

Engineering Research: A tool for development of manufacturing industry in developing countries: Nigeria - A case study

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ABSTRACT

This paper presents the importance of engineering research to the advancement of manufacturing industry. It identifies the problems in the research institutions and industrial sector. It notes that both sectors suffer from human and non-human challenges that militate against their service delivery and contributions to national development. Strategies for technological and industrial development are highlighted. Such strategies are expected to result in the development of endogenous technology that makes the best use of the local resources of a country. Technological collaborations between industries within a country on the one hand and overseas industries, on the other hand should provide good synergy that could hasten industrial development. The paper concludes that research-driven industries exhibit high efficiency, low consumption of resources, contribute to improved standard of living of the citizenry and overall growth in national economy.

1.0 INTRODUCTION

Nigeria is regarded as a nation endowed with abundant human and material resources but her inability to effectively utilize these potentials has resulted in widespread poverty, low standard of living at individual level and rising unemployment in the country as a result of her pursuit of mono-economic practice that focuses on crude oil and drastic neglect of other sectors of the economy such as manufacturing, agriculture and mining industry. Adeola (1) noted that the history of industrial development and manufacturing in Nigeria is a classic illustration of how a nation could neglect a vital sector through policy inconsistencies and distractions attributable to the discovery of oil.

Engineering research focuses on the generation of scientific knowledge and application of it in the production of scientific and technical manpower, the development of material processing systems, the production of machinery and equipment for general and specialized functions and the application and service needs of the society. Falade (2) indicated that research is generally directed at discovering, creating and adding to a pool of knowledge. Such research results are disseminated by researchers to the industry through the training of the students by incorporating the research findings in their classroom activities thus enriching both teaching and learning situation within the department and the students are later employed to work in the industry where ideas are shared among the other employees. The findings can also

be transferred directly to the industry via seminars, workshops and conferences etc.

The difference between a developed, rich and prosperous country and the developing or underdeveloped country is the difference in their level of scientific, engineering and technological advancements. Technology is sometimes confused with engineering; it is often mistaken for machinery or computing device. Technology embraces more than machines as it also involves processes. It is possible for technology not to involve any equipment. Engineering uses scientific ideas to develop technology. By implication without engineering a country cannot move from stage of developing to a developed nation. Ideally, engineering research institutions should provide solutions to problems in the industry for the development of manpower needs, development of new materials and new technologies but the operations of the two sectors appear to be at variance in most of the developing countries including Nigeria, and this, in part, is responsible for the low level of industrialization and technological developments in these countries. Engineering research can be oriented towards:

- (i) Adoption of imported technology
This concept can be in form of a joint research between two participating countries (North-North, North-South or South-South) tailored towards the improvement of production line or a joint venture between local and foreign companies. The basis of this type of research could be as a result of information derived from research publications through research journals and books or direct linkage through attendance at seminars, conferences or workshops.
- (ii) Complementary research
This type of research is carried out when the existing information available on a subject matter is not sufficient for its full usage and further research works are required to ensure that the findings of the research could be effectively used.
- (iii) New Research
Innovation and market survey may lead to the conceptualization of research idea to develop new product.

