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Technology Transfer with Reverse Technology Approach in the Least Developed Countries "LDCs"

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Abstract: Today, under developed countries for progress in science and technology and decreasing the technological gap with developed countries, increasing the capacities and technology transfer from developed countries. One of the methods for transfer of complex technologies is reverse technology. This paper is to address the factors, mechanism and benefits of reverse technology, as it can be applicable to the least developed countries in bringing meaningful technological and economic growth, suggesting a procedure for reverse technology process in manufacturing as a way forward in achieving the possibility of bridging the gap between LDCs and developed countries if implemented.

Keywords: Technology, Technology Transfer, Reverse Technology, Foreign Direct Investment

1.0 INTRODUCTION

Technological advance has been recognized as the key driving force in economic development not only in industrially advanced countries but also in newly industrializing countries (NICs). Nigeria, for instance suffered from almost all the difficulties facing most poor countries today. Technological development accounted for the "lionic" share of economic growth in advanced countries [8]. We may want to ask, why the interest in practicing technology transfer? The simple answer is that without technology transfer there is no advancement. A central aspect of technology transfer is the building of local capacity so that local people, farmers, firms and governments can design and make technologies which can be diffused in the domestic economy [16].

After the early 1960s, countries such as Korea, Taiwan, China, and Singapore have transformed themselves from technologically backward and poor countries to relatively modern and affluent economies. Each now has a significant collection of industrial firms producing technologically complex products and competing effectively against firms based in developed countries. Nowadays, new communication technologies, particularly the internet, appear to offer exciting possibilities for overcoming geographical access and cost barriers to learning. Yet it is hard to imagine that these technologies can have a positive influence on the education of children and adults who lack basic living resources and live with an under developed educational infrastructure in an environment of political instability [1]. Olli [12] focuses on the mechanism for industrial innovation and new business creation based on the transfer of new industrial technologies to basic research in order to foster commercialization and new business development. His findings revealed that technology transfer provides a great potential for fruitful new modes of basic research-industry collaboration to catalyze new technology- based industrial innovation.

One of the most important aspects for access to technology is reverse technology. In this way, a group of specialists in different subjects of sciences, for exactly introducing the functional mechanism of a product and access to its technology and by use of equipment and laboratory instruments including the suitable management and organization, analyzing the technology of products and trying after gain of documents an product's designs, be active in manufacture and production of products. In under developed countries reverse technology is a short cut method for access to technology and develops and completes it [18]. Some authors argued that reverse engineering is a reverse forward engineering which is a transformational approach in design decisions, this methodology is a kind of transformation of a forward engineering based on engineering codes[6].

The paper focuses on the need for the least developed countries to rise up to the challenges of adopting reverse technology transfer from developed countries in terms of economic development, infrastructure development etc., and as such to decrease the gap with developed countries. Also, the paper discusses the processes of technological learning through reverse technology transfer in which the capability to use an improve technologies that is being put in place, together with technological innovation, benefits in reverse technology, and appropriate government policy for a new technologies that are used to deliver new or improved products to markets [7].

2. Basic Concept and Definition

2.1 Technology Characteristics and Definitions of Reverse Technology

Technology characteristics affect both the cost of "reverse technology transfer" and the appropriate research and development (R & D) results. They therefore influence the expected revenue expected from and the propensity to engage in such transfer [17]. The characteristics of technology-recipient have been affirmed by many studies as the important factors that affect knowledge transfer. As technology transfer involves the process of transmission and absorption of knowledge [14]. A comprehensive definition of technology transfer, however, involves not only the purchase and acquisition of equipment but includes the transfer of skills and know-how to use, operate, maintain as well as to understand the technology hardware so that further independent innovation is possible by recipient firms. It also includes the ability to make the technology through "imitation" or reverse engineering, to adapt it to local conditions, and eventually to design and manufacture original products. Reverse technology has to do with the redesigning process during which the product is examined by observing the physical structures, and the design specifications, functional analysis, disassembled, tested and documented [8].

