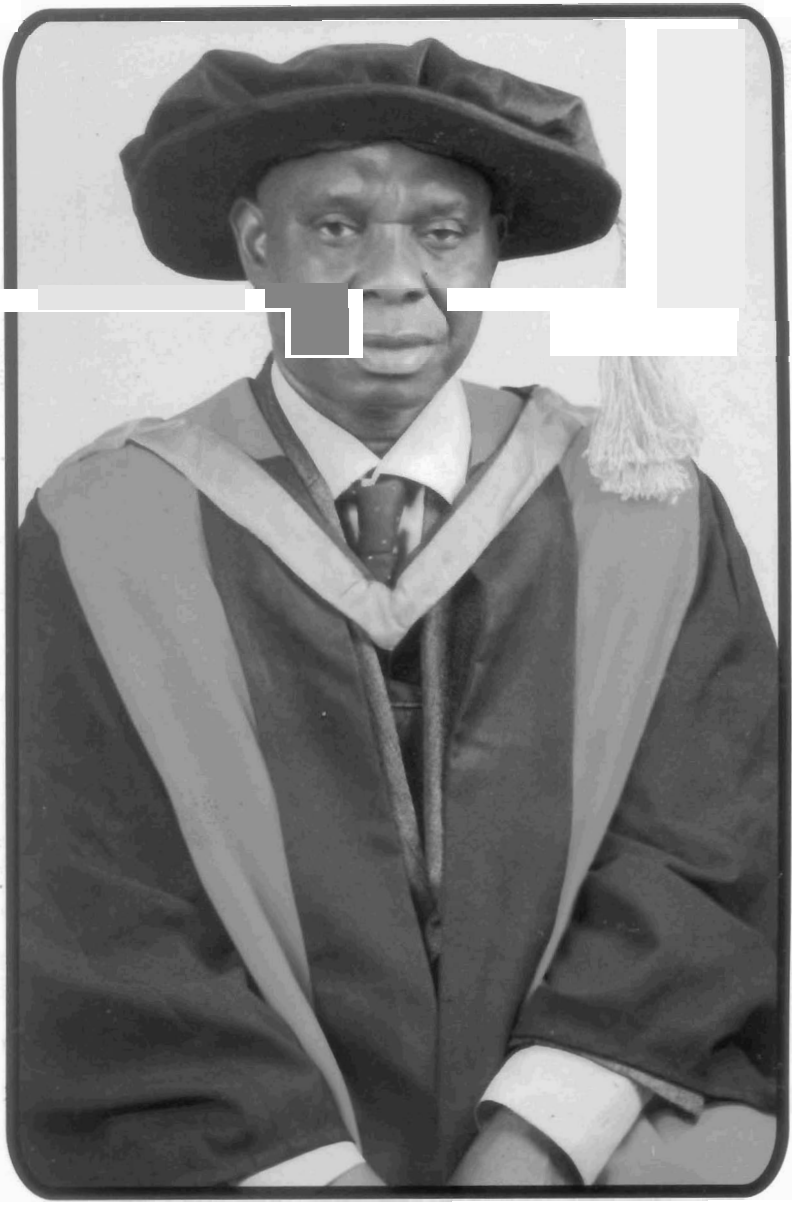
INAUGURAL LECTURE SERIES 321

NEXUS BETWEEN TECHNOLOGY MANAGEMENT AND REJUVENATION OF THE NIGERIAN ECONOMY

By

TIMOTHY OYEDEPO OYEBISI
Professor of Technology Management



TIMOTHY OYEDEPO OYEBISI

Professor of Technology Management

NEXUS BETWEEN TECHNOLOGY MANAGEMENT AND REJUVENATION OF THE NIGERIAN ECONOMY

An Inaugural Lecture Delivered at Oduduwa Hall, Obafemi Awolowo University, Ile-Ife, Nigeria. On Tuesday, 26th June, 2018.

By

TIMOTHY OYEDEPO OYEBISI
Professor of Technology Management

Inaugural Lecture Series 321

ISSN 0189-7848

Printed by

Obafemi Awolowo University Press Limited,
Ile-Ife, Nigeria

NEXUS BETWEEN TECHNOLOGY MANAGEMENT AND REJUVENATION OF THE NIGERIAN ECONOMY

Preamble

Mr. Vice Chancellor Sir, Distinguished Ladies and Gentlemen, it is with utmost gratitude to God that I stand before you to present the 321st Inaugural Lecture which is the 3rd to be presented by a Professor in the African Institute for Science Policy and Innovation (AISPI) of this great citadel of learning. Thanks be to my Creator who, being the Truth Himself, has graciously given me the opportunity to unravel an infinitesimal strand of truth; the summary of which I am presenting today. My boast is in Him who has made me qualified to stand before this august audience to testify to His mercy and faithfulness. This is the Lord God almighty who specialises in bringing something good out of what people thought had no value. It was He who had been directing my steps since I was brought to this world over 63 years ago and particularly in the last 33 years. I have tasted and found that the Lord is good. Praise the Lord. Halleluyah!!! Glory be to His name Amen.

My career in Technology Management began when I joined the then Western Nigerian Broadcasting/Western Nigerian Television (WNBS/WNTV) in 1975 as an Engineering Assistant 1 after my OND in Elect/Elect from The Polytechnic, Ibadan. While I was still with the broadcasting organisation which later metamorphosed into Nigerian Television Authority (NTA), I got the opportunity to obtain HND in the same institution; this I completed in 1979. I served this country during my National Youth Service Corp (NYSC) year in the then Nigerian Telecommunications Ltd (NITEL), Bauchi between 1979 and 1980. It was during this time that I prepared for the Part II (Final) examinations of the Council of Engineering Institutions of Great Britain which was equivalent to B.Sc. degree in Engineering in the United Kingdom, which I passed in 1980. This made me to be qualified for admission into the M.Sc. degree programme of the Department of Electronic and

Electrical Engineering of University of Ife in 1981 which was my first contact with the University. That was the first time a candidate with my type of qualifications would be admitted into the M.Sc degree programme of the Department of Electronic and Electrical Engineering of the University. This was made possible by the recognition which the then Heads of Department (HODs); Prof. Owolabi and Late Prof. Buraimoh – Igbo, accorded the Council of Engineering of Institutions of Great Britain. Thanks be to God, I did not disappoint them.

In 1984 I transferred my services as a Senior Engineer from NTA to OAU as Lecturer II (courtesy of Council of Registered Engineers of Nigeria [COREN]) in the Department of Electronic and Electrical Engineering and started my Ph.D. programme in the same department which I completed in 1991.

My quest for a career in the management of technology got a boost when I registered for a Master of Business Administration (MBA) degree in the Department of Management and Accounting of this University and completed it in 1995. Mid-way, I transferred my services from the Department of Electronic and Electrical Engineering to Technology Planning and Development Unit (Now, African Institute for Science Policy and Innovation) in 1994 as a Research Fellow I. By providence, I rose to the post of Research Professor in Technology Management in 2004. It is therefore my humble priviledge, not only to give a summary of account of my teaching, research, and administrative experience in the last 33 years but to enlighten the general public on the importance of this emerging body of knowledge, Technology Management, which is domiciled in the African Institute for Science Policy and Innovation (AISPI), to the quest of Nigeria for achieving sustainable and inclusive economic growth.

THEOLOGY OF CREATION

*Begin where we will, God is there first. In the beginning God..... (Gen. 1:1). Not matter, for **matter** is not self-causing. It requires antecedent cause, and God is that cause. Not **law** for law is but a*

*name for the course which all creation follows. That course had to be planned, and the planner is God. Not **mind**, for mind also is a created thing and must have a creator back of it. In the beginning **God**, the uncaused Cause of matter, mind and law. There we must begin.* (A.W. Tozer.).

God created the physical and spiritual universe at the first 'out of nothing' *"ex-nihilo"* (Gen. 1:1). Providence asserts that God, having called the world into being continually, sustains, renews, and orders it. This continuous creative activity can be illustrated by what we call the 'natural' order. Stars and seasons, changes in weather, the life cycle of the meanest creature and the whole human life cycle are directly referred to as the work of God. God is the owner of all things, including the earth we inhabit and all its forms, all of its fauna and flora. "The earth is the LORD's and everything in it" (Ps. 24:1, cf. Heb. 2:8, 1 Chr. 29:11). Hence our dominion is a **responsible dominion**, in the exercise of which we are totally accountable to God, and one day we shall be required to hand over accounts to Him.

God has now delegated the creative power in the universe to mankind. This creative power is translated to Dominion and Recreation. It therefore behoves us to be responsible, faithful (1 Cor. 4:2) and trustworthy with the resources God has endowed us with. It is a call to responsive leadership; after all, our dominion is leasehold and not freehold. Since the creator God is also ordering the universe towards the realisation of His goals, we may safely conclude that **God is the first and chief manager**.

Management as a universal concept can be seen as an act involving a responsible response of a creature (mankind) to the creator. Management can therefore be described as what everybody engages in; that is, ensuring that things follow normally prescribed course of action towards the realisation of the set goal. One can safely opine that **management is a universal phenomenon of ensuring that human beings are involved in a responsible response to resources (RRR) given by the creator**. God has

delegated this central responsibility to the government of nations whose main interest (derived from God) is the maintenance of security and welfare (1999 constitution of FRN as amended). This can be summarised as the provision of human security which, according to Fukuda-Par and Messineo (2012) and Menon (2007), gives seven dimensions of human security which are:

(i) Economic security (an assured basic livehood derived from work, public and environmental resources or reliable social safety nets, etc);
(ii) Food security (ready physical and economic access to basic food);
(iii) Health security (access to pursue health care and protective public health regimes among others);
(iv) Environmental security (safety from natural disasters and resource scarcity as a result of environmental degradation);
(v) Personal security (physical safety from violent conflict, human rights abuse, domestic violence crime, child abuse, and self-inflicted violence such as drug abuse among others);
(vi) Community security (safety from oppression, community practices and from ethnic conflict among others); and
(vii) Political security (freedom from state oppression & abuses of human rights).

The submission of Fukuda-Par and Messineo (2012); and Menon (2007) though not totally inclusive, provides largely the context in which mankind operates. So God has given mankind the instincts to navigate the terrain of human endeavour. These instincts lead us to find ways, means and techniques for ensuring personal survival and self-preservation.

Definition and Scope of Technology

Technology conjures up different images in the minds of different people. Etymologically, the word "technology" is derived from the Greek word "technologia". Structurally, the Greek word is presented below:

	Technologia	=	techne	+	logia
i.e.	(technology)		(technique)		(study, knowledge)

Thus, technology has been variously and simplistically defined as: A technique, or procedure, or process, study or knowledge of techniques or processes, science of technical processes in a field of knowledge, science of the industrial arts, among others (Daussage *et al.*, 1992). Its expression is seen as tool, physical manifestation, knowledge, applied science and academic discipline (Gaynor, 1996)

According to Kumar *et al.* (1999), technology is a physical component which comprises items such as products, tools, equipment, blueprints, techniques, and an informational component which consists of know-how in management, marketing, production, quality control, reliability, skilled labour and functional areas. Technology is always connected with obtaining certain results, resolving certain problems, completing certain tasks using particular skills, employing knowledge and exploiting assets (Lan and Young, 1996). The concept of technology does not only relate to the technology that embodies a product but it is also associated with the knowledge or information of its use, application and the process in developing the product (Bozeman, 2000 and Arrow, 1962). Technology can also be seen as the integration of the physical objects or artefacts, the process of making the objects and the meaning associated with the physical objects. Maskus (2003) has broadened the concept of technology and described it as 'the information necessary to achieve a certain production outcome from a particular means by combining or processing selected inputs which include production processes, intra-firm organisational structures, management techniques, and means of finance, marketing methods or any of its combinations'. The word "technology" can also be used to refer to a collection of techniques. In such a context, it is the current state of humanity's knowledge, either in a particular field or in general, of how to combine resources to produce desired products, to solve problems, fulfil needs, or satisfy wants. It includes technical methods, skills,

processes, techniques, tools and raw materials. Terms such as "medical technology", "space technology" and "state-of-the-art technology" refer to the state of the respective **field's knowledge** (as well as the tools used). So it is fashionable to talk of the management technology, social technology and even law technology.