Manufacturing sector plays a catalytic role in a modern economy and has many dynamic benefits crucial for economic transformation. Manufacturing provides an avenue for increasing productivity related to import replacement and export expansion, creating foreign exchange earning capacity, and raising employment and per capital income which causes unique consumption patterns. It also creates investment capital at a faster rate than any other sector of the economy while promoting wider and more effective linkages among different sectors. In terms of contribution to the Gross Domestic product, the manufacturing sector is dominant but it has been overtaken by the services sector in a number of Organizations for Economic Co-operation and Development (OECD) countries. Rynn (3) described manufacturing as the path to development and that it has been the strategic achievement of rich nations over the last several hundred years to develop national wealth and power. He asserted "it is not enough simply to have factories and produce more goods; you have to know how to make the machinery that makes the goods". The key to power, then, is to make the 'means of production'. The growth of manufacturing machinery output and technological improvement to that machinery, are the main drivers of economic growth. However, in developing countries, there is a lot of dependence on importation of machinery for the operations of the manufacturing industry. The machinery is expensive because of high rate of foreign exchange. Acquisition of machinery by an industry does not imply that the machinery would be operated efficiently (at best practice). Access to foreign technology, by itself is not sufficient to ensure local technological and industrial development. Local capabilities and skills are required to optimize the utilization of the imported machinery. At times, the competence to maintain the imported machinery is largely lacking in developing countries apart from the fact that the spare parts are not readily available. Because of paucity of funds, most of the industries are unable to acquire state-of-equipment; they rely on old machines that require high running cost and low output. A central component of a country's industrial development policy strategy is technological effort oriented to the absorption, adaptation, mastery and improvement of technology. Nigeria operates more or less a free market system which allows her market to be flooded with foreign machinery, goods and services with little emphasize on local capacity building. In modern world, manufacturing sector is regarded as a basis for determining a nation's economic efficiency (Amakom, 4). Industrialization involves extensive technology based on development of productive (manufacturing) system of an economy. Thus, the development of the industrial sector represents the deliberate and sustained application and combination of suitable technology, management techniques and other resources to more automated and efficient system of mass production of goods and services.

It is the findings from basic engineering research integrated into technological solution that sustain industry and commerce, which effectively promotes the economic development of a nation. However, over the years the input from the research institutions has been at low ebb

because of some problems while the industry on the other hand is faced with some challenges.

2.0 PROBLEMS OF ENGINEERING RESEARCH

Generally, engineering research has witnessed a lot of problems that militate against its advancement to an enviable state, to make meaningful contributions to the growth of the nation via industrialization.

2.1 Personnel

In tertiary institutions and research institutes, engineering faces serious challenge of shortage of personnel. Emovon (5) reported that in 1990 the total number of research and development scientists and technologists in developed countries was estimated at 4,463,788, that is, an average of 3,684 per million of the population. In contrast, the number of such experts in developing countries was 759,816 that is 189 per million. It was further noted that, the situation in Africa, including Nigeria is more shocking and is put at 74 per million. This situation of low critical mass of scientists and technologists is worsened by brain drain due to lack of adequate facilities for self-actualization in the research system and poor reward accorded the researchers and technologists. There is a dearth of statistical information regarding the total number of research personnel in engineering but the number of scientists and engineers on ground is inadequate to meet the challenges. Uvah (6) reported that in Europe the number of personnel that engaged in research varies from 4 to 8 per thousand as against 0.2 in India and 0.06 in Nigeria. Falade (7) also noted that large students' intake into tertiary institutions amounted to overloading of staff. Faculty members therefore have little time to spend on developing research goals.

2.2. Infrastructure

Many Nigerian Universities are fast decaying in infrastructure. The infrastructure for engineering, such as telecommunication and power are underdeveloped. The epileptic power supply is a source of frustration for any research to be carried out.

2.3. Funding

Inadequate funding remains a major constraint to research output in engineering and hence the development of endogenous new technologies. During the period between 2010 and 2013 the budget allocations to education by the Federal Government has no specific trend but fall short of UNESCO recommendation of 26% of annual budget. Within this period the allocation to the sector in 2010 is 6.40% while in 2011, 2012 and 2013 the allocation are 1.69, 10.00 and 8.70% respectively of the total annual budget (CBN, 8). Salam (9) noted that industrialized countries generally spend 2.5% of their GNPs on research, development and modification, adaption plus the utilization of science and technology. According to him, no country in the south approaches this except South Korea which spends 2.0% of its GNP on R & D in science and technology. He further noted that the other "high

spenders" among developing countries are Argentina, Brazil, Chile, Cuba, India, Kuwait and Mexico which spend between 0.5% and 0.9% of their GNPs on science, engineering and technology.

2.4. Inadequate library and other information services.

The Nigerian research system is lapsing into isolation because of poor library facilities as well as current books and journals. If researchers in engineering must be current and impact on advances of knowledge, adequate support must be given to the mobility of scientists and technologists and acquisition of the Information and Communication Technologies (ICT). The greater infrastructure challenge for the use of ICTs in research is the inadequacy of Campus Local Area Network (LAN), WAN and access to PCs to distribute service internally in the form of intranets. Poor access to electronic journal due to unaffordable subscription rate and difficulty associated with remission of subscription.