2.2 Definitions of Reverse Technology

- The reverse technology is defined as the process of discovering the technological principles of a device, object, or system through analysis of its structure, function, and operation [9]. It often involves taking something (e.g., a mechanical device, electronic component, software program, or biological, chemical, or organic matter) apart and analyzing its workings in detail to be used in maintenance, or to try to make a new device or program that does the same thing without using or simply duplicating (without understanding) the original.
- The process of recreating a design by analyzing a final product.
- The process of duplicating an existing component or product and their assemblies without the help of drawings, documentation or computer model [4].
- A systematic methodology for analyzing the design of an existing device or system, either as an approach to study the design or as a prerequisite for re-designs.
- The process of analyzing an existing system to identify its components and their interrelationships and create representation of the system in another form or at a higher level or abstraction
- Reverse technology is a four stage process in development technical data to support the efficient use of capital resources and increase productivity. Four stages consist of data evaluation, generation, design verification and implementation (Ingle, 1994).
- Reverse technology is a process that is used to create 3D CAD models directly from physical parts with little or no additional design documentation [2].
- The process of learning how a product is made by taking it apart and examining it.
- Reverse technology is the determination of someone else's trade secret information via examination and testing of publicly available information.
- Reverse engineering is generally a lawful to acquire technical know-how about manufactured products.

As the definitions above highlight, the most important aspect of technology transfer is the underlying knowledge of how technology works and how it can be applied to real-life problems. The skills needed to implement this knowledge in a practical form are also crucial, and it may be beneficial to physically transfer technology as well, but the physical transfer is usually least important from a technology-transfer perspective.

2.3 Different between Reverse Technology and Duplicating

Someone believes that the reverse technology is the same as duplicating mistakenly. Duplicating is on the bases of short times benefit and is based on profit. A product that manufacture by use of duplicating process, has not more properties and functional specifications of original product standards. Duplicating different from the reverse technology means about product with low level of technology and if the product is complex in nature and intelligence, duplicating products has no means and concept, but manufactured product by use of reverse technology process has quality standard the same as original or even better than it. Also, manufactured products by this way are based on wide time benefit and innovation.

2.4 Mechanisms for Technology Transfer

Technology transfer takes place through a number of different channels; see table I for a market - non- market breakdown [10]. Key among these are foreign direct investment, licensing agreements, joint ventures, and research collaboration between private companies and universities or government agencies [5]. Bernard et al. [3] encourages national and international policy options on international transfer of technology, distinguishing between the major channels of transfer mentioned above. Precisely which channel is most important depends in part upon the characteristics of the 'recipient country' (i.e., domestic research capacity, strength of intellectual property rights regimes, etc.) and the nature of the technology being transferred (i.e., the potential for imitation and reverse engineering).

Table 1: Technology transfer taxonomy

Market-mediated transfer	Non-market transfer
Trade in goods and services	Imitation and reverse engineering
Foreign direct investment	Employee turnover
Licensing	published information (journals, test, data, patent applications)
Joint venture	
Cross-border movement	

The choice of mechanism for individual companies depends largely on business strategy, risk tolerance, and available resources. A combination strategy may also be used. For instance, when technology has implications for more than one industry, the originating company or research center may choose to license its innovation for certain uses outside its expertise while directly developing the technology for those areas it is most competent. In addition, multinational corporations, particularly those based in the United States, Western Europe, and Japan, act as major transfer of technology to Least Developed Countries (LDCs).

2.5 Reasons for Reverse Technology:

- Interoperability.
- Lost documentation: Reverse engineering often is done because the documentation of a particular device has been lost (or was never written), and the person who built it is no longer available. Integrated circuits often seem to have been designed on obsolete, proprietary systems, which means that the only way to incorporate the functionality into new technology is to reverse-engineer the existing chip and then re-design it.
- Product analysis. To examine bow a product works, what components it consists of, estimate costs, and identify potential patent infringement.
- Digital update/correction. To update the digital version (e.g. CAD model) of an object to match an "as-built" condition.
- Security auditing.
- Acquiring sensitive data by disassembling and analyzing the design of a system component.
- Military or commercial espionage. Learning about an enemy's or competitor's latest research by stealing or capturing a prototype and dismantling it.
- Removal of copy protection, circumvention of access restrictions.
- Creation of unlicensed/unapproved duplicates.
- Materials harvesting, sorting, or scrapping.
- Academic/learning purposes.
- Curiosity.
- Competitive technical intelligence (understand what your competitor is actually doing, versus what they say they are doing).