Technological changes have been known to contribute to industrial innovation. There is empirical evidence that technological intensity affects organisation performance (Klepper and Simons, 2000) and indeed have positive effect on overall survival rates. (Agarwal and Gort, 1996)

From the foregoing, we can infer that humans are co-authors with God and an all-encompassing definition of technology can be inferred as ***"the ability which the Creator has endowed the mankind to be able to effectively, efficiently and sustainably harness the forces of nature both material and mental and all other resources for the benefits of mankind"***. It can also be a process or means to an end, or both.

We can safely conclude that **technology assists human beings to comprehend themselves and their environment better.** For one to do justice to the advantages and uses of technology is to write volumes and volumes of treatise because it can be said that in technology we live. We use it and come across it in one form or another in almost all areas of our daily living. It is basic and central to productivity, social inclusiveness and even security.

NEGATIVITIES OF TECHNOLOGY

With increase in population, stressed facilities, resources depletion, changes in socio-cultural and economic milieu, people have to adjust themselves to changing realities. This response is the cause for a creative search for ways and means of survival. There is also the danger of unintended impacts of these unfolding realities and these make the business world and day-to-day living complex and

dynamic. **Therefore, the development of technology is an unending quest of mankind.**

It is evident from the foregoing that **technology is neutral and inanimate.** However, when it is not appropriate, well planned, coordinated and controlled it can be grossly counterproductive. These are manifested in virtually all spheres of application of technology. For instance, in teaching and learning, the same information and communications technology (ICT) tools that are used in learning are also sources of distraction for students, and sometimes even teachers can get hooked in the social media platforms (such as Facebook, Twitter, YouTube and Instagram) rather than in the subject content. Marketing effort of big data houses such as Google, Microsoft and Yahoo are not exempted. Applications such as e-calculator tend to reduce the reasoning ability of human beings particularly when used too early or when over used; that is, training mental faculty to reason at a slower pace by being too lazy to solve simple reasoning activities for kids and young children.

Next is the impairment of social life. There has been an increased crime rate due to abuse of ICT leading to fraudulent purposes. Cybercrime commonly known as 'Yahoo! Yahoo!' in Nigeria parlance which is as a result of usage/deployment of ICT for negative purposes is on the increase. Also, exposure to images and texts that contain adulterated objects could enhance negative character development in the young users. In addition, we have the issue of unscrupulous people hacking into personal information of an individual, an organisation and government.

In addition, the use of social media platforms by various individuals has led to situations where rumours and unconfirmed news become so pervasive and misleading; thereby creating chaos, unrest and damage of trust or reputation. A piece of news that is not broadcast by mainstream media companies on the Internet should be handled with caution. An unconfirmed piece of news needs to be regulated through confirmation via mainstream media.

People also need to be sensitised to check and cite sources of information before rebroadcasting them via social media platforms.

Reduced Level of Physical Interaction in Human Relationships
Intense use of IT tools has also led to isolation of the inter-physical aspect of human relationships in society. Relationships are almost becoming virtual commitment as more and more people tend to use social networks and telephone calls rather than physical presence to communicate with their loved ones. If relationships in societies are to thrive effectively, the need for real empathy and physical human-to-human interaction should not be absolutely replaced by electronic means of communication; that is, computer-mediated human interaction.

The use of computers and computerised processes in industries often leads to **manpower redundancy and high employee turnover**. As such, it is basically cost ineffective for corporate management to sustain such employees whose jobs can be done better using technology since they are no longer essential. The resultant effect of an organisation's adoption of information systems and information technology automation, more often than not, is the removal of low-cadre staff from its workflow. Artificial intelligence and automation of systems have led to **reduction in the need for manpower in some industries; thereby creating a decrease in need for manpower** at the base of the organisational pyramid. In addition, Internet insecurity is negatively affecting e-commerce, with significant amounts of personal information supplied online, including financial information; privacy and security have become a priority. The findings of Aladesanmi (2015), a Ph.D. research work mainly supervised by me established that the openness, global reach, and lack of physical cues that are **inherent characteristics of e-commerce also make it vulnerable to fraudulent activities with attendant** costs such as legal costs, manpower loss and reputational damage for e-commerce merchants.

Environment

There are elements included in the design and installation of ICT that could be seen as unsustainable. Damaging materials are used in ICT components, for example, the batteries in mobile telephones contain toxic metals such as lithium or cadmium. The ores of such metals are quarried and then undergo lengthy and expensive refinement processes, causing significant environmental pollution. The average lifetime of a personal computer (PC) used for business purposes is three years and, in Europe, the replacement cycle of a mobile phone is 18 months. As technology advances and more functions and capacity are offered, the number of obsolete or undesirable products increases. Dealing with electronic wastes without damaging the environment is a major challenge. Such ends up eventually in landfill sites, where polluting substances used in ICT components can leak into the ecosystem. **It is clearly evident that for technology to achieve the desired outcomes, it must be properly managed.**

DEFINITION AND SCOPE OF TECHNOLOGY MANAGEMENT

Technology Management can be described as a discipline which interfaces between producers and users of technology. It is seen as a critical nexus between the generator and the recipient of technology and research and development (R&D) outputs. Really, its proper usage as a tool can enhance largely the utility of science and technology for national economic development. It is a means or body of knowledge for effective harnessing of science, technology and innovation for national development. It enables us to master and not to be slaves to technology.

Technology Management assists immensely in the translation/transformation of technology into goods and services. That is, it is the science and art of transforming research ideas into prototypes which can later be commercialised and deployed effectively. It is core in the fulfilment of the divine mandates of man's earthly existence (Gen. 1:26; 2:7). **Thus, Technology**

Management is a critical nexus between the fundamental bodies of knowledge, sciences and humanities.

As a discipline, it can be seen as one with three basic pillars; namely, technical feasibility, economic viability and **social acceptability** of technology. In this wise, it seeks to reduce wastes, increase acceptance, reduce tension in usage, operations and deployment, and increase effectiveness of technology. **As a management function, the discipline involves forecasting, planning, coordinating, controlling and organising activities and resources involved in the generation/production and deployment of R&D results towards the realisation of the goals and requirements of the users and other stakeholders.**

Technology Management is the bond that seeks to coordinate all stakeholders in the production of goods and services and the users of same. In this wise, the necessary and unnecessary conflicts that can impede the flow of technology and thereby reduce its impacts can be drastically minimised by technology management.

Technology Management as a discipline has three functional phases or activities namely development, transfer (diffusion) and usage/deployment of technology as shown in Fig. 1.

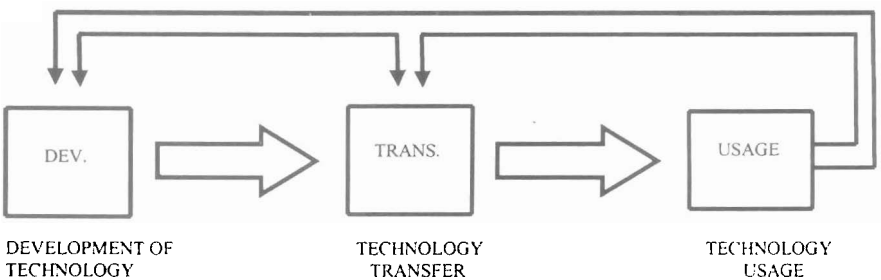


Figure 1: Core Activities in Technology Management

Development of Technology: This phase involves the production of technology which includes Research, Development and Innovation (RD&I) activities. Research (R), in this context, refers to the analysis, experimentation, conceptualisation, synthesis, and

theory-testing that relate to new scientific ideas and discoveries and new technological applications. Development (D) refers to experimental development which consists of the adaptation, testing, refinement which leads to practical applications in the field of Science and Technology (UNESCO, 2016). This has to do with the systematic use of research results to bring out new products and processes, materials, devices including pilot plants and prototypes. Here the technical feasibility, economic viability and social acceptability of the products, both the embodied and disembodied technology also needs to be considered. Innovation in the Technology Management parlance simply refers to the commercialisation of technological change which means the introduction of new or improved or modified products or process to the market. This ensures that the new ideas, discoveries and inventions are effectively utilised for the benefit of mankind.

Between the development phase and the usage of technology phase is the transfer phase. In this phase, there are diffusion and integration of technology. Activities here include transfer of technology in the form of research results into the industry, spillover effects such as imitation, reverse engineering, modification and exchange of information among customers, suppliers and competitors among others.

The third phase is the actual usage and deployment of activities such as operation, maintenance, repairs and reliability enhancement of technology. Obviously, these involve availability of well trained and skilled operators, engineers, technologists, with an adequately equipped workshop to be able to achieve both effectively and efficiently. It also requires that all appropriate and relevant stakeholders in the usage and deployment of technology must be actively involved in the making of decisions relating to the technology procurement and development. There have been instances where some pieces of equipment were bought without the provision for a well-written service manual and schematic circuit diagrams, which could have greatly helped the technicians in the effective maintenance and possible reliability enhancement of the

facilities. Next to having a well-equipped workshop are the issues of adequate motivation for the operators, technicians and engineers as well as the provision of materials and consumables. These are premised on the availability and accessibility of stores that are well managed.

The foregoing underscores the need for appropriate application of technology management techniques. Thus, one can safely come to a conclusion which is more inclusive than what obtains in the literature; that is, **"Technology Management is the discipline or body of knowledge that involves forecasting, planning, organising and controlling activities which relate to the development, diffusion, operations, maintenance and reliability enhancement of technology."** It is therefore a key factor in the achievement of organisational goals.

Technology Management in Manufacturing Environment

In the manufacturing setting, production and operations management is the main thrust. Here, key activities as far as Technology Management is concerned can be classified into activity scheduling, inventory management, and capacity management. Activity scheduling involves operations scheduling; this means specifying, in advance, the timing of occurrence of events within the system such as arrivals to and departure from inventories. Inventory management has to do with planning and control of physical stocks, raw materials, work-in-progress, and finished goods (Heizer and Rendar, 1988). The need for effective management arises as the availability of inventory may mean higher customer services, insulation against demand fluctuations and smoothened operation. However, it may also involve tying down of considerable amount of capital, and a need for the provision of adequate storage with associated holding costs. Capacity management concerns matching capacity of the plant or system with customer's demand. This is necessary because excess capacity gives rise to low resource utilisation while its inadequacy may mean poor customer service. Capacity management decisions determine how the production and operation management system

will accommodate the levels of customers' demand with their uncertainty and fluctuating tendencies. These decisions which are strategic in nature provide the context within which inventories and operations scheduling will be both planned and controlled. To a very large extent, the decisions determine the operating policy of the organisations. **Inventory management and operations scheduling problems can thus be seen as being more tactical while capacity management is largely strategic.**

Tactical and Strategic Components of Technology Management

As a management function, technology management encompasses both tactical and strategic considerations. While the issues relating to operations, maintenance and reliability and other deployment and diffusion can be considered tactical, the strategic components lie largely in the development of technology. The strategic components consist of making a technological choice of selection and acquisition decisions. In most cases, these considerations or factors which determine the acquisition of technology can be internal development or acquisition of a firm possessing the technology, Joint venture, External R & D contacts (out-sourcing), Licenses model or Private labels (Dussauge *et al.*, 1992).