2.5. Quality of Research in Engineering

Universities serve as major sites for discovery of new ideas, invention of gadgetry for improving the welfare of the human race, establishment or revision of theories and evolution of such theories to laws. These activities are largely accomplished through research. Some quality basic and applied researches have been and continue to be carried out in engineering in Nigerian universities but the society is largely unaware of them. However, currently the inadequate staffing situation is adversely affecting research work. There appears to be a vacuum created in academic structure of the tertiary institutions in general and engineering in particular. Most departments/units are top heavy, this is likely to pose a serious problem in no distant future when the old experienced academics retire and there is no replacement for them.

2.6. Attitude to Research and Development

Poor attitude of Nigerians to research and development militate against giving research and development the pride of place in the country as well as that some of the researchers have also developed nonchalant attitude to serious research work because of inadequate facilities and lack of acknowledgement of their contributions to knowledge by the public.

2.7. Brain Drain

In an attempt to improve the quality of its research personnel, many developing countries including Nigeria provide financial facilities for their talented academic staff without PhD or students to study in universities abroad. This strategy has its risks; it often happens that many of these people (staff and students) decide to stay abroad. This implies a transfer of talents from developing to developed countries rather the contrary, as it would be necessary. In an effort to guide against non-return of the sponsored personnel on overseas study, government of many developing countries, including Nigeria, provide grants to their students to study abroad under the condition that they will return to work in their native countries after

the completion of their studies abroad. However, many of them renege on their promise.

2.8. Facilities

Ibidapo-Obe (10) noted that the inadequacy of facilities has always been a major factor inhibiting research and development. These facilities include:

- (a) Space, inadequate laboratory, offices and classrooms

- (b) Equipment

Most institutions lack up-to-date and adequate quantity and quality research equipment. Poor equipment may be responsible in part for the tendency to conduct superficial, fact-finding survey-type and non-innovative research rather than mission-oriented research.

2.9. Students' Enrolment

There has been a consistent increase in the students' population in the tertiary institution. In 2004/2005 session, university system in Nigeria admitted a total 122,492 candidates in 2005/2006, 76,984 were admitted, this rose to 88,524 in 2006/2007 while in 2007/2008 and 2008/2009, 107,370 and 200,000 candidates respectively (Shu'ara, 11). Within the same period there was an increase in the number of universities built not proportionately. It is worth noting that there has not been any significant improvement in the teaching and research facilities for a long time whereas the student population has increased many fold. This trend has affected the quality of research because ample time is spent on teaching and examining students with limited time to develop research goals.

3.0 MANUFACTURING INDUSTRY

The industrial sector is beset by a number of challenges which have made it impossible for the sector to break new grounds either in the production line using the emerging new technologies or developing new ideas. Some of these challenges are:

3.1 State of Infrastructure

The biggest problem facing manufacturers in Nigeria over the past decade has been inadequate infrastructure in general and lack of power supply in particular. The country set a target of generating 6,000MW of electricity by the end of 2009, but estimated national demand is 25,000MW. Manufacturing industry as whole generate around 72% of its own energy needs by operating generators to power their production line because of inadequate supply from the national grid. In an effort to revitalize the energy system the federal government put a new structure of the New Power Holding Company of Nigeria (PHCN) which resulted in the unbundling of the former National Electric Power Authority (NEPA) into three independent groups (Generation, Transmission and Distribution). This effort has not produced the necessary enabling environment for the industrial sector as the economy still experiences severe epileptic power supply especially the industries. The power outage has serious negative impact on business operations (formal and informal) in the country. Between 2000 and 2010, more than 850 manufacturing companies have either shut down

or temporarily halted production (www.corporate-nigeria.com/index/industry). Telecommunications and transportation that are sine quo-non to industrialization are in poor state. Road network for distribution of goods and services are underdeveloped. No effective railway network for transportation of raw materials and finished products.

