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Akinola Johnson OLAREWAJU

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Impact of Engineering in the Economic Development of a Nation – An Overview

Akinola Johnson OLAREWAJU

Civil Engineering Department, Federal Polytechnic Ilaro, Ogun State, Nigeria

Abstract: *This paper examines the role and impact of engineering professions in the economic development of any nation with a view to strengthen the areas of weaknesses to further boot the economic generation and enhancing job opportunities within and outside the nation. The ingredients were thoroughly defined. Available certificated engineering professions in the world were examines. In addition to this, basic engineering tools and their contribution to the economic development of a nation was critically and objectively discussed. The various factors for the economic growth and decline in the manufacturing industries were equally analyzed within the context of the globally available opportunities and possible solutions and way forward were suggested. Finally, the technical capacity building plans were exhaustively discussed and if fully implemented, will strengthen the engineering profession and eventually act as catalyst to the growth of the profession and the economy of the country at large.*

Keywords: *Engineering, Profession, Economy, Development, Innovation, Research*

Background Study

Role is the function assumed or part played by a person or thing in a particular situation. In the same vein, engineering could be defined as the application of mathematics and scientific, economic, social, and practical knowledge in order to invent, innovate, design, build, maintain, research, and improve structures, machines, tools, systems, components, materials, processes, solutions and organizations. The discipline of engineering is extremely broad and encompasses a wide range of more specialized fields each with a more specific emphasis on particular areas of applied science, technology and types of application. The term Engineering is derived from the Latin ingenium, meaning cleverness and ingeniare, meaning to contrive or devise. Economy on the other hand is the state of a country or region in terms of the production and consumption of goods and services as well as the supply of money. An economy is an area of the production, distribution, or trade and consumption of goods and services by different agents in a given geographical location. Understood in its broadest sense, the economy is a social domain that emphasizes the practices, discourses and material expression associated with the production, use and management of resources. Economy is the large set of inter-related production and consumption activities that aid in determining how scarce resources are allocated and this is also known as an economic system. Economic agents could be individuals, businesses, organizations or governments.

Economic transactions occur when two parties agree to the value or price of the transacted goods or services, commonly expressed in a certain currency. Monetary transactions only account for a small part of the economic domain. Economic activity is spurred by production which uses natural resources, labor and capital. This activity has changed over time due to technological advancements such as automation, accelerator of process, reduction of cost functions and innovation activities. These innovative activities could be in the form of new products, services, processes, new markets, expands markets, diversification of markets, niche markets, increases revenue functions like that which produces intellectual property and changes in industrial relations. Example is the child labor being replaced in some parts of the world with universal access to education. A global economy and domestic economy is the result of a set of processes that involves its culture, values, education, technological evolution, history, social organization, political structure and legal systems, as well as its geography, natural resource endowment, and ecology as main factors. These factors give context, content and set the conditions and parameters in which an economy functions. The economic domain is a social domain of human practices and transactions which does not stand alone.

Engineering economics previously known as engineering economy is a subset of economics concerned with the use and application of economic principles in the analysis of engineering decisions. In some developed and developing nations of the world, in the undergraduate Civil Engineering curricula, engineering economics is a required course. It is a topic on the Fundamentals of Engineering and questions might also be asked on the Principles and Practice of Engineering, both are part of the Professional Engineering registration process. As a discipline, it focuses on the branch of economics known as microeconomics in that it studies the behavior of individuals and firms in making decisions regarding the allocation of limited resources (Wikipeda, 2017). Thus, it focuses on the decision making process, its context and environment. It is pragmatic by nature, integrating economic theory with engineering practice. But, it is also a simplified application of micro-economic theory in that it avoids a number of micro-economic concepts such as price determination, competition and demand/supply. As a discipline though, it is closely related to others such as statistics, mathematics and cost accounting, it draws upon the logical framework of economics but adds to that, the analytical power of mathematics and statistics.

The engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects. Fundamentally, engineering economics involves formulating, estimating, and evaluating the economic outcomes when alternatives to accomplish a defined purpose are available. Considering the time value of money is central to most engineering economic analyses. Cash flows are discounted using an interest rate, except in the most basic economic studies. Costs as well

as revenues are considered, for each alternative, for an analysis period that is either a fixed number of years or the estimated life of the project. The salvage value is often forgotten, but is important, and is either the net cost or revenue for decommissioning the project (Royal Academy of Engineering, 2015; South Pacific Engineers' Association, 2012; Maria et al. 2012; John, 2017; James, 2008; UNESCO Report, 2007; Ernesto e al., 2017; Osborne and Kumar, 2017; Raza, 2008).

Available Engineering Disciplines

Engineering as broad as it is comprises of many broad specialized fields namely; civil, mechanical, electrical/electronic and chemical engineering which are the big four disciplines, and this account for approximately 64 percent of Canada's engineering professions (Infrastructure Canada, 2012). These are some (but not limited) of the world notable certificated engineering fields available in many higher institutions of learning in the world today: Electrical/Electronic Engineering, Computer Engineering, Mechanical Engineering, Mechatronics Engineering, Civil Engineering, Structural Engineering, Environmental Engineering, Geotachnical Engineering, Online Engineering, Engineering Management, Architectural Engineering, Biomedical Engineering, Biomechanical Engineering, Automotive Engineering, Project Management, Chemical Engineering, Agricultural Engineering, Robotics Engineering, Impact Engineering, Metallurgical and Material Engineering, Micro Electronic Engineering, Material Science Engineering, Paper Engineering, Sustainability Engineering, MBA in Engineering, Industrial Engineering, Systems Engineering, Manufacturing Engineering, Petroleum Engineering, Geological Engineering, Nuclear Engineering, Marine Engineering, Engineering Physics, Photonics Engineering, Nanotechnology Engineering, Mining Engineering, Ceramics Engineering, Geomatics Engineering, Aerospace Engineering, and so on and so forth.