The strategic components of technology management as a discipline also involve establishing a strategic alliance with relevant stakeholders. This includes maintaining close link with an existing source of technology such as university research laboratories and other R & D centres. Such relationship fosters integration of scientific research and technologically applied works. Next to be considered is the role of government in developing technology. As a chief cornerstone of both national security and economic development, technology is one of the top priorities of government of all industrialised nations. Usually, the forms of government intervention are in two categories; namely, R & D financing and steering technological development (Dussauge *et al.*, 1992). Also, government can control the wheel of technological progress by awarding contracts; thereby providing

market for the technologies developed. By deliberately favouring certain suppliers of their choice, government can guide the technological specialisation of firms. The import of the aforesaid is that winning government contracts may not be solely on a traditional consideration such as performance and cost but, almost inevitably, from political dimensions. Of course later in more open market, firms benefit from technological advantage which earlier government interaction has afforded them. The scenario just painted is that of the USA, Japan, France, and other European countries and most industrialised nations of the world. For instance, the Internet which started as a research effort of NASA was funded primarily by the USA government but has now become a global communication infrastructure. The development of the Boeing 707 aircraft was 80% financed by the US defense budget. In Japan, the Ministry of International Trade and Industry (MITI) is the instrument of government industrial policy which ensures that the nation's economy is in tandem with the interest of the private sector (Dussauge *et al.*, 1992). In another Ph.D thesis supervised by me, it was established that the major impetus for the Nigerian software industry for global competitiveness is for the government to encourage domestic use of the locally developed software products (Binuyo, 2012).

In addition to the deliberate intervention by the government, other strategic issues which technology management will have to contend with include government regulations such as factory laws, corporation laws, company and allied laws, taxes, labour legislation, economic fluctuations such as changes in market demand and price levels, and socio-cultural and religious issues, and rapid technological development.

METHOD OF RESEARCH IN TECHNOLOGY MANAGEMENT

The method of research in technology management is that of scientific management which uses an objective, empirical method whereby it begins with a problem or need, collects, classifies and analyses data, and formulates a tentative principle or law which it

then applies in order to determine its validity and usefulness. In its procedure, scientific management relies largely on other sciences such as economics, statistics, and industrial psychology.

Presently, the analysis of data in technology management is based centrally on statistics, econometrics and engineering economy methods. One thing that is common to these tools is the use of models to represent the real world. Of course, we know that models **actually inform our sense of judgement and not replace our value judgement**. They do immensely assist us (humans) to always reduce complexities associated with the real world but they have limitations that make their usage not to be complete as they are made on assumptions which often are not adequate.

First, not all information such as opinions or perceptions about the observed phenomena needed for an informed decision is quantifiable. Of course, there are tools such as Likert rating scale which one can use to convert qualitative data into quantitative form but the fact still remains that there are high elements of subjectivity in such exercise.

Second, there is the issue of incomplete data. For a decision maker to arrive at the most accurate judgement, he has to be in possession of near complete information (absolute truth) which by nature is NOT possible. Hence, he has to make some assumptions, and this makes models based on such inadequate information to be, at best, not the ideal.

Third, some decisions need critical information to make informed judgement, and when such information are subject to whim and caprices of the manager, the accuracy of the decision could be impaired. Most often than not, such information is premised on extraneous considerations such as political, religious and socio-cultural, and even psychological issues. In that case when data are subject to only statistics/econometrics or engineering economic analysis, the decision maker/manager could not make the most accurate decision.

Furthermore, there is an issue of natural order/disaster that cannot be predicted. These include but not limited to weather, theft, and accident. It is therefore very clear that a decision made based only on quantitative models cannot be very accurate.

The issue of ethics is another major consideration in the management of technology as the deployment of technology is also based on the attitude of the managers/users/developers of such a technology. Attitude can be summarily described as a state of feeling as regards some issues. So largely, the manager is influenced by what he considers the best in a given situation. **This lends credence to the fact that "Technology is neutral"**.

Next to be discussed is issue of history. For a researcher to do justice to the pursuit of truth or unknown, he must be able to raise pertinent questions on the phenomena. Most often than not, the researcher is largely influenced by his past knowledge which is simply history. So in order to be able to properly choose and, at times, deploy technology effectively, history of the technology and its usage including challenges must be known.

There have been instances where decisions in business and projects to be undertaken were based on quantitative models such as Net Present Value (NPV), Internal Rate of Return (IRR), pay-back period, net worth, and cost-benefit analysis. So when put in the overall context of unfolding realities the models were not the best or optimal. As a result, another method of analysis is desirable.

Introduction of System Dynamic Method of Analysis

The business world and other situations in which the technology manager is to operate are complex and dynamic in nature. This is because there are many variables which are often **interrelated, nonlinear,** and **more often than not,** are the causes of another set of effects. The seemingly obvious solutions to problems sometime fail or actually worsen the situation which is often referred to as policy summersault.

The dynamic aspect of business/world realities comes with the fact that change in systems occurs at many time scales. Because the variables interact strongly with one another and with the natural world, systems are naturally governed by feedback. In addition, cause and effect are distant in time and space while we tend to look for causes near the events we seek to explain. Furthermore, delays create instability in dynamic systems indicating that the long-run response of a system to an intervention is often from its short-run response (Forrester, 1968).

The present methods of analysis in technology management involving the use of optimisation, statistics/econometrics, and engineering economic tools are premised on the availability of purely quantitative data, and usually the model developed is based on a linear model. This makes the use of the model less accurate as realities unfold in nonlinearities. In the Ph.D. research work of Engr. (Dr.) Obawole which was mainly supervised by me, it was found out that even with front-end planning adopted in the management of the Nigerian upstream oil and gas projects, the failure rate in project costing for projects over $500m was as high as 40% (Obawole, 2011).

Furthermore, optimisation-based models are essentially equilibrium models that focus predominantly on the short-term performance of the system, though, this has not precluded the existence of a few long-term market analysis based on optimisation techniques (Olsina, 2005). On the other hand, econometric models are inherently descriptive, aiming at reproducing the actual observed market behaviour regardless of whether it deviates from the ideal behaviour described by the prescriptive models or not. Thus, even though the econometric models are extensively used by economists for representing the statistical relationship between economic variables, they have not been applied, for example, to the long-term modeling of liberalised power system performance (Dyner and Larsen, 2001; Ford, 1997; and Ventosa *et al.*, 2005).

Moreover, model optimisation and econometrics including engineering economy assume linearities of cause-effect relationships that negate natural realities which are essentially non-linear. So non-linearities, feedbacks, time delays, and accumulations make the understanding of the problem which we seek to solve much more complex. Therefore, simulation is the only practical way to test and articulate these models. Besides, decision made often require hundreds of feedbacks; both positive which is reinforcing and negative which is self-correcting. There is, therefore, a need to make use of other models of analysis that remove these functional realities. What readily comes to mind is the use of system dynamics (SD) method of analysis. System dynamics is grounded on the theory of nonlinear dynamics and feedback control developed in mathematics, physics and engineering. Since these tools are applied to human behaviour including social technical systems, SD draws on cognitive and social psychology, economics and other social sciences. In the use of SD tools for researchers to find answers to real world problems, they must learn to work effectively with groups of policy makers on how to influence sustained change in an organization (Forrester, 1968).

Skills required to make successful approaches to learning about complex dynamic systems include (i) tools to elicit and represent the mental models we hold about the nature of difficult problems (ii) formal models and simulation methods to test and improve our mental models, design new policies and practise new skills; and (iii) methods to sharpen scientific reasoning skills, improve group processes and overcome defensive routines for individuals and teams (Forrester, 1968).

INDUSTRIAL COMPETITIVENESS AND SOCIO-ECONOMIC DEVELOPMENT

Economic growth is the increase in the goods and services produced by an economy, typically a nation, over a long period of time. It is also the increase in a country's productive capacity, (Jones, 2016). Economic growth is often contrasted with economic

development which refers to the adoption of new technologies, transition from agriculture-based to industry-based economy, and general improvement in living standards. Economic development which is the process of raising the level of prosperity through increased production, distribution and consumption of goods and services are premised on industrial competitiveness (Oyelaran-Oyeyinka, 2017).

Industrial competitiveness of any nation is described as the capacity or the ability of that nation to position itself in the production of essential goods and services in a manner that it can compete globally; thus promoting socio-economic development (Muchie, 2017). Socio-economic development can be described as progress in terms of economic and social factors within a geographical unit which is measured with indicators, such as gross domestic product (GDP), life expectancy, literacy and levels of employment. It therefore follows that **when industrial competitiveness is sustained and addressed to the basic and essential needs of the citizenry, it follows almost directly that socio-economic development of the nation will rise.** In other words, sustained industrial competitiveness shapes socio-economic development of any nation.

For a nation to have sustained industrial competitiveness, **technology development and innovation are the key drivers.** In the global arena, interests in technology development and industrial innovation have increased as concerns mounted on the economic growth; development and transformation of nations have increased. **It has been established that the economic growth, sustainable development and global competitiveness of any economy depend on its science, technology and innovation (STI) capabilities** (Ilori *et al.*, 1996; Siyanbola *et al.*, 2012; Camisón and Villar-López, 2014; Dada, 2014). Technological capability is the ability to create new technologies and to develop new products, processes or new industries in response to changing economic environment (Kim, 1997). Building local technological capability, therefore, is a necessary condition for any nation

aspiring to grow and develop (Adeoti, 2002). This calls for a number of interventions to enhance the productivity of new and existing investments and thus improve competitiveness.

Due to low technological capability in Nigeria, indigenous firms have resorted to externally source for technology in an unmodified state. This situation has led to inadequate utilisation of domestic resources including human and environmental resources, and it has also resulted into minimal linkages between different sectors of the economy because foreign technologies are designed for foreign economies. Firms which complement technology imports with intra-firm technology transfer and in-house development are better positioned to bring about technological paradigm shifts and so increase their competitiveness (Hitt *et al.*, 2000). **This is the essence of Technology Management.**

TECHNOLOGY MANAGEMENT AND COGENT ISSUES RELATED TO SOCIO-ECONOMIC DEVELOPMENT OF NIGERIA: MY REFLECTIONS

There are lots of issues in Nigeria, listing them would be endless, ranging from unemployment to pollution. Technology, when properly managed, could actually be used to mitigate these challenges.

Unemployment and Poverty: One of the major challenges bedevilling our nation is unemployment and poverty with the vast majority living below one dollar daily ($1 per day). Most of our youths (secondary school leavers and graduates of Universities and Polytechnics) are roaming the streets without jobs and the ones engaged are grossly under-employed. The major cause of this is lack of planning and over dependence on oil as the major source of revenue for the nation; neglecting agriculture which used to be the mainstay of our economy in the post-independence years. There need to diversify the economy especially by focusing attention on agriculture which has the potentials to provide jobs for the teeming youth population. In this connection, proper application and deployment of appropriate technology would increase the

production level of cash and food crops through the application of appropriate pesticide, improved seedlings, automatic mechanisation and other agricultural inputs. With the automation of post-harvest processes, it is possible to increase the value chain of crops with the resultants spinning-out of agro-allied industries that would provide job opportunities. In addition, this will enhance the foreign exchange earning capacity of the nation hence, leading to the strengthening of the monetary value of our currency.

i. **Corruption:** The issue of corruption which is endemic is on the front burner of the nation's discourse and is a major focal point of attention of the present Federal Government of Nigeria (FGN). This scourge can be confronted in three ways; namely, **national value re-orientation**, **detection** and **sanction**, and **prevention**. While the first one cannot be directly influenced or controlled by technology, prevention and detection of corruption can be enhanced largely by deploying appropriate technology. Technology, for example, can be deployed to facilitate transparency and accountability at all facets of governance starting from electing public officers to the actual governing of the nation. For example, in one of the Ph.D. theses I supervised, it was demonstrated that adequate and appropriate deployment of well-managed database, network and computing technology could greatly assist in reducing waste and enhance transparency and accountability of electoral processes (Omoleke, 2011).

ii. **Insecurity of Lives and Property:** Considering the issue of safety and security in Nigeria, insurgency, kidnapping, armed robbery and other vices dominate the nation's social-economic space. Adequate deployment of appropriate remote sensing and other satellite and terrestrial technologies would facilitate prompt detection, arrest and even monitoring and prediction of crimes. The judiciary and the entire legal profession are not left out. Litigations of cases are always prolonged partly due to the long and tedious manual process involved. Proper deployment of appropriate technology would assist largely in redressing this.

iii. **Environmental Pollution:** Environmental pollution and flooding are major issues needing national attention. The 2012 water flood readily comes to memory when we discuss flooding in Nigeria. The major causes of flood are two. First, it is the blockage of drainages which is normally caused by indiscriminate dumping of wastes especially in the drainage, and the second cause is the rise in the ocean water level occasioned by climate change which is in turn caused by the emission of greenhouse gases (GHGs). Technology, when it is properly and adequately deployed, would certainly provide solutions to these challenges. Such technology can be used effectively and efficiently to recycle wastes and possibly convert them to useful energy sources and intermediate/ industrial goods. In addition, the adoption of non-conventional and renewable energy technology sources which are alternative to fossil fuel (oil and gas) would reduce largely the emission of the greenhouse gases by the manufacturing industries and deforestation activities, likewise, as proven by Fayetole, one of my Ph.D. students, satellite technology can be effectively and efficiently deployed to monitor, predict, adapt, and even mitigate the effects of climate change (Fayetole, 2015).

iv. **Inadequate Coordination of Ministries, Departments and Agencies (MDAs):** There is lack of coordination among various relevant and cognate ministries, departments, and agencies (MDAs) of the federal and state governments. For instance, it is not uncommon to find that excavation for the laying of cables and pipes by different government organs are done haphazardly without prior planning or consultations, among them for the installation of infrastructural facilities. Pipelines for water and power supply utilities and telecommunications cables are laid in the same space mostly at different times. Even roads mending/repairs and construction are not carried out in a way to prevent damaging these facilities.