Learning: Learn from others' mistakes. Do not make the same mistakes that others have already made and subsequently corrected.

2.6 Universities Central to the Process

Universities, research institutes, and government-sponsored agencies are a major source of new technology that is ultimately exploited in the commercial realm. In the late 1990s estimate, university technology transfer alone is worth more than $21 billion a year in the United States.
The emphasis of the top U.S. research universities on the commercial applications of research also resulted in part from a widespread perception that the United State was losing out to its international competitors in both basic and applied research. This led government, industry, and university representatives to undertake initiatives to develop new linkages between companies and top research universities. Among these linkages were university ownership of equity in firms established on the basis of university research, liaison or technical assistance programs, research partnerships, and the establishment by universities of patent and technology licensing offices. Many top research universities in the United States took the route of equity ownership in start-up companies. It was argued that this method facilitated technology transfer, created the possibility of large financial gain for universities, and helped to attract and retain faculty who might otherwise be tempted to join the commercial venture themselves.

Federal funding to universities continues to play a paramount role in the developed countries. Out of the 1,500 or more patents in all fields issued to universities each year, some 80 percent come from projects that receive federal funds. The federal government has provided two-thirds of total university research funds, with private industry providing a relatively small though rapidly growing share. To a lesser extent, federal funds also target small businesses through such initiatives as the Small Business Technology Transfer (STTR) program. Education is a vital part of the technology transfer process and of the development process more generally. A gap often exists between the technical education levels in source and recipient countries. Employees must have sufficient training to efficiently operate and maintain machinery. More than that, innovation and research and development typically require highly educated technicians. LDCs often attempt to minimize their technical dependence on outside sources such that they are able to generate innovation from within, creating the possibility of a more self-sustaining

development process.
The role of education becomes increasingly critical with the expansion of electronics-based and other medium- to high-tech goods. Accordingly, new product and process development generally requires a higher level of technical knowledge. At the same time, a larger share of all manufacturing production is beginning to be controlled by computers in highly integrated processes.

2.7 Developed Economy to Developing Economy

While technology is transferred internally in developed countries and LDCs alike, studies of technology transfer are often concerned specifically with transfers from the more advanced economies to LDCs. In this sense, technology transfer is central to the study of newly developing economies. In his essay "International Business and the Trans border Movement of Technology," Denis Simon defined three classes of technology transfer: material transfer, design transfer, and capacity transfer. Material transfer refers to physical goods ranging from product parts to fully operational plants. Design transfer refers to blueprints or other types of information used to build products or production facilities. Capacity transfer refers to education and training not only to operate existing plants but also to develop innovations in products and processes.
Japan is often referred to as a case of an advanced country that developed in large part through technology transfer. Previously developed capitalist countries such as Britain, the United States, and Germany relied to a larger extent on domestically produced technologies.
Japan's developmental success in the post-war years provides a contrast with the patterns observed in many LDCs. In particular, many LDCs have depended heavily on exports of raw materials, which often suffer from unstable prices in world markets, and have consequently run up large trade deficits and suffered from crushing debt burdens. Part of the appeal of technology transfer is that it creates the possibility for development that is less reliant on native sources of raw materials and is more self-sustaining. The newly industrialized countries of the Pacific Rim including Taiwan, Hong Kong, South Korea, and Singapore along with Brazil and India have recently emerged as significant beneficiaries of transferred technologies.

2.8 Benefits of Reverse Technology Transfer

Sustained economic growth and substantial poverty reduction in the LDCs requires the development of productive capacities - physical, human and institutional in a manner which enables the working population to become more fully and productively employed. National productive capacities develop through the closely related processes of capital accumulation and technological progress.