3.2. Importation of Machinery, Materials and Chemicals.

Most industries rely on imported machinery for their production process as well as foreign raw materials and chemicals as input materials. With age, some of the machines have broken down and require replacement of spare parts but since the fabrication of the spare parts are not done in Nigeria; they need to be imported along with the materials and chemicals at high costs because of the high exchange rate. This has left the industry to produce at high cost thus making the unit cost unaffordable and higher than the cost of imported alternatives.

3.3. Tax

Heavy tax burden including multiplicity of taxes imposed on business by the three tiers of governments (Local, State and Federal) add to the unit costs of industrial products thus making the products unaffordable to the majority of the population.

3.4. Dearth of Personnel

There is shortage of quality managerial/technical capability in the sector. Many industries do not invest in the training and retraining of their staff and therefore the staff is unable to cope with the modern challenges posed by advances in science, engineering and technology (SET). Any new technology will go astray and become short-live without strong initiative and high quality workforce.

3.5. Low aggregate demand/consumer purchasing power

Low aggregate demand/consumer purchasing power (growing impact dependency and the expansion of the population of people living below the poverty line.

3.7 Uncompetitive cost of production

The high production cost increases the cost of manufactured goods and the cost increase is passed on to the consumers, making difficult for Nigerian goods to compete with cheaper imported goods. Naturally, high unit costs of products make consumers more often to prefer the less expensive imported alternatives.

3.8 High cost of capacity

High interest rate on loan and advances from banks increases the unit costs of industrial products. Atimes the loans are not easily accessible because of the constraints imposed by the lending institutions. Because of the high interest rate, many manufacturing firms in the country have continued to rely heavily on internally generated funds, which have tended to limit their scope of operations.

4.0 STRATEGIES FOR TECHNOLOGICAL AND INDUSTRIAL DEVELOPMENT

Quantitative improvement in the production line and output of manufacturing industry can only be achieved through the promotion of engineering research to develop endogenous technology that will largely drive the operations of the industry. The locally developed technology can be supplemented with imported technology which operators will be specially trained in the country where the technology is developed such that in event of any breakdown there will be available skill personnel that would be in a position to carry out maintenance work on the machinery.

Some countries, such as South Korea and Taiwan, have traditionally preferred to pursue a strategy of industrial development based on national firms (12, 13). This has required the active attitude of governments opening alternative channels of knowledge flows, for example, by fostering scientific and technical collaboration with developed countries at the highest degree available, while simultaneously investing in technological capabilities, including South Africa, Chile, Brazil, India, Malaysia and Thailand, have encouraged foreign firms to operate in the country and have tried to use them for acquiring productive, managerial and technological expertise.