In addition, telecommunications base station masts of different GSM service providers were erected without any possible

collaboration among which could have helped them synergise and reduce the number of such installations. This increases the negative effects of radiation of electromagnetic (EM) wave on people and the environment. However, such collaborations where GSM service providers are using the same masts have started recently. These will reduce the number of such installations and their accompanying negative effects. This collaboration should be strengthened.

Furthermore, efforts of the Ministry of Agriculture at increasing production of food and cash crops for extended value addition and possible exportation are not linked with the activities of the Ministry of Industry, Trade and Investment. It is however gratifying that the trend is being changed by the present Federal government of Nigeria.

MY RESEARCH OUTPUT

Mr. Vice Chancellor Sir, my research efforts in the last 33 years in the University spans research and development and innovation management, maintenance management and reliability of infrastructure, networking, collaboration and alliances, information technology management, environmental technology management, Nigerian economy and research methods (use of system dynamics).

I. Research and Development and Innovation Management

Electric pulse generator and D.C. voltage source constitute major test signal in Electronic and Electrical Engineering. In 1987, a high precision pulse generator and D.C. voltage source was designed and tested at our laboratory in the Department of Electronic and Electrical Engineering. It produced output pulses with linearity and accuracy better than 0.1% which could be used in an electronic laboratory (Buraimoh-Igbo *et al.*, 1987). Figure 2 shows the linearity of the pulse generator.

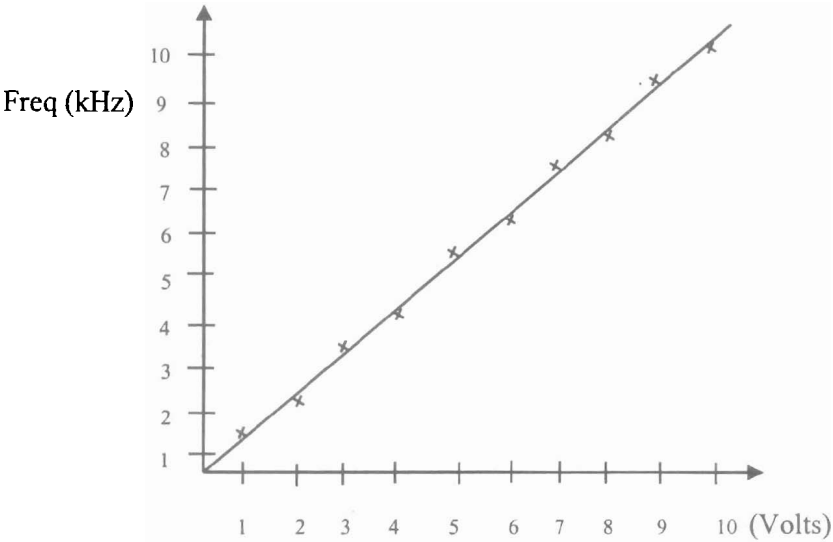


Figure 2: Linearity characteristics of the pulse generator

A computer-based acquisition system for ground-foot forces in pathological gaits was also designed and tested in our laboratory. This system is useful for assessing locomotor dysfunction and in monitoring the rate of recovery in the rehabilitative procedures (Oyebisi *et al.*, 1994).

A model of computer-based information systems for the management of industrial wastes which acquires real-time data on the pollutant in the solid, liquid and gaseous wastes, process toxic registers and properties of toxic substances, and finally effectively describe environment situation was also developed (Oyebisi, 2001a).

A study was conducted to address the problem of waiting line identified in some traditional food service enterprises in Southwestern Nigeria. Using waiting line models, the study established that (i) the efficiency of single channel service method used by the enterprises was not optimal and (ii) the use of self-service and creation of more channels of service could improve the situation (Oyebisi et al., 1999).

Firms acquire technological capabilities through various means such as technological learning. The auto-mechanic repairers in Southwestern Nigeria acquired a measure of technical capabilities over the years through imitation and learning-by-doing (Oluwale *et al.*, 2012). These capabilities found in both clustered and standalone mechanic workshops, have kept the various brands of imported vehicles running in the era of harsh economic climate. The auto-mechanic repairers are also able to generate some grassroot innovations especially in the area of adaptation or modification of some spare parts which are not readily available in the country (Oluwale *et al.*, 2013).

The tremendous growth of wireless networks demands the need to meet different multimedia (audio, video and data) applications over the networks. These application demands and allocations could lead to congestion if the network has to maintain such high resources for the quality of service (QoS) requirements of the application. Therefore, a new admission control policy for a wireless mobile multimedia network which uses a dynamic guard channel allocation scheme and a buffer to share handoff calls if there are no channel available instead of dropping (rejecting) them was designed and implemented (Oyebisi and Ojesanmi, 2008).

Aderemi and Oyebisi (2012) also developed a software, using visual basic programming language for the evaluation of technological capability (TC) in the information and communications technology (ICT) firms in Nigeria. The software developed, showed that TC like licensing, copying, and imports and hardware manufacturing skills promotes the generation of innovations in the firms. Policy instruments that could be used to boost technological learning and development in the industry were identified.

II. Maintenance Management & Reliability of Infrastructure

Works and maintenance departments in the local governments (LGs) in Nigeria are the bodies responsible for the maintenance of public infrastructures at the grass root level. However, we found

out that they were not explicitly involved in the formulation of maintenance policy. It was the caretaker committee or the chairmen and councillors that were responsible for maintenance policy formulations with little or no input from maintenance department/workshops. The maintenance departments were inadequately funded and lack adequate tools for effective performance. These problems often led most LGs to embark on breakdown maintenance strategy with little or no preventive and or conditional maintenance strategy. Policy measures to ameliorate these problems were recommended (Ilori *et al.*, 1997).

Oyebisi (1992) established that factors responsible for the breakdown of engineering infrastructures include limited life-span of the material components, and performance limitations of the infrastructures as well as destructive effects of the environment on these facilities. In addition, the study also highlighted factors affecting the development of culture of maintaining engineering infrastructures which include level of education of the maintenance personnel, rewards and incentive schemes of the organisation. Federal Government has a major coordinating role in the development of engineering infrastructural maintenance culture for a sustained and highly productive economy. This is a way of providing an appropriate framework as most of the problems influencing the development of maintenance culture have either legislative or multi-agency co-ordination implications that can be effectively handled at the national level.

Changing technology and scientific research requires a dynamic and efficient maintenance management strategy for technology infrastructures. Though, the maintenance of the laboratory facilities in Obafemi Awolowo University is carried out by competent professionally trained and experienced personnel, there are manpower problems, coupled with inadequate supply of modern maintenance facilities, spare parts and limited maintenance fund. The maintenance organisational structure for the maintenance units of the university was substandard as a result of lack of maintenance policy awareness within the repair units and the lower echelon of

maintenance personnel. The adopted maintenance strategy for the repair of laboratory equipment in Awolowo Obafemi was largely corrective maintenance rather than predictive and preventive maintenance strategies (Oyebisi *et al.*, 2000a).

It was also discovered that public infrastructures such as telecommunications may not operate effectively in situations where strikes, communal clashes, and index of planning such as exchange rate, interest rate, basic tariff, and government policies fluctuate within wide amplitudes (Oyebisi *et al.*, 2000b). Strategies for making the infrastructures perform effectively and efficiently were recommended.

Electronic equipment constitutes the prime-mover of the information age and the industrialised world. However, they were found by a study carried out by Oyebisi (2000a) to be greatly affected by some environmental variables such as temperature and humidity, dust and entomological activities. These effects are more pronounced in the tropics than in other regions of the world. It was further established that these factors affect the reliability of electronic equipment in the tropics. Appropriate maintenance policy measures were recommended to reduce the adverse effects of these factors on these pieces of equipment. Policies that must be put in place to tap the huge energy potential from the abundant sunshine in the tropics to drive these electronic equipment for the corporate survival were recommended.

III. Networking and Collaboration/Linkages and Alliances

Alliances are essential relationships which allow organisations to cooperate so as to enhance their capabilities. Factors influencing the implementation of strategic technology alliances among telecommunications service providers in Nigeria were investigated by Ajao *et al.* (2017). The results revealed that non-technological factors such as socio-cultural, geographical, economic and political factors as well as technological factors such as investment in machinery, on-the-job trainings and educational background of the

staff influenced the firms' engagement in strategic technology alliances.

Despite the cultural differences between university and industry, the mutual benefits from the cooperation between these organisations have long been recognised in the advanced countries. Recently, this type of collaboration has been receiving attention in developing countries. These prompted us to evaluate the existing collaboration between Obafemi Awolowo University (OAU) and some enterprises in its neighbourhood. The study established that the most common type of linkages between OAU and the enterprises were in the area of consultancy, organisation of seminars and workshops. There was, however, little or no research linkage between the academia and the industry (Oyebisi *et al.*, 1996). We then investigated the various models that could be used to facilitate the transfer of technology (research results) from the academia to the industry in Nigeria. Those identified include information, licensing, venture capital, joint venture, science park and ferret models. It is interesting to note that the Ministry of Science and Technology has set up technology incubation centres (ITCs) in some parts of the country; though not popular among the academics. The university has many commercial ventures but there is none in manufacturing which could utilise the R & D findings of the laboratories. Strategies for using these models to facilitate technological collaborations between the academia and industry were recommended (Ilori *et al.*, 1996). Utilization of idle capacities in research and educational institutions by the industry could form a sort of collaboration between the academia and the industry. Oyebisi et al. (2001) identified and assessed the degree of utilisation of these idle capacities in selected research and educational institutions in Southwestern Nigeria. The study revealed low utilisation of these capacities, and the excess capacities could not be used by the industry because the facilities are meant for teaching and research in accordance with the institutions' policy.

The main mandate of research institutes in Nigeria is to conduct research and transfer the research results to the private sector (entrepreneurs) for commercialisation. We evaluated the business development and transfer of technologies to small manufacturing companies by research institutes in Nigeria. The technology transfer strategies employed by the research institutes include licensing agreements, cooperative R & D agreement/contract research, joint ventures, self/exploitation, spinout/spin-off, training workshops, technical assistance and consultancy services. The most frequently used technology transfer strategy was training workshops (Oyedoyin *et al.*, 2014). However, our study showed low commercialisation of the R & D and innovation outputs from research institutes in Southwestern Nigeria, and this was due to inadequacy of fund and infrastructural facilities. The study concluded that there was a need to source for fund aside from government to conduct research. In addition, the institutes should be encouraged to commercialise their R & D outputs so as to increase channels of funding (Oyedoyin *et al.*, 2015).