There is widespread agreement on the importance of technological progress for economic growth. Technological change increases the productivity of land, labour and capital, reducing costs of production and improving the quality of outputs. The ability to be internationally competitive also depends on having up-to- date technology. Moreover, the-importance of international technology transfer (ITT) is widely recognized and it has been argued that barriers to technology adoption to explain the income gap been developed and developing countries [1]. Economic growth is likely to reduce poverty if more labour intensive technologies are adopted; it implies that more people will participate in the benefits of growth. Poverty reduction will also occur if technological progress is associated with structural change. The promotion of technological change through reverse technology transfer will therefore best support, sustained economic growth and poverty reduction if it is part broader strategy to develop productive capacities and expand productive employment opportunities (Istanbul 2007).

Technology transfer helps to synthesize disparate technical developments, from multiple sources into a useful product, and keep us on the right track. In addition, many developing countries, including Africa, have improved their investment environments and to offer numerous incentives to attract foreign direct investment (FDI), often at great cost. Indeed, there is a real risk of 'racing to the bottom' among developing countries as they compete for FDI [11].

2.9 Role of Multinational Corporations in Technology Transfer

Multinational firms engage in technology transfer through licensing arrangements with non-affiliated firms or through foreign direct investment with affiliated firms [3, 15]. These are sometimes referred to as external and internal technology transfer respectively. Multinationals generally prefer internal technology transfer. Bernard (1987) presented a paper on "Contractual Agreements and International Technology Transfer," and described this preference as follows: "Foreign direct investment is normally preferred since the owner of the technology is thus in a position to capture all the rents attached to his technological advantage, while licensing is more risky in this regard. Contractual agreements will be entered into only when the potential benefit from intangible assets cannot be otherwise exploited."

There are a number of factors that impede technology transfer within a firm, making external transfer more viable. Smaller firms may lack the resources to engage in direct investment. Firms may have inadequate managerial experience in overseas production and marketing. In other cases, the host country may restrict foreign direct investment, leaving licensing as the only option. More generally, firms are more inclined to license older products and processes, for which the relative technological advantage and profitability are generally less.

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2.10 Factors Affecting Reverse Technology Transfer

Government policy plays a major role in reverse technology transfer. The advanced capitalist countries typically have policies that restrict the outflow of certain technologies. Among these is military equipment or technologies with potential military applications. Exporting technologies may also be restricted in an effort to protect competitive advantages in certain high-tech goods. Among these goods are supercomputers and superconductors. The government policies of LDCs vary widely in the extent to which they regulate technology transfers. While many LDCs compete with each other to accommodate multinational corporations, others restrict foreign ownership, foreign investment, and joint ventures.

Market transaction is one factor that is responsible for technology transfer. This is hampered by three major problems: 1) asymmetric information, 2) market power and 3) externalities.

Asymmetric information - Technology transfer involves exchange of information between those that have it and those that do not. The former cannot fully reveal their knowledge without destroying the basis for trade, creating a well-known problem of asymmetric information. Here, the buyers cannot fully determine the value of the information before buying it. This can lead to large transactions costs that stifle market-based technology transfer.

Market power - Owners of new technologies typically have substantial market power resulting from lead time and patents and other intellectual property rights (IPRs). This means that the price of technology will exceed the socially optimal level (i.e., marginal cost). While this divergence between price and cost allows innovators to profit from their innovation, it implies a reduction in national welfare of those importing technologies.

Externalities - These may arise if the costs and benefits of technology exchange are not fully internalized by those involved. A major share of benefits to recipient countries of technology transfer is likely to arise from uncompensated spillovers [12]. Positive spillovers exist whenever technological information is defused into the wider economy and the technology provider cannot extract the economic value of that diffusion. Spillovers can arise from imitation, trade, licensing, foreign direct investment and movement of people. Peter et al. [13] examines the productivity impacts of foreign ownership in China's electronics industry, where he addressed two questions. First, do the productivity spillover effects tend to diminish over time, following the establishment of foreign affiliates? Second, does FDI affect all market segments within an industry, or only certain segments?

There are other barriers to effective transfer of technology to developing countries. Among the barriers that are normally listed are poor infrastructure, inadequate laws and regulations, lack of absorptive capacity, shortage of skilled personnel, lack of finance, ignorance of technological issues, high cost of certain technology agreements, problems created by equipment suppliers, and intellectual property rights (particularly patents and trade secrets) [16].