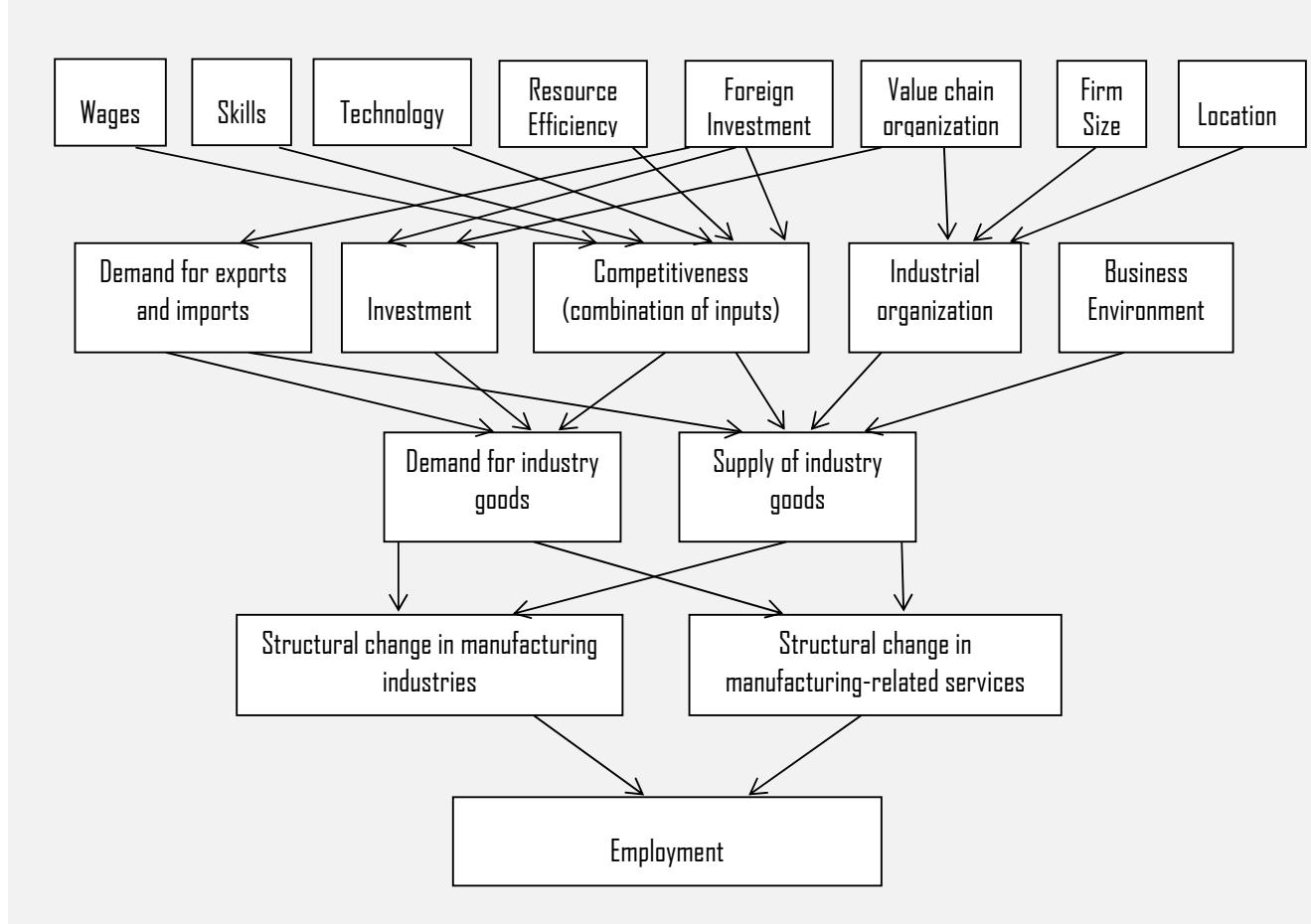


Fig. 1: Drivers of Structural Change in Manufacturing
Source; UNIDO (14)

In developing countries, technology constitutes a major factor that has been militating against the development of viable manufacturing industry. The technology transferred to the developing countries is usually created in developed countries in response to the perceived market conditions in the former countries. Some of the imported technologies require highly specialized manufacturing skills with a focus on technical subjects such as engineering and mathematics and strong technical and vocational education and continued on-the-job training which are to a large extent lacking in most developing countries. In order to address the low capacity and effective capacity utilization in the manufacturing industry, it is important that firms come together to identify the requirements of each firm under the concept of needs analysis.

4.1 Needs Analysis

It is important that manufacturers in developing countries develop a synergy to collaborate to identify the technology required for their production processes and map out strategies on how relevant machinery can be produced locally and if there are challenges in producing the machinery locally partnership with foreign firm(s) can be initiated. Efforts should be directed at the development of appropriate technology that is simple to use and maintain. Each firm has to exert considerable absorptive efforts to

learn the tacit elements of technology gain and adequate mastery.

Technological collaborations occur, when two firms decide to establish joint ventures with the aim of developing technical knowledge and/or products. According to Bartlett and Ghoshal (15) three conditions needs to be respected:

A single ‘brain’ located within the manufacturing industry concentrates the strategic resources: top management, planning and technological expertise. The ‘brain’ distributes impulse to other subsidiaries scattered across host countries. Even when some overseas R&D are undertaken, this basically focuses on adapting products to the need of the local users.