IV. Information Technology (IT) Management

Investment in information and communications technology has become an important component in both strategic and tactical management in organisations in order to ensure a competitive advantage. The organisational impact of information technology (IT) on some banks and insurance firms in Nigeria was evaluated. Eight leading commercial banks and six highly rated insurance firms which have branches in Lagos - the commercial centre of Nigeria - and two other state capitals were selected for the study. The investigation used both local and global impact criteria. The study revealed that IT had appreciable positive impacts on the efficiency and productivity of the organisations in terms of the local and global criteria with each having both direct and induced variations. The direct local impact criteria identified are time saving, error rate reduction, management decision support, and improve service delivery, while the induced local impact criteria are reduced paper work, savings in labour, quick access to data, and loss of skills to machines. The direct global impact criteria are

competitive advantage market segmentation, high revenue generation and forecasting while the induced global impact criteria identified are development of new business niche, increase in market share and network in security (Ugwu *et al.*, 2000).

However, Oyebisi et al. (2000c) established that assimilation of information technology in the banking and insurance sector of the Nigerian economy was low. This was because there were no policies in place that regulated the extent to which IT hardware were imported and utilised in the industries, and all the IT hardware and accessories were sourced for mainly from foreign manufacturers.

Notwithstanding, ICT has been used extensively to achieve both cost and differentiation competitive advantages and has also been deployed to reduce material consumption and cut down on the labour cost. Differentiated services obtained as a result of ICT utilisation are time saving, error rate reduction, and quick access to data. In addition, ICT was used to create a profit enabling environment in the Nigerian banking industry (Oyebisi and Ajayi, 2001).

Automation has also continued to change the structure, content and quality of banking operations. The prevailing automated environment prepares grounds for the introduction of telecommuting to the socio-economic life of Nigeria. However, a lack of enabling environment which should be provided by functioning electric utility and telecommunications infrastructural facilities in the country has reduced the level of assimilation of the automation services and systems in the Nigerian banking industry. From all indications, automation presents great potentials for business engineering or the Nigerian financial industry (Agboola *et al.*, 2001).

In another Ph.D. work which I supervised, it was established that manufacturing companies in Nigeria were able to deploy ICT effectively to face competition because of their capability to

dynamically integrate ICT and competitive strategies (Olamade *et al.*, 2007 and 2013). Oyebisi (2001b) emphasised the need for maintaining an operative balance among the key-players in the usage of the Internet in Nigeria. These key-players include Internet service providers (ISPs), government, the organised private sector and the management of the national telecommunications carriers, and the electric utility boards.

V. Environmental Technology Management

To woo householders into harnessing the cooking energy potential of biogas in order to solve the perennial cooking energy problems at household level in Nigeria, Adeoti *et al.* (2000) carried out a study on engineering design requirement, and used engineering economic methods to evaluate the $6.0m^3$ family-size biogas project in Nigeria. The project has an initial investment cost of 41.09 naira, annual expenditure of 59.09 naira and an annual benefit of 13.35 naira. The net present value (NPV), Internal Rate of Return (IRR), Benefit Coot (B/C) and payback period of financial analysis are 0.050 million naira, 17.52%, 2.26 and 6.6 years, respectively. This shows that the $6.0m^3$ family-sizes biogas project using cattle dung as substrate has a good economic potential.

Three scenario analyses were adopted to examine the future prospects of biogas in Nigeria. While a generated energy from biogas would range between 5.0-171.0 x 10^{12}J in the period 2000 – 2030 under a moderate ambitious biogas technology programme. Some constraints may hinder this realisation. These include economic, technical and socio-cultural constraints. Recommendations to overcome these constraints and make biogas technology penetrate even more than already projected into the rural communities and poor urban households were suggested. Some of the envisaged benefits of biogas use to the national economy include the avoidable CO_2 emissions (Akinbami *et al.*, 2001).

Location analysis of family-sized biogas plants in the four agro-ecological zones of Nigeria was also carried out to locate the most

favourable zone that best suits the siting of these plants. The study established that climate factor (temperature), community attitude and culture, availability of suitable place (land); inputs (cattle excrements and water), construction, materials and labour as well as farming units for slurry disposal are important in locating biogas plants. Using break-even analysis, the zone which was found to be the most appropriate agro-ecological zone for siting family-sized biogas plant is the Northern Guinea Savannah in Nigeria (Oyebisi *et al.*, 2000d).

Akinwumi *et al.* (2001) examined a few sources of environmental degradation in Nigeria as well as their implications. The global action concept of sustainable development and the Nigerian government efforts towards compliant were examined and came out with factors that influence the development of an environmental-friendly culture in Nigeria. These factors are education, mass mobilisation, adequate motivation and legislation framework.

VI Nigerian Economy

Oyebisi *et al.* (2004) noted that the policy objectives of the Federal Government of Nigeria on telecommunications were guided by the need to deploy and utilise telecommunications infrastructure and services to accelerate the socio-economic and political development of the country; thereby enhancing the quality of life of the Nigerian citizenry. To achieve these objectives, the government planned to implement, among others, network development, which will ensure that the country meets and exceeds the International Telecommunications Union (ITU) recommended minimum teledensity of one telephone to 100 of the habitants. These laudable objectives are however contingent on the availability of appropriate capabilities for improving the existing and future telecommunications infrastructures. This study identified these capabilities which include investment, service, major change, linkage and R & D capabilities (Oyebisi, 2014).

All over the world, enterprises and properties owned and managed by government, at little or no profit, are now being turned over to private ownerships through the process of privatisation. The Nigerian government is not an exception. A study was designed to assess the performance and technology development of a company in the country before and after privatisation. The company was very active in new product development activities and local raw material substitution before privatisation. It also performed very well during the five years (1989-1993) of privatisation. The returns on investment (ROI) were very high and the company was able to pay very high dividends to its shareholders. However, the business became unprofitable in 1994 with negative return on investment (ROI) in the period 1994 to 1998. The period witnessed no new product development activities due to inefficient functioning of plants, machineries, poor maintenance activities, economic recession, epileptic power supply and high cost of fuel for running generating sets. This poor performance is contrary to expected benefits from privatisation. Strategies that would enable companies to reap the benefits of privatisation were recommended (Ilori *et al.*, 2003).

Advances in technology largely drive the social and economic development of any nation. With all its major attractions IT is regarded as a possible technology that can leap-frog Nigeria into the technological world. However, IT development in Nigeria has not taken its rightful position to achieve this due to social, economic, political and ecological problems, probably because of poor funding of research and development, inadequate skilled manpower, and the poor state of existing infrastructures. This is why the nation relies on massive importation of virtually all that is needed to satisfy local demands. This tells seriously on national competitiveness and creates digital division exemplified by rapid and unrelenting gaps in the IT infrastructure between Nigeria and the developed economies. For Nigeria to be reckoned with in the IT industry, suitable infrastructures, adequate manpower and good policies must be put in place (Oyebisi and Agboola, 2003).

One of my Ph.D. students worked on Software Development in Nigeria. The study showed that though the Nigerian software developers were adopting best practices, the effectiveness and acceptability of their products are being vitiated by dearth of skill, experienced software professionals and other contingencies such as lack of investment capability (Binuyo *et al.*, 2014).

VII Research Method/Use of System Dynamics

There is high technology facility failure in Nigeria and the planning process could be implicated for this. Most policies/laws establishing these facilities are premised on analytical thinking that is, looking at a part and not the whole. For example, the electric power system in Nigeria is decoupled from the economy, despite the fact that studies have shown that electricity is the singular most needed input to improve industrial base of the country (Momodu, 2012). In Oyebisi and Momodu (2012), we proposed a paradigm shift of planning and management approaches of high technology facilities in Nigeria from analytical thinking to system thinking. The system thinking approach encompasses system dynamics principles as well as performance and recommendation analysis. We concluded that the paradigm shift will involve creative tension that would generate learning for better planning and management of the high technology facilities in the country.

A system dynamic model was therefore developed to evaluate the long-term performance of the electricity power system in Nigeria. Both primary and secondary data were used as baseline information to implement the model. Results from this model formed an input to develop a four-sector-model in Vensim software for the long-term evaluation of the Nigeria's electric power system. Leverage points in the model were identified from the validated model using data from 2005 to 2009 as the base run. The system behaviour based on two other scenarios (Scenario 1 representing improved basic level of consumption and Scenario 2 representing industrialisation target), was then evaluated on a time frame of 30 years starting from 2009. The study concluded that Compounded Annual Growth Rate (CAGR) and Economic Growth

Rate (EGR) were the most critical policy leverage intervention points for Nigeria's electric power system (NEPS) improvement within the next 30 years (Momodu *et al.*, 2012).

Table 1: Parameters/Leverage Points in the Nigeria's Electric Power System

Parameters	Base Run	Scenario 1	Scenario 2
CAGR	0.0234	+100%	+200%
Availability Factor	0.52	+20%	+50%
Tx Loss	0.12	-50%	-80%
Distribution Losses	0.1	-50%	-80%
Non Technical Losses	0.2	-50%	-80%
Non billed losses	0.23	-50%	-80%
Price of electricity	0.0702	±50%	±50%
Substitute			
Economic growth rate	0.053	±50%	±120%
Access level	0.46	+50%	+80%

Mr. Vice-Chancellor Sir, permit me to inform this august gathering that Dr. Momodu's Ph.D. was supervised by me and it was during this period that the idea of using system dynamics came up.

In addition, in Oyebisi *et al.* (2013), the six models for managing technological innovation system (TIS) in manufacturing setting were reviewed. These are: Technology Push, Market Pull, Coupling Innovation Process (CIP), Functional Integration Innovation Process (FIIP), System Integration and Networking Innovation Process, and System of Innovation models. Because of some of drawbacks of these models for managing technological innovation system, system thinking approach was then proposed as a suitable alternative for addressing these drawbacks.

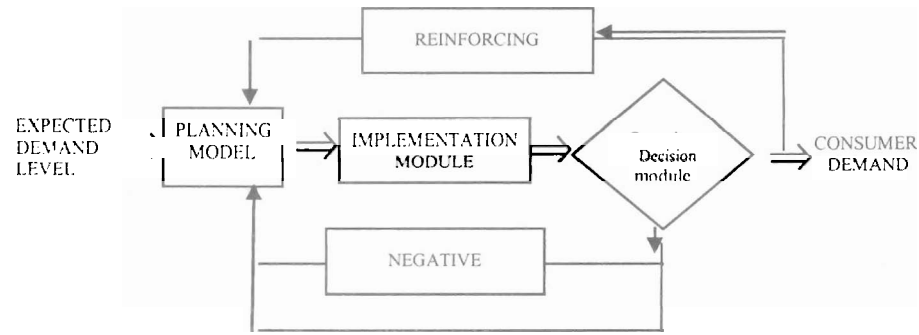


Figure 3: *Modified Canonical Form of Control System for Managing TIS adapted from Oyebisi & Momodu (2012)*

The system thinking concept of managing TIS is depicted in Figure 3. The proposition is adapted from the canonical form of control system. The diagram shows both negative (balancing) and positive (reinforcing) feedback. The planning module represents the point where initiative inputs are "mixed" and decisions are made and forwarded to the implementation module for actual action.

The system works in a way as to monitor the rate of demand for organisations' products. This information is fed into the planning module, where it is compared with the expected level of consumer's demands. If the demand is less, the reinforcing loop is affected whereas the balancing loop is used when the demand is higher. Of course, in business, the demand is expected to be higher – even higher than the set level. The information will assist in the planning stages for the right level/amount of technological

capabilities, investment, production and linkage capabilities, and other resources to be put in place to maintain the desired level of product demand. However, understanding and using this model are premised on the availability of knowledge and skills in computer modelling and simulation software (e.g., Ithink, Vensim and Powersim) (Oyebisi *et al.*, 2013).

Analysis of manufacturing business environment is very complex because of some competing variables such as government policy, technological factor, socio-cultural, consumers' change taste among others. However, Olamade *et al.* (2013) proposed a "**longitudinal analysis**" approach which holds potentials to offer more insights into the complexity. This confirms our submission that a better method of analysis is not only desirable but also imperative.