3. Method of Achieving Technological Breakthrough

3.1 A Model for Reverse Technology Process

Reverse technology process presented in Fig. 1 explains the different phases a project can undergo through technology transfer.

Step 1: Functional Analysis and Technology Process

There is definition of **requirements**, targets and required specifications of product. Also, primary selection team for selecting the products and introducing the prototypes for reverse engineering and present the different concepts. The feasibility studies about the product and selection of the prototype for reverse engineering should be done by use of technology assessment and forecasting by decision making methods.

Step 2: Preparation of Primary Infrastructures

Phase 2 of the diagram consists of team of experts of different areas of sciences and experienced persons having a project manager as a team leader; accumulate and study technical data of prototype for reverse engineering; also indicates required documents discrepancies; determined main functional parameters of product and number of production for required prototypes; carry out the estimation process activities, tests equipment and required human resources, and required facilities for disassemble.

Stage 3: Disassemble of Product

In this phase, carried out inspection and primary test on prototype and record its result. Then disassemble product to assemble parts. During the operational stages of disassembling, provide all photograph and firm of treatment. Note as well in this phase the sensitivities of the parts and important parameters are needed. Recognizing the sample of sealing and filling materials, manual simulation of connections and assembling of parts. In the next stage, carry out the primary identification of parts and assemblies including the primary coding and primary tree diagram of product.

Stage 4: Planning and Management

After disassembling, project divides into subproject. Then indicate activities and programs including administrational requirements for the project, providing acceptable facilities, making sure special teams with concurrent engineering principles to handle the job. Also check the work project process according to the time of the program.

