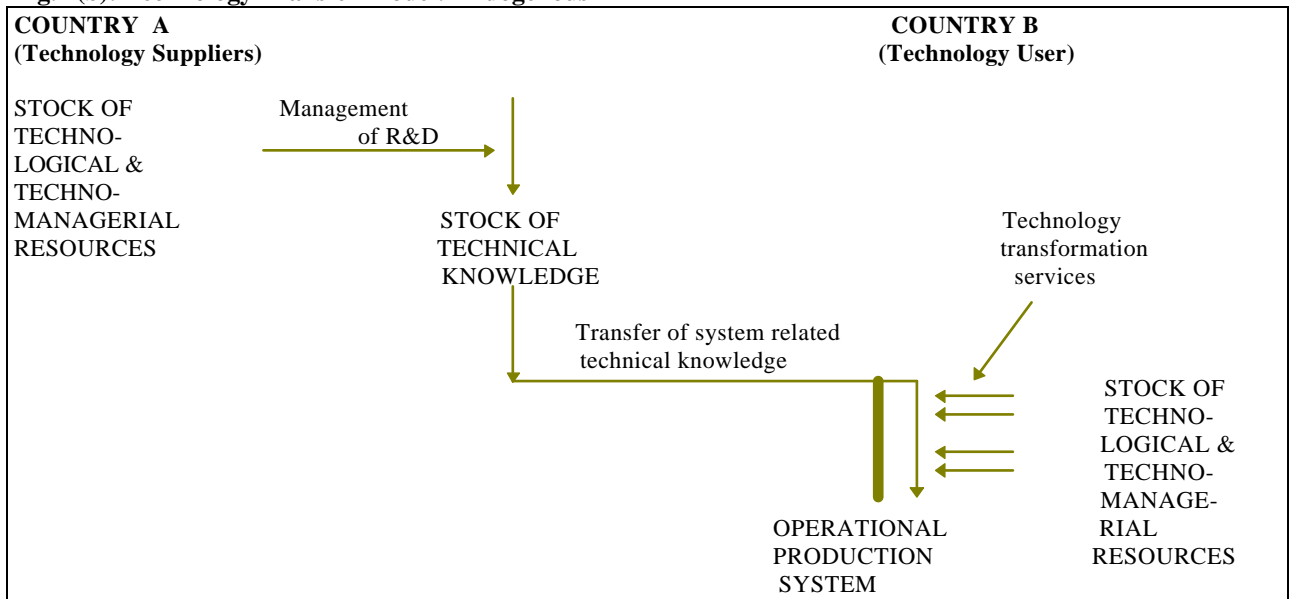
Fig. 2(a): Technology Transfer Model: Exogenous



Legend: Sequences of technology transforming tasks
 Sequence of techno-managerial decision making tasks

Source: Quazi (1984)