SUMMARY OF MY ADMINISTRATIVE EXPERIENCE AND OTHER CONTRIBUTIONS

Mr. Vice-Chancellor Sir, this is a summary of my administrative experience during my stay as a lecturer in Electronic and Electrical Engineering and Research Fellow/Senior Research Fellow/Principal Research Fellow and Research Professor in the African Institute for Science Policy and Innovation (AISPI).

Short History of the African Institute for Science Policy and Innovation

The African Institute for Science Policy and Innovation (AISPI) was established as Technology Planning and Development Unit (TPDU) in 1974 primarily to conduct policy research on how to harness Science and Technology (S&T) for economic development and to advise government on S&T matters. The Unit designed M.Sc. and Ph.D. programmes in Technology Policy and Planning which were approved by the Senate of the University in 1983. This made Obafemi Awolowo University the first African University and one of the few in developing countries to award postgraduate degrees in this field. In 1994, the postgraduate degrees in Technology Policy and Planning were replaced with programmes

in Technology Management to make the programmes relevant to public and private sectors. Based on the need to expand the scope and activities of the Unit, the University in collaboration with the Nigerian Universities Commission (NUC) and UNESCO agreed to upgrade the unit into an institute. This was necessary to meet the increasing demand for training in Technology Management and S&T policy studies and to further promote Technology Management as a backbone for national development. Thus, the unit was upgraded to the African Institute for Science Policy and Innovation in May 26, 2011 by the Senate of the University. The final approval was given by the Governing Council of the University in June, 2011. As a result of this, the NUC designated OAU as the hub of the National Network of Science Policy Programmes and Centers.

I like to place on record the efforts of our former Vice-Chancellor Prof. M. O. Faborode towards the upgrading of the Technology Planning and Development Unit (TPDU) to African Institute for Science Policy and Innovation (AISPI). Likewise, I am using this medium to thank the present Vice-Chancellor, Prof. Eyitope Ogunbodede, for his efforts to further pursue the process of upgrading the Institute to UNESCO Category II Institute.

I have made some contributions to the pursuit of excellence in the University. My supervision of Master and Ph.D. students have been largely in Technology Management which is the focus of my teaching and research for over 33 years. I have served as either the main or a co-supervisor of 26 Ph.D. These students cut across many disciplines including Technology Management, Pharmacy, Computer Science, Mechanical Engineering and Electronic & Electrical Engineering.

Mr. Vice-Chancellor Sir, some of these students are now professors, associate professors, senior lecturers and senior research fellows with about 30% of the staff of AISPI mainly or co-supervised by me. Some are also in the public sector as directors and in the private sector as consultants/managers.

God has helped me to serve as Director in both acting and substantive capacities under four Vice Chancellors including the current Vice-Chancellor, Prof. E. Ogunbodede. I have served in many Department/Faculty/University committees including the University Honorary Committee and Chairman of OAU Research and Development Fair (RESDEF). I have been serving as a member of the Academic Research Committee / Board of the Postgraduate College for over 4 years.

I have also served as an examiner in M.Sc. and Ph.D. examinations in and outside OAU, cutting across many disciplines/departments, including Computer Science and Engineering, Electronic and Electrical Engineering, Education, Management Technology, Law, Management, Environmental Design and Management (EDM), Sociology, Economics and Local Government Studies.

Outside the University (OAU), I have served as a member of NUC Resource Verification Panel to the Ekiti State University, Ado-Ekiti for her Entrepreneurship Programme. I served as the Chairman of the Accreditation Team/Panel to the Department of Information Management Technology of Federal University of Technology, Owerri. I also served as the Chairman of the Accreditation Panel to the Departments of Management Technology of Lagos State University and BELLS University of Technology, Ota. Furthermore, I was an Associate of the School of Management Sciences of National Open University of Nigeria (NOUN). Providence has also made me to be the local supervisor of a Ph.D. Technology Management candidate in the Faculty of Design, Media Management of Buckinghamshire New University, United Kingdom and his research is nearing completion.

I have also had the priviledge of serving as a lecturer, Associate Professor and Professor on Sabbatical, Department of Electronics, and Department of Management Technology, Lagos State University (LASU). The impact I made are there for posterity.

Permit me Sir, to add that I have had the rare opportunity to coordinate the affairs of AISPI at a time when the Institute hosted AfricaLics 2017, the very first to be held in Nigeria. AfricaLics stands for African Network for the Economics of Learning, Innovation and competence Building Systems. About 30 Ph.D. students were selected from various countries in Africa and beyond to participate in the academy which lasted for two weeks. During this period, the PhD students were exposed to the theories and practices of Science, Technology and Innovation. The facilitators made useful inputs into their various Ph.D. research works.

I have also had the opportunity to visit University of Stellenbosch, University of Pretoria and Tswane University of Technology, South Africa, under the auspices of UNESCO, on fact-finding mission in the preparation for upgrading TPDU into category II UNESCO Institute which will be a Centre of Excellence in research in Science, Technology & Innovation Management in Africa Region. The current effort of our Vice-Chancellor, Prof. Eyitope Ogunbodede, in trying to resuscitate the noble initiative is highly commendable.

Mr. Vice-Chancellor Sir, permit me also to say that, the ICT-Commercialisation and Innovation arm of the African Centre of Excellence in Software Engineering is being coordinated by me. This is a dream come true, as the research results from Computer Science and Engineering and other allied disciplines could now be commercialized.

POLICY GUIDELINES FOR PROMOTING INDUSTRIAL COMPETITIVENESS AND RAPID SOCIO-ECONOMIC DEVELOPMENT THROUGH TECHNOLOGY

i. **Human Resources in Technology**: There should be an enhancement of capacity building in technology which involves education, training and research and development. In the area of education, institutions for providing basic education in science and technology especially computer science, engineering, mathematics, management, sciences,

economics, entrepreneurship, law and other fields should be strengthened. All inclusive curricula in the basics of technology and adequate improvement of laboratories and workshop should be encouraged. Training human capital must include the provision of adequate means of acquiring the right and appropriate skills in technology such as software application development, database management, networking, and hardware repair and maintenance. Under human resources in research and development (R&D), there should be availability of scientific and technological resources in the right caliber, mix and quantity. Balance must be ensured between research and development in all the R&D activities. Human resources in scientific and technological research [R] and experimental development (D) should be accorded appropriate attention (Oyebisi, 2014 and Oyebisi 2017a).

ii. **Funding of Technology Education Training and Research**: Adequate fund must be provided by the government and other stakeholders for the provision of basic education, training and the conduct of R & D in computer, electronics, mathematics and allied disciplines. Two models for private funding are identified:

a.Venture capital

- **Interested scientist entrepreneurs in ICT could** commercialise their results through funds from financial institution and equity capital.
- Availability of funds for ICT scientists to establish their own firm and commercialise their R & D effort.

b. Large company joint venture

- ICT scientists working with large companies on collaborative basics (Oyebisi, 2014 and 2017b)

iii. **Infrastructural Facilities for Technology Development**: Scientific and technological infrastructures such as installations, equipment and other facilities that are required by researchers, engineers and technicians who are responsible for research activities in technology services must be provided. Institutional framework that promotes and fosters

creativity and innovativeness in technology should be created and adequate supply of reliable power supply must be ensured (Oyebisi, 1997 and Oyebisi, 2014).

iv. **Collaboration among the Stakeholders**: Proper networking among the key stakeholders of the National Innovation System must be established. This is to ensure coordination of the activities of the National Innovation System (NIS) especially in research result exploitation for general socio-economic goals. Shallow mentality among key stake holders must be eliminated. There should be inter-agency collaboration to avoid unnecessary and wasteful duplications (Oyebisi, 2014).

v. **Investor-friendly Government Policies**: Government policies must facilitate processes or methods for technology development. Such policies must be investor friendly, mitigate multiple taxation, provide tax holiday and incentives, favorable policies on raw materials while local content initiatives must be encouraged in technology. The establishment of S & T Park, the establishment and the provision of adequate funding of financial institutions must be encouraged; patronage and protection of local entrepreneur in technology, establishment of technology clusters must be ensured while regulatory agencies must be well funded, and provision of broadband infrastructure must be ascertained (Dada and Oyebisi, 2016).

vi. **Enhancing Absorptive Capacities of Domestic Enterprises:** It is imperative for governments to establish and implement policies that help boost the absorptive and adaptive capacities of local firms. This involves the creation of a skilled workforce to promote high quality, competitive domestic enterprises. To accelerate skills formation in relevant areas, governments need to be informed about the skills in demand. Inclusive education policies also need to evolve over time as the demands from industry change when countries develop. Governments can strengthen the capabilities of small and medium-sized enterprises by including improvement of extension and training services.

Governments can also provide venture capital to encourage local entrepreneurs (Dada and Oyebisi, 2016).

vii. **Targeting Specific Technologies and Companies:** Governments need to target the promotion of specific technologies relevant to the priorities in their development strategies. Governments can seek to attract trans-national companies (TNCs) into specific (high) technology industries by using fiscal or financial incentives. Also, the establishment of science and technology parks can be used to create a more conducive environment for innovation and R&D while enterprises should be in close proximity to universities and other public research institutes. Developing industrial parks with high-quality infrastructures may attract high-technology investors. Likewise, public–private partnerships in R&D can play an important role (Dada and Oyebisi, 2016).

viii. **Promoting Technology Dissemination through Technology Alliance:** Technology alliances and linkages between transnational companies (TNCs) and domestic firms are among the key modes of transmitting of know-how and technology. Whether domestic companies acquire technology from TNCs, to what degree and at what speed, depends on the type, scale and quality of the interface that exists between them. The type of interface may involve joint venture partners, public-private partnerships (PPPs). For instance, joint ventures can result in an effective transfer of technologies provided there is mutual trust between the partners. Such linkages could be promoted by offering fiscal benefits to R&D or the exploitation of its results. Also, the establishment of local technological and industrial clusters with the participation of both domestic firms and foreign affiliates can enhance the exchange of know-how and expertise formation (Dada and Oyebisi, 2016).

ix. **Improving University–Industry Linkages:** The technological capability building in the country should be characterised by a dynamic process involving the interplay between imported technologies and indigenous research and

development (R&D) efforts by public research institutes. This will need a re-configuration of the innovation system shaped by overall economic growth and development strategies. To build technology-based enterprises and become increasingly globally competitive, Nigeria needs to harness the technology entrepreneurial potential and opportunities within the national innovation system for economic growth and development. Historically, there has been poor interaction between knowledge institutions and industrial sector with respect to research and innovation (Oyebisi, *et al.*, 1996; Oyewale, 2003, 2005; Dada *et al.*, 2014). A number of government initiatives such as Agricultural and Industrial Transformation Agenda are in the right direction to redress this situation. In an effort to foster proactive collaboration and create a channel for communicating the demands and needs of industry to the education community, the new science, technology and innovation (STI) policy has also made provision for such an industry-academia collaboration system. The provision in the policy, if implemented, would allow the needs of the industrial sector to be met by the knowledge institutions; thereby improving the much needed collaborations and linkages among the stakeholders of NIS (Dada and Oyebisi, 2016).

x. **Attractive Investment Policies:** Another policy direction for promoting technology transfer and dissemination for industrial competitiveness and socio-economic development is to complement attractive investment policy. For example, provision of competitive R&D and innovation funds for micro, small and medium enterprises (MSMEs) could be incorporated into the proposed National Research and Innovation Fund (NRIF) under the new science, technology and innovation (STI) policy. Initiatives such as SURE-P, YOU-WIN, Software Development Fund for MSMEs can be further enhanced by the government. Other initiatives may include government redressing the issue of multiple taxations; organisations such as Bank of Industry, Bank of Agriculture, among others should make funds available in

form of loan with minimal interest rate and special funds more accessible to stakeholders. The present anchor – borrower programme of the Central Bank initiated by the current Federal Government of Nigeria is commendable. This will enhance the capability and innovations in the industrial sector. Government can also promote foreign direct investment (FDI) in manufacturing activities by strengthening export processing zones, science park, technology incubator and using public research institutes (PRIs) such as Federal Institute, Industrial Research, Oshodi (FIIIRO), National Agency for Science and Engineering Infrastructure (NASENI), Projects Development Institute (PRODA) among others to act as technology leverage and builders of national technological competences. Lastly, formation of the SMEs into Ward-Based-Cluster (WBC) in different states that will foster interactions among the actors of the innovation systems should be encouraged (Dada and Oyebisi, 2016).