One, two or more manufacturing industries join to produce a technology, may develop technological know-how to serve local needs. The interactions among the companies are, entered on the view point of developing technological innovations.

The manufacturing companies, rather than concentrating their technology activities in the home country, they distribute R&D and expertise in variety of host locations.

This allows the company to develop each part of the innovative process in the most suitable environment. The effectiveness of such a strategy relies on intense intra firm information flows.

Collaboration between industries will lead to innovation. The industries will have the wherewithal to engage researchers to work for them.

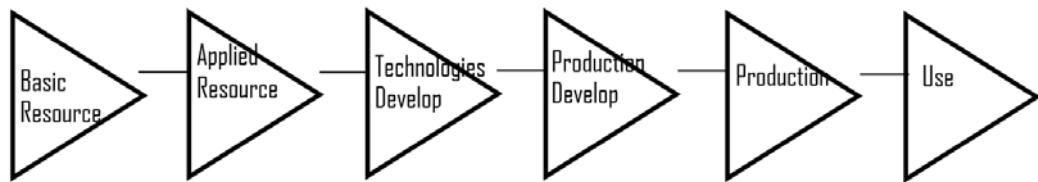


Figure 3: Six-phase linear model of an innovation process

This model supposes that technological innovation begins with the performance of basic research which produces results that are to be of commercial interest. During the technological development phase, the first pilot production plants are developed, tested and evaluated. Based on the results obtained, the actual production processes for the material are designed and then for any auxiliary chemical added. In product development, the material is tuned to other market demands. After the production (manufacture), the product is planned for delivery to the users.

The collaboration between the manufacturing industries can be coordinated by Chambers of Commerce in each

A technological innovation is often the result of 'heterogeneous engineering' involving a wide array of activities. Mylder (16) presented a six-phase linear model that assumes a linear sequence that starts with basic research and leads to the use of new products by consumers.

developing country. In Nigeria the agency is called National Association of Chambers of Commerce, Industry, Maritime and Agriculture (NACCIMA). The starting point will be to carry out the needs analysis of the manufacturing companies.

An interactive model that depicts the effect of industry-oriented research on the output capacity in the industrial sector is provided in Fig 4. The model indicates that based on the input from research, there could be mass production of goods which will reduce the production cost and therefore translate to reduced unit cost and high demand for products.

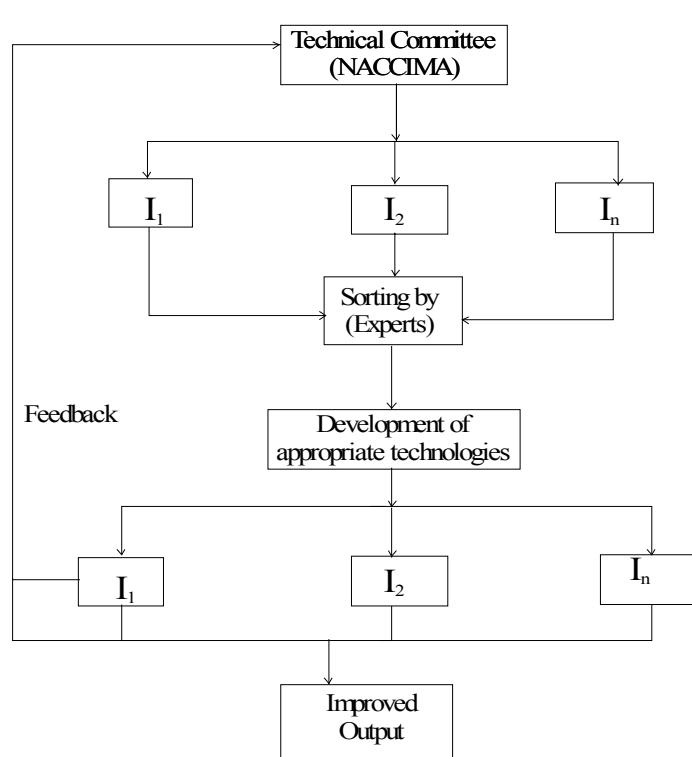


Fig. 4: Model for technology enhanced output based on appropriate technology.