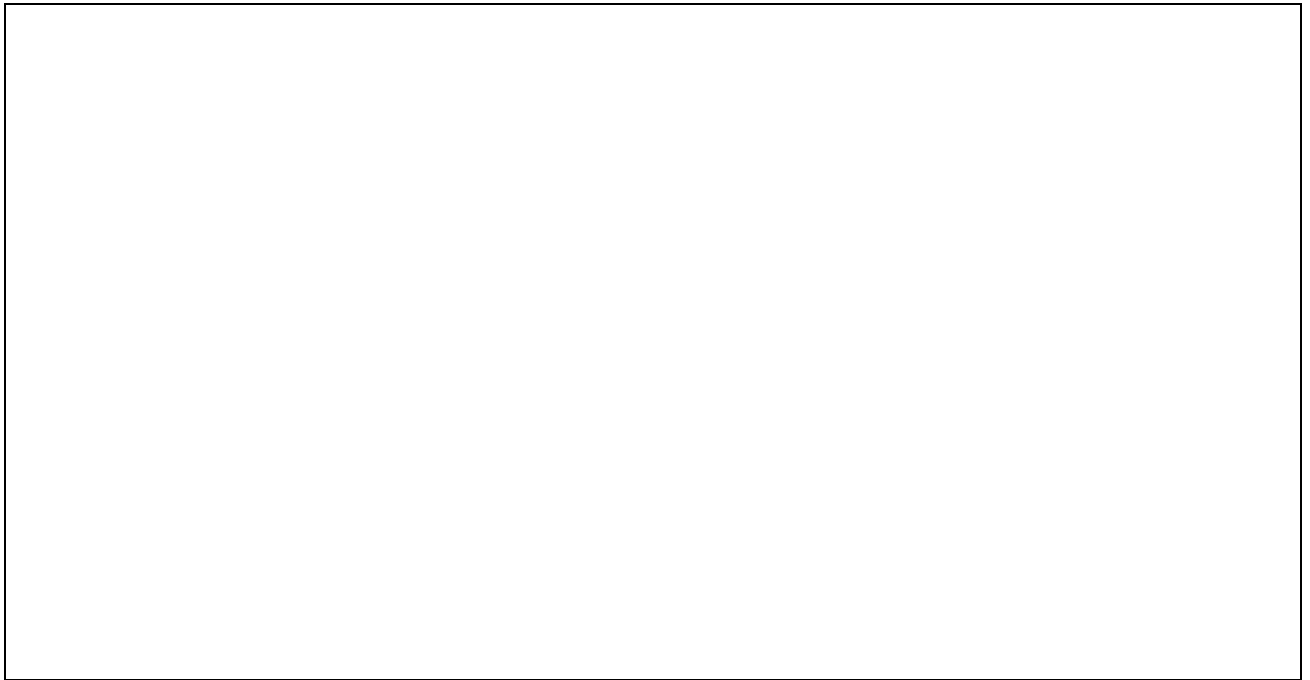
Fig. 2(b): Technology Transfer Model: Endogenous



Legend: Sequences of technology transforming tasks
 Sequence of techno-managerial decision making tasks

Source: Quazi (1984)

Fig 3: QFD House



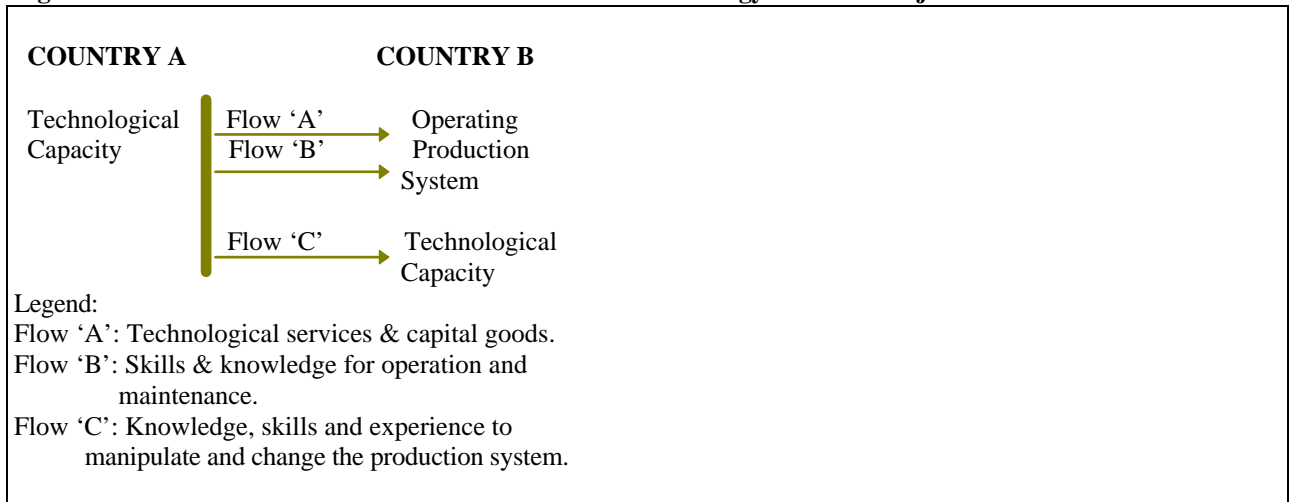
Source: Goetsch, D. and Davis, S. (1994).

Fig. 4: QFD Process



Source: Goetsch, D. and Davis, S. (1994).

Fig. 5: Illustration of Different 'Flows' in International Technology Transfer Projects



Source: Adapted from Quazi (1984)

Fig. 6: International technology Transfer and TQM: An Integrative Model