CONCLUDING REMARKS

From the foregoing, one can clearly see that technologies are not just to be applied, but must be appropriately chosen, acquired and rightly and efficiently and functionally deployed in an inclusive and sustainable way before one can reap its almost uncountable and immense benefits. In this wise, technology management which is the discipline that centrally focuses on this holds the key to improved socio-economic development of Nigeria.

Technology management can be said to be both a science and an art discipline. It is a science because its rules of engagement and research are systematic and logical. It is also an art because technology is neutral being inanimate. Hence, its proper choice and application are largely influenced by attitude, intention, history, ethics, and value orientation of the manager among others.

It has also come to the fore that, for technology to achieve the desired results, it must be well planned. In Nigeria, the

inauguration of the National Council on Innovation and Research, even though rather belated, is a step in the right direction. The inter-ministerial council together with the Presidential Industrial Policy Competitiveness Advisory Council would ensure that there is a proper coordination of the efforts of the key stakeholders in the national innovation system; thereby eliminating wastes, inefficiency and ineffectiveness that currently characterise the operations of different elements of the systems.

It is also very clear that managers, engineers and scientists must be well-trained, adequately equipped and well-motivated to be able to manage technology excellently.

ACKNOWLEDGEMENTS

I wish to acknowledge the following people/groups who have contributed to my career. I recognise and appreciate Late Engr. S. A. Thanni who introduced me in the '70s in the Polytechnic, Ibadan to Control System Engineering as a body of knowledge. The discipline and seriousness that he stimulated in me made me to pass the Council of Engineering Institutions (CEI) examinations of Great Britain, which was equivalent to B.Sc. Eng in U.K at a sitting after one year of self-tutored in 1980. I am indebted to my M.Sc. and Ph.D. supervisor in the Department of Electronic and Electrical Engineering, (OAU) Late Prof. L. A. Buraimoh-Igbo and Late Prof. V. C. B. Nwuga who co-supervised my Ph.D. My appreciation also goes to the then Control and Instrumentation team – Prof. L. O. Kehinde, Prof. M. O. B. Olaogun and Mrs. Nwuga. The contributions of Prof. G. A. Adegboyega of the Department of Electronic and Electrical Engineering to my career development in and outside of the Department are well appreciated. His efforts and that of former Vice-Chancellor, Prof. M. O. Faborode, in exposing me to higher administrative experience are well acknowledged. All my other colleagues in the Department of Electronic and Electrical Engineering are equally appreciated.

I also wish to register my appreciation to Prof. M. O. Ilori of AISPI who in the early '90s enjoined me to come to TPDU from the

Department of Electronic and Electrical Engineering to build the unit together, and in co-supervising my M.B.A Long Essay with Prof. M. L. Nassar of the Management and Accounting (1993 - 1995). My love also goes to my other senior colleagues in AISPI; Prof. F. E. Ogbimi and Prof. J. B. Akarakiri who along with Prof. M. O. Ilori inducted me into the world of Technology Management, and to all other colleagues including the secretariat staff for their support, cooperation and understanding. I am really putting on records the understanding and support of the AISPI Alumni especially Engr. (Dr.) A. B. Obawole, Dr. Abass Balogun, Dr. A. F. Lawal, Dr. M. Omoleke, Dr. I.A. Abereijo, Dr. A.S. Momodu and many others including the current students for their contributions towards the success of the AfricaLics 2017. I am deeply grateful to the management of the then NTA for sponsoring my M.Sc degree programme and equally indebted to the management of the University for sponsoring my Ph.D. in Electronic/Electrical Engineering and M.B.A. on day-release. My appreciation also goes to UNESCO for sponsoring me to South Africa on fact finding mission towards the upgrading of AISPI into Category II Institute.

I am also using this medium to appreciate the Baptist family including churches in Modakeke Baptist Association, World Outreach Christ Evangelistic Ministry (WOCEM) outreaches, and Fellowship of Ministers, All Souls Chapel, OAU.

My special thanks go to my in-laws, Prof. & Mrs. J. O. Fawole, Dn. J. O. Akinola, Dn P. M. Akinola, Mr. E. O. Akinola, and my children in-laws. I am eternally grateful to my late parents, Pa John Ojo Oyebisi and Mama Ruth Yetunde Oyebisi who brought me to this world, laboured and nurtured me to make me what I am today. My special appreciation goes to my siblings; Mr. Taiwo Samuel Oyebisi, Rev. & Mrs. M. O. Olaleye, Mrs. G. O. Oyesunle, the Olanikanjus, kinsmen and friends including Engr. (Dn.) S. O. Oyedokun from Oyo. I would also want to show my appreciation and gratitude to everyone who has contributed to the success of this inaugural lecture. I am also putting on record, the understanding and support of my children and grandchildren. My

deepest appreciation goes to my loving wife, Dr. (Mrs.) Elizabeth Oyepeju Oyebisi, my best friend, adviser and mother for her uncommon understanding and love for me.

Finally, all glory, honour, adoration, dominion and power to the only Wise, Invisible, Immortal and Eternal God from Him, and through Him and for Him are all things. For in Him we live, we move, and have our being.

To Him be the Glory.

Mr. Vice-Chancellor Sir, ***This lecture is obviously subject to review, the author being human and mortal. This is my own little way of looking at realities as they have unfolded to me in the last 33years as a university staff. I am now commending myself, the listeners and the readers to the final authority who is the Truth Himself, the secret of the universe and the key to life. He does not change neither His word subject to any review. In Him hidden all treasure of wisdom and knowledge. In fact, His is the one who has solved permanently and completely the problem of life and death. He is not only reality but the final reality. He is the one who is, who always was and who is still to come having the seven-fold Spirit before His throne. He is the first to rise from the dead and the commander of all the rulers of the world.***

All praise to Him the Alpha and Omega who loves us and has freed us from our sins by shedding His blood for us. He has made us His kingdom and His priests who served before God His father. Give to Him everlasting glory. He rules forever and ever amen!!!

Thanks for your attention.

References

Adeoti, J. O. (2002): Building technological capacity in the less developed countries: the role of a national system of innovation. *Science* and *Public Policy,* 29(2):95-104.

Adeoti, O., Ilori, M. O., **Oyebisi, T. O.** and Adekoya, L. O., (2000) "Engineering Design and Economic Evaluation of a Family-sized Biogas Project in Nigeria" TECHNOVATION (*The International Journal of Technological Innovation, Entrepreneurship and Technology*), 20:103-108.

Aderemi, H. O. and **Oyebisi, T. O.** (2012) Management and Evaluation of Technological Capability in ICT Firms: An Information system Approach, *Int. J. Business Information Systems*, University of Granada, Spain, Indersilence Publishers Ltd. 11(2):127 – 147.

Ajao, B. F., **Oyebisi, T. O.**, Aderemi, H. O., Olomu, M. O. and Atoyebi, M. K. (2017) "Impact Factors of Strategic Technology Alliances in the Nigerian Telecommunications Industry." *International Journal of Service Science, Management and Engineering*; 4(3):17-24.

Agarwal, R. and Gort, M. (1996). The Evolution of Markets and Entry, Exit and Survival of Firms. The Review of Economics and Statistics, 78(3):489-498.

Agboola, A .A., **Oyebisi, T. O**., Nassar, M. L., Ilori, M. O. (2001): "Automated Banking Operations in Nigeria *Advances in Management* 2(1): 32-43.

Akinbami, J. F. K., Ilori, M. O., **Oyebisi, T. O.**, Akinwumi, I. O., and Adeoti, O. (2001): "Biogas Energy Use in Nigeria: Current Status, Future Prospect and Policy Implications" *Renewable and Sustainable Energy Reviews*, 5: 97-112.

Akinwumi, I. O., **Oyebisi, T. O.**, and Salami, A. T. (2001): "Environmental Degradation in Nigeria: Implications and Policy Issues: A View Point" *International Journal of Environmental Studies (IJES)* 58:585-595.

Aladesanmi, T. A. (2015). Assessment of Technologies for Building Online Trust in E-commerce in Nigeria. A Thesis Submitted in Partial Fulfilment of the Requirement for the Award of the Degree of Doctor of Philosophy in Technology Management at the African Institute for Science Policy and Innovation (AISPI), Faculty of Technology, Obafemi Awolowo University, Ile-Ife, Nigeria

Arrow, K. J. (1962). Economic Welfare and the Allocation of Resources for Invention, in: R. R. Nelson, The Rate and Direction of Inventive Activity. Princeton University Press, New Jersey.

Binuyo, G. O. (2012). Evaluation of Computer Software Development in Nigeria. A Phd Thesis Submitted to African Institute for Science Policy and Innovation, Obafemi Awolowo University, Ile-Ife, Nigeria.

Binuyo, G. O., **Oyebisi, T. O.**, Olayinka, A. and Afolabi, (2014) "Effectiveness of Software Products Development in Nigeria." *Int. Journal of Scientific and Engineering Research,* 5(2):327 – 344.

Bozeman, B. (2000). Technology Transfer and Public Policy: A Review of Research and Theory. Research Policy, 29, 627-655.

Buraimoh-Igbo, L. A., Bayer, R.., and **Oyebisi, T. O.** (1987): "Design of a High Precision D.C. Voltage and Pulse Generator". *Ife Journal of Science*, 2(1&2):17-26.

Business Dictionary (2018): Definition of Economic Growth. (www.businessdictionary.com) Accessed 10th May, 2018.

Camison, C. and Villar-Lopez, A. (2014): Organizational Innovation as an Enabler of Technological Innovation Capabilities and Firm's Performance, *Journal of Business Research*: 2891 – 2902.

Dada, A. D. (2014): Evaluation of Technological Capability and Innovations in the Nigerian Cassava Processing Industry. An unpublished thesis submitted in partial fulfilment of the requirement for the award of the degree of Doctor of philosophy in Technology Management, Obafemi Awolowo University, Ile-Ife, Nigeria.

Dada, A. D and **Oyebisi T. O**. (2016). Harnessing Technology Transfer and Diffusion for Industrial Competitiveness and Socio-Economic Development in Nigeria: Issues, Opportunities and Policy Guidelines, *Journal of Sustainable Technology*, 7:(1).

Dussauge, P., Hart, S., & Ramanantsoa, B. (1992): Strategic Technology Management. Integrated product technology into global business strategy for the 1990s. John Wiley and Son, New York.

Fayetole, A. A. (2015): "A Study of the Potential Application of Space Technology for Climate Change Management in Africa" Unpublished Ph.D. thesis submitted to Obafemi Awolowo University, Ile-Ife 2015.

Ford, A. (1997): "System dynamics and the electric power industry. Jay Wright Forrester Prize Lecture, 1996. System Dynamics Review, 13(1):57-85. http://dx.doi.org/10.1002/SI-CI)1099-1727(199721)13:1<57:AID-SDR117>3.0CO:2-B

Forrester, J. W. (1968). Industrial dynamics—after the first decade. *Management Science*, *14*(7):398-415.

Fukuda-Par, S. and Messineo, C. (2012). Human Security: A Critical Review of the Literature. CRPD Working Paper.

Gaynor, H.G. (1996). Management of Technology: Description, Scope and Implications. *Handbook of Technology Management* Ed Gaynor, H.G. McGraw-Hill Professional. 912.

Heizer, J. and Render, B. (1988): "Production and Operations Management Strategies and Tactics, Allyn and Bacon, Inc., Boston.

Hitt M. A., Ireland R. D., Camp S. M., & Sexton, D.L. (2001). Strategic entrepreneurship: Strategies for Wealth Creation. Strategic Management Journal, 22 (3-4), 479-491.