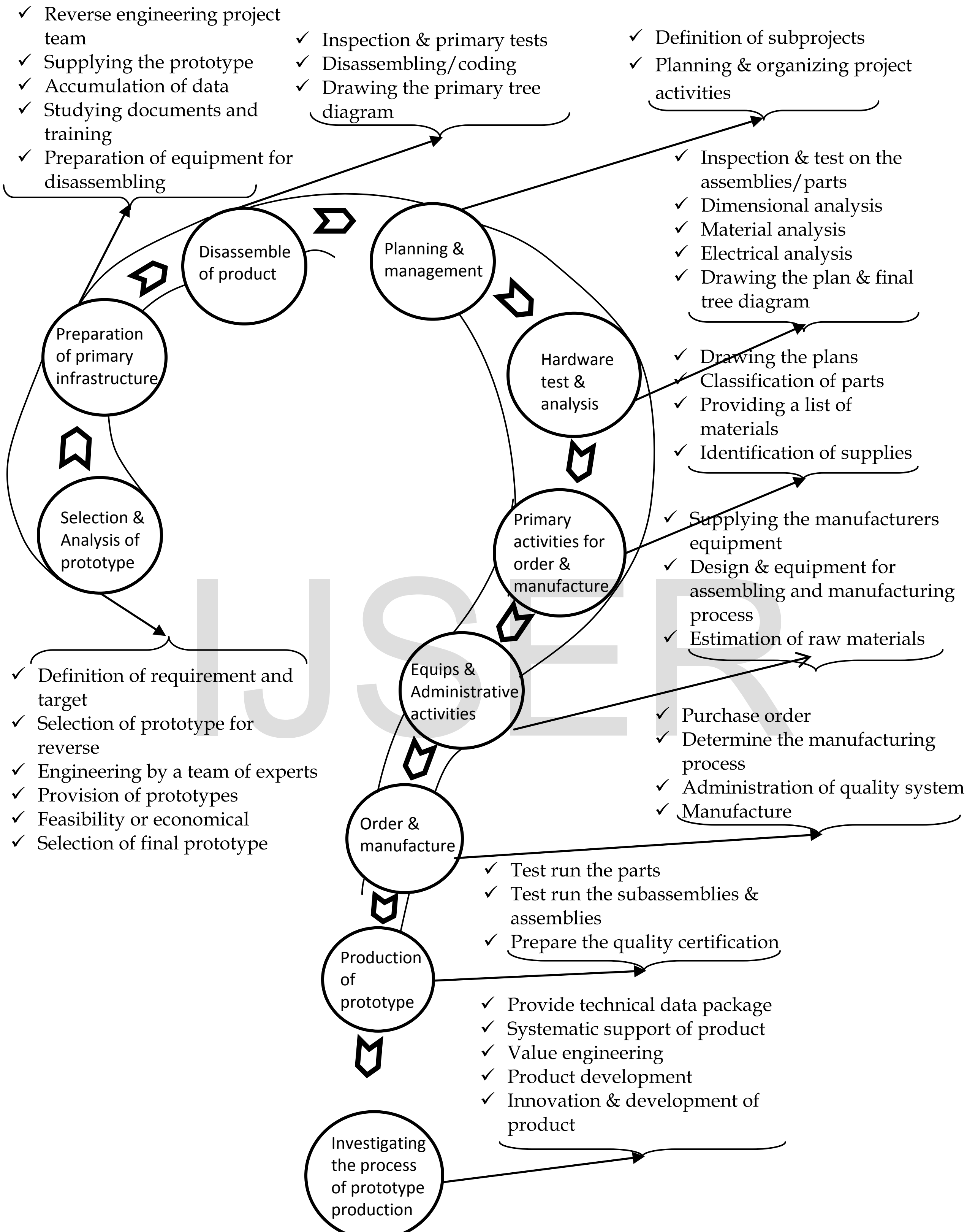

Fig. 1: Phases of technology transfer

Stage 5: Test and Hardware Analysis
This is most important phase in reverse engineering process that carry out primary inspection and required test upon parts and assemblies and indicates measure, parts shape,

tolerance and its limited ranges by means of dimensional analysis and register all test results. Also, consider material analysis which consists of metallurgical and chemical analysis. Electronics analysis on parts and assemblies with electronic units should be done. Finally, provide systematic drawings of parts, stating all the engineering specifications. Documentation is also very important in this phase.

Stage 6: Primary Activities for order and Manufacture
Drawing the main plan of the parts with indicated dimensions and tolerance should be done in this phase. After that, begin the drawing of the assembling plan and complete it with submitted dimensions. In the next stage, carry out the classification of parts which consist of standard bolts, nuts, washers etc. necessary for manufacture.

Stage 7: Equips and Administrational Activities
In this phase, carried out the adequate preparation and make necessary provision for manufacture and assembling process. Also, provide a list of tools, fasteners for required equipment in performing tests. Determine supportable items and planning for manufacturing. Estimation of raw materials for purchase order, design of storage and transportation principles and design of works stations.

Stage 8: Order and Manufacture
Make purchase order of raw materials for manufacturing; take into consideration the number of prototypes and safety factor necessary for the design. Other fundamental activities is quality control, which comprises of administration of quality assurance system, quality control of documents, quality control of equipment, calibration devices, tools and machines.

Stage 9: Production of Prototype
After the production of manufacturing parts, provide a warehouse and standard parts and equips the assembling process, carry out assembling of parts and performs required test and record the results. Make preparation for the final test and package the product, i.e., the prototype of the product is prepared for field test and thereafter, quality certification of the product done.

Stage 10: Investigating the Process
In this phase, complete investigation of the process is done by value engineering; thereby applying necessary innovation that required improvement on the product. Confirm the process and provides the final technical data package (maintenance and repairs) if required modifications is made. Finally, administrating, organizing and planning for semi manufacturing should be fine-tuned for development of new products.

4. CONCLUSION

Technological change in least developed countries occurs primarily by learning the technologies that are already exist in more advanced economies and not by pushing the knowledge frontier further. Neoclassical and endogenous growth theories view this as a transfer of technology in which access to foreign technology automatically follows from openness to trade and foreign investment, and access is equivalent to effective use.

Least developed countries to have access to complex technologies requires methods that will make it possible to bridge the gap between them and developed countries as appropriate consideration to factors such as cost, time and risk affecting reverse technology. Government should therefore put in place good policy that will support 'technology transfer and also collaborate with universities to promote R & D, and link it more effectively to processes of innovation for economic growth.

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