Fig. 4, shows that to bring the unit cost down there is need to adopt appropriate technology that ensures low production cost. To this end, there is need to identify the requirements of each industry by a Committee to be set up by National Association of Chambers of Commerce, Industry, Marine and Agriculture (NACCIMA). The Committee identifies and collates problem areas in difference industries (I_1, I_2, \dots, I_n). Then sorting takes place by a body of Experts that are selected from industries and research institutions. The problems are later classified based on the needs analyses of individual industries e.g. processing, manufacturing, fabrication etc. Once the technology need of each industry is determined the proposal for the development of engineering basis and the required technology is referred to engineering institution for appropriate investigation and recommendations. Universities and polytechnics are repositories of knowledge. Experts in various disciplines relevant to manufacturing industry are available in these institutions whose primary duty is to extend the frontiers of knowledge. The involvement of researchers will further enhance the diffusion of know-how within the universities and other public research institutes which will propel industrial development. Such efforts should lead to the development of endogenous technology which usually makes the best use of local resources of a particular country in order to improve the economy of that country. Endogenous technology does not exclude the adoption of 'foreign' or 'international' or 'exogenous' technology but such technology must necessarily be adopted to suit the particular needs, conditions and resources of the developing country. This may result in the development of clusters.

Good workforce skills are also a fundamental condition for the emergence of clusters – group of enterprises that gain performance advantages through their mutual proximity. Specialized competencies are developed both within and between firms offering a competitive advantage for the firms within the cluster. A proactive role for government of clusters and in supporting cooperation between firms in clusters can help to simulate the adoption of technologies and skills upgrading programmes. Apart from the adoption of appropriate technology, industry needs constant research for a feedback from the consumers of their products to enable them assess how well they have satisfied them and to plan and project into the future.

4.2 Attribute of Research Driven Industry

Industrial processes depend on input, human resources and equipment. The production line of an industry that relies on obsolete equipment would be cumbersome and the products expensive because of low production level and high consumption of resources. The aftermath is that the unit pride of the product is always higher, higher than the imported alternatives. In Nigerian market today, it is common to see foreign products that are cheaper than the locally made 'goods' which are often preferred by the consumers. The inability of the industry to compete with their foreign competitors has led to closure of many industries thereby throwing their workers to the labour market while the industries resort to alternative buying and

selling to remain in business. But when the production line of an industry is driven by modern technology arising from findings of engineering research, there will be high efficiency, low consumption of resources, with high output per unit of time. This results in low unit cost, affordable products, high product demand, improved standard of living and overall growth in the national economy. In Nigeria, Agricultural sector is witnessing tremendous improvement in output because of the partial adoption of mechanical farming. The universities, polytechnics and research institutes are working assiduously to develop endogenous technologies that will enhance the output of the manufacturing industries

5.0 CONCLUSIONS

The following conclusions are made from the foregoing:

- (i) The research institutions are poorly funded and lack necessary facilities to conduct researchers.
- (ii) The local raw materials, chemicals and equipment in the industry are underdeveloped.
- (iii) The operations of both research institutions and industry are adversely affected by the poor state of national infrastructure especially electricity.
- (iv) There is low level of awareness, lack of communication between the research institutions and the industry.
- (v) Collaboration within manufacturing industries within a nation on the one hand and foreign firm on the other hand will lead to innovation and development of endogenous technologies.

6.0 RECOMMENDATIONS

The following recommendations are made:

- (i) Improvement is required in the funding and facilities in research institutions
- (ii) The industry needs to embark on training and retraining of its staff to make them relevant in the emerging new technology and decision taking for the promotion of industrialization.
- (iii) Industry should be involved in the review of engineering curricula and development of research goals in research institutions for their relevance to the industry needs.
- (iv) The needs analysis should always be carried by a body of experts to enhance the development of problem solving research.
- (v) NACCIMA should champion a procedure that brings effective partnership between research institutions and industry.
- (vi) Manufacturing industry should cooperate with each other to promote innovation.

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