Ilori, M. O., Nassar, M. L., Okolofo, J. O., Akarakiri, J. B., and **Oyebisi, T. O.** (2003): "An Evaluation of Business Performance and Technology Development in the Pre- and Post-Privatization Period of a Public Company in Nigeria" **TECHNOVATION** (*The International Journal of Technological Innovation, Entrepreneurship and Technology*) 20:103-108.

Ilori, M. O., **Oyebisi, T. O.** and Nassar, M. L. (1996): Models for Transferring Technology from the Laboratory to the Industries: Relevance and Implications for Developing Countries. *UNILAG Journal of Business.* 1(1):1-8..

Ilori, M.O., **Oyebisi, T. O.**, and Irefin, I. A. (1997): "An Evaluation of the Maintenance Policy on Selected Local Government of Nigeria" In Adeyemo, D.O. (ed.) **Financial and Administrative Procedure in Nigerian Local Governments** ISBN 978-32563-2-7. Remitol Publishers, Ibadan 1997, Pp. 315 – 321.

Kim, L. (1997): Imitation to Innovation- The Dynamics of Korea's Technological Learning. Boston: Harvard University Press.

Jones, C.I. The Facts of Economic growth. Handbook of Macroeconomics, Volume 2A. http://dx.doi.org/10.1016/bs.hesmac.2016.03.002

Klepper, S. and Simons, K. (2000). The Making of an Oligopoly: Firm Survival and Technological Change in the Evolution of the U.S. Tire Industry. Journal of Political Economy. 108(4):2

Kumar, V., Kumar, U. and Persand, A. (1999): "Building Technological Capability Through Importing Technology: The case of Indonesian Manufacturing Industry. *The Journal of Technology Transfer*, 24:81-96.

Lan, P. and Yang S. (1996): "International Technology Transfer Examined at Technology Component Level: A case Study in China. Technovation. 16(6):277 – 280.

Maskus, K. E. (2003). Encouraging International Technology Transfer. UNCTAD/ICTSD Capacity Building Project. On Intellectual Property Rights and Sustainable Development.

Menon, S.V. (2007). Human Security: Concept and Practice. Munich Personal RoPEc Archieve, http://Mpra.ub.unimuenchen.de/2478/1/MPRA paper 2478.pdf. Retrieved 2nd Feb. 2017.

Momodu, A. S., **Oyebisi T. O. and** Obilade T. O. (2012) "Modelling the Nigeria's Electric Power System to Evaluate Its Long-term Performance" Presentation made at 2012 International Conference of System Dynamic Society, University of St. Gallen, Switzerland, July 22 – 26, 2012.

Momodu, A. S. (2012): Evaluation of the Nigeria's Electric Power System. Unpublished Ph.D. Thesis submitted to African Institute for Science Policy and Innovation OAU.

Muchie, M. (2017) "Integrating Science Technology, Engineering and Innovation in Re-Framing the Africa's Development Agenda". A Paper presented at the 5th AfricaLics Academy held in Obafemi Awolowo University between 19th – 30th June, 2017.

Obawole, A. B. (2011). Evaluation of the Management of the Nigerian Upstream Oil and Gas Project. Unpublished PhD. thesis Submitted to African Institute for Science Policy and Innovation, Obafemi Awolowo University, Ile-Ife, Nigeria.

Olsina, F. (2005): "Long-term dynamics of liberalized electricity markets (Ph.D. thesis)." Department of Postgraduate Studies, Faculty of Engineering, National University of San Juan, San Juan, Argentina. Retrieved from www2.ing.puc.cl/power/paperspdf/Olsina.

Oluwale, B. A., Ilori M. O. and **Oyebisi T. O.** (2012): Factors influencing indigenous technological learning and innovations in the auto-mechanic industry in Nigeria. *Journal of Management*, 2 (5):180 – 187.

Oluwale, B. A., Ilori M. O. and **Oyebisi T. O.** (2013): Clustering and Innovation in the Auto-mechanic industry in Nigeria. *African Journal of Science, Technology, Innovation and Development*, 5(5):180 – 187.

Omoleke, M. (2010): A Study of the Application of Technologies in the Management of Electoral Process in Nigeria. Unpublished Ph.D. thesis submitted to AISPI Obafemi Awolowo University, Ile-Ife.

Olamade, O. O., (2007); "Application of Information and Communications Technology to Environmental Scanning in the Manufacturing Companies in

Southwestern Nigeria." Unpublished Ph.D. thesis submitted to African Institute for Science Policy and Innovation, Obafemi Awolowo University, Ile-Ife.

Olamade, O. O., **Oyebisi T. O.** and Egbetokun A. A (2013); "Manufacturing Business Environment in Nigeria. Strategic Characteristics and Implications." Advances in Management and Applied Economics, 3(6):53 – 65.

Oyebisi, T. O., (1992): "Developing Maintenance Culture of Public Engineering Infrastructures in Nigeria", *Reviews of African Political Affairs*, 6:(1&2):22-29.

Oyebisi, T. O. (1997): "Policy Framework for Local Manufacturing of Meteorological Instrumentation System" Proceedings of the International Conference on SUSTAIN AFRICA held by the Nigerian Meteorological Society, 3:1-4.

Oyebisi, T. O. (2000a): "On Reliability and Maintenance Management of Electronic Equipment in the Tropic" TECHNOVATION (*The International Journal of Technological Innovation, Entrepreneurship and Technology*), 20(9):517-522.

Oyebisi, T. O. (2001a): "A Model of Computer-based Information Systems for Industrial Waste Management" **I***fe Research Publications in Geography*, 8: 18-24.

Oyebisi, T. O. (2001) "Internet and the Commercial Sector of the Nigerian Economy: Policy and Technology Management Implications", TECHNOVATION (*The International Journal of Technological Innovation, Entrepreneurship and Technology*), 21(6):369-374.

Oyebisi, T. O. (2014): "Promoting Technology Transfer and Dissemination for Industrial Competitiveness and Socio-Economic Development: Issues, Opportunities and Policy Guidelines". A paper presented at the 5th Annual Technology Management Forum for Directors

of Science and Technology in Nigeria, Fostering Indigenous, Non Technological and Technological Innovation for Competitiveness and Inclusive National Transformation. 24-25th November, 2014, Asaba, Delta State.

Oyebisi, T. O. (2017a): "ICT Clusters and Regional Development in Africa". A Paper presented at the 5th AfricaLics Academy, 2017 held in Obafemi Awolowo University between 19th and 30th June, 2017.

Oyebisi, T. O. (2017b): "Technology Management: A Tool for Socio-Economic Development". Paper presented at the National Conference on Law and Socio-Economic Change in Nigeria Issues, and Prospective, 18th – 21st July, 2017 at Moot Court. Faculty of Law, Obafemi Awolowo University.

Oyebisi, T. O. and Agboola, A. A., (2003): "Impact of the Environment on the Growth of Nigerian IT Industry", International Journal of Information Management (IJIM), 23(4):313-321.

Oyebisi, T.O. and Ajayi, G.O. (2001). "Strengthening Competitive Advantage in the Nigeria Banking Sector using Information and Communications Technology" *The Journal of Banking and Finance (JBF)* 5(1):1-10.

Oyebisi, T. O., Ilori, M. O. and Adedeji, C. O. (2000) "An Assessment of the Strategies for the Maintenance of Laboratory equipment at a University in Nigeria", Ife Social Review, 18(1):235-244.

Oyebisi, T. O., Ilori, M. O. and M.L. Nassar, (1996): Industry-academic relations: an assessment of the linkages between a university and some enterprises in Nigeria, *Technovation,* 16(4): 203-209.

Oyebisi, T. O., Ilori, M. O., Akarakiri, J. B. and Adeoti, O., (2000d): "Locational Analysis of Small Scale Biogas

Plant in Nigeria", *Nigeria Journal of Engineering Management (NJEM)*, 18 (1):235-244.

Oyebisi, T. O., Ilori, M. O. and Oladimeji, M. A., (2000b): "Utilization of Telephone Facilities in Nigeria", *Nigeria Journal of Engineering Management (NJEM)*, 1(1):27-32.

Oyebisi, T. O., Ilori, M. O., and Oyeleke, T. A. (1999): "Characteristic of the Waiting Line in Selected Traditional Food Services Systems in Osun State of Nigeria" **Nigeria Institute of Industrial Engineers, Manufacturing Engineering Conference** held between Nov. 22-23, 1999, at the Conference Centre, University of Ibadan, Conference Proceeding 1:74-88.

Oyebisi, T. O., Ilori, M. O., Ugwu, L .O. and Adagunodo, E. R., (2000c) "A Study on the Assimilation of Information Technology in Selected Banks and Insurance Firms in Nigeria", *Nigeria Financial Reviews*, 9(1): 57-69.

Oyebisi, T. O., Kehinde, L. O., Buraimoh-Igbo, L. A., and Olaogun, M. O. B. (1994): "Computer-based Data Acquisition System for Ground foot Forces in Pathological Gaits" *Journal of Computer Association of Nigeria*, 6(1):1-15.

Oyebisi T. O. and Ojesanmi O. A (2008): Development of Congestion Control Scheme for Wireless Mobile Network. ***Journal of Theoretical and Applied Information Technology***. 4(10):965-972, Published by Asian Research Publications, Pakistan. Available online at http:/www.jatit.org/volumes/researchpapers/Vol4No10/10Vol4 No10.pdf.

Oyebisi, T. O., Ojewale, B.A., Ilori, M.O., and Akinwumi, I.O. (2001): "An Evaluation of Exploitable Idle Capacities in some Polytechnics, Universities and Research

Institutes in South western Nigeria" *Nigerian Journal of Industrial Systems Studies (NJISS)*, 1(2): 27-37.

Oyebisi, T. O., Olamade, O. O. and Agboola, A. A., (2004): "An Assessment of the level of Availability of Technological Capabilitues in the Nigerian Telecommunications Industry", International Journal of Information Management (IJIM), 559:1-10.

Oyebisi, T. O. and Momodu, A. S. (2012). 'Planning for High Technology Facility in Nigeria'. A Perspective International Journal, Technology, Policy and Management, 12(1):48 - 57.

Oyebisi, T. O., Momodu, A. S. And Olabode, S. O. (2013). "System thinking in Managing Technological Innovation Systems in Manufacturing Companies" *Nase Gospodarstvo*/Our Economy. 59(3-4): 50 – 57.

Oyedoyin, B. O., Ilori, M. O., **Oyebisi, T. O.**, Oluwale, B. A. And Jegede, O. O. (2014). Involvement of Stakeholders in the R&D and Innovation Process: an Analysis of Nigeria's Innovation System. *Journal of Entrepreneurship and Innovation Management,* 3(1): 1 – 24.

Oyedoyin, B. O., Ilori, M. O., **Oyebisi, T. O.**, Oluwale, B. A. and Jegede, O. O. (2015). Factors influencing R&D and Innovation Output in Nigeria. *Journal of Industrial Research and Technology,* 4 (1): 101 – 116.

Oyelaran-Oyeyinka B. (2017): Industrialization and Structural Transformation". A paper presented at the 5th AfricaLics Academy held in Obafemi Awolowo University between 19th – 30th June, 2017.

Siyanbola, W. O. (2010): Managing Intellectual Property (IP) for Wealth Creation and Sustainable Development: Policy Impact. Being a lecture delivered during the short term

courses held in NACETEM Abuja Office, 2nd – 6th August 2010.

UNESCO, (2016). Perspectives on Emerging Issues. Available on https://en.unesco.org/sites/default/files/usr15_perspectives_on_emerging_issues.pdf

Ugwu, L.O., **Oyebisi, T.O.**, Ilori, M.O. and Adagunodo, E.R. (2000): "Organisational Impact of Information Technology on Banking and Insurance Sector in Nigeria" **TECHNOVATION** (*The International Journal of Technological Innovation, Entrepreneurship and Technology*) 20(12): 711-721.

Ventosa, M. Balilló, A. Ramos, A., and River, M. (2005): "Electricity market modelling trends. Energy Policy, 33, 897-913. http://dx.doi.org/10.1016/j.enpol.2003.10.013