Engineering as a Tool for Economic Development of a Nation

Engineering is central to the well-being and economic development of every nation. Creative and dynamic as it is, it evolves continuously to meet the needs of human civilization, urbanization and industrialization. Engineering is pervasive in our modern society, enabling every sector from communication and entertainment to finance and healthcare, as well as its more visible applications in construction, manufacturing and transport. Progress is driven, as it has always been, by human curiosity and experimentation, but resources are finite and the art of engineering is to devise affordable solutions to problems. Engineering research offers sophisticated tools for the modeling of complex physical phenomena which enables the design of improved products and processes in the future. For United Kingdom alone, the total value added by construction industries is 278 Billion Pounds (20%). The roles played by engineering professions in any society of the world are hereby enumerated below.

Innovative Engineering

Innovation in engineering is characterized by new ideas or things and therefore ngineering provides the means to convert excellent research into new and improved products and services that can and do make a substantial contribution to the economy. Innovative engineering is the key to future growth in the developed and developing nations and there is need to make increasing use of the intellectual abilities and creative talent to take advantage of this opportunity. Engineering is vital to all the sectors prioritized in the government's industrial strategy, which builds on the existing strengths in aerospace, pharmaceuticals, software and computing, etc. Engineering graduates and postgraduates help to drive product development and innovation across many parts of the economy and sectors with high concentrations of graduate engineers all report higher than average levels of innovation activity, innovation-related income and labor productivity.

Emerging Technologies

Engineering has changed dramatically during the last few decades. Emerging (newly formed) technologies now provide important opportunities for future growth. The boundaries between traditional disciplines are becoming increasingly blurred as many of the most exciting discoveries and developments are made at these boundaries. This is an entirely new area of exploration that has arisen through the interaction of chemistry, biology, medicine, engineering and other science related disciplines.

Engineering Research

Research is a diligent inquiry or examination to seek or revise facts, principles, theories, applications while engineering is the application of mathematics and physical science to the needs of humanity and the development of technology.

Drawing Inward Investments

Encouraging inward investment by international companies and multinationals like oil companies, mobile operators, etc is a crucial component of the nation's industrial strategy. The undisputed quality of engineering research conducted combined with access to world-class engineering facilities and businesses will help in attracting substantial high-value and high-technology inward investment from other parts of the world.

Drawing External / Overseas Investments
Overseas investors are drawn to the recognized engineering expertise and their support is helping to benefit regional economic development initiatives and integration. For example, it has been reported in Wales that the Japanese electronics giant Panasonic is creating a new fuel cell research and development centre in Cardiff while around 260 jobs are being created by a US global engineering firm in County Tyrone. According to the report, Terex manufactures equipment used in the construction, quarrying and mining industries has factories in Dungannon and Omagh in Northern Ireland which is part of a £21.7million investment and jobs will be created over the next few years. Terex plans to build new factory space, purchase new equipment and invest in research and development. Nissan and Mazda automobiles have planned to esteblished their factories in the US and this will create over I million jobs. These are but a few examples of the many inward investments being made by companies attracted by factors such as engineering research, talent base, enabling environment, and so on and so forth.

Successful and Competitive
Engineers also have the skills and ability to tackle the grandest of challenges and find solutions that work. Whether in research, technology, business or policy, they are equipped to analyze problems, synthesize solutions, manage projects that create the right outcomes and turn those experiences into new opportunities. As a result, engineering research plays a key role in policy and public services.

Engineering Skills
Great talent is essential for great innovation and great business. It is well known and documented that in many countries in the world that skills shortage particularly in engineering, postgraduate skills in the right areas can influence an industry's international competitiveness or even the performance of a country's knowledge economy.

Powering the Nations and Sub-Regions
High-quality engineering research institutions can have a very positive impact on national and regional development and integration. It will help in generating new economic activities and employment in the war ravaged areas as well as the sub-regions. Stimulating enterprise is essential to revitalize economically deprived areas and the contribution of micro companies.

Leading the World
Engineering research and postgraduate training in internationally recognized institutions have an enormous influence on engineering internationally. Many international consulting engineering companies, like Julius Berger, Reynold Construction Company (RCC) and many others, are hugely successful in large numbers of countries throughout the world, because they are applying the high quality engineering research and postgraduate training provided to their engineers. Involved nations are at the forefront of contributing to global infrastructure and urbanization especially in emerging economies. For instance, palm oil production in Malaysia has turned the country into the leading producer of palm oil in the world.

International Engineering Activities
International engineering activity is increasingly driven by engineering research and training undertaken in developed nations. This will both extend the international network of engineering research collaborations and ensure that engineering research community continues to contribute to poverty alleviation across the world. Engineering research is essential to enable the nations to forge ahead with its industrial strategic plans.

Engineering for Growth
Economic growth is a means of improving quality of life, addressing society's challenges, strengthening social cohesion and creating the education and training that can give young people real opportunity. The major challenge affecting engineering is the ability to remain competitive on a global stage. However, real and sustained support from across the political spectrum will be essential if the nation is to reap the full rewards offered by engineering ingenuity and innovation (Royal Academy of Engineering, 2015; South Pacific Engineers' Association, 2012; Maria et al. 2012; John, 2017; James, 2008; UNESCO Report, 2007; Ernesto e al., 2017; Osborne and Kumar, 2017; Raza, 2008).

Factors Affecting the Growth of Engineering

Decline of Manufacturing Industries
Manufacturing base of most developed and developing nations has been suffering a decline as a result of global economic changes and other pressures. The major causes of this decline among others are the failure of traditional manufacturing industries to modernize and retain international competitiveness. This has led to closure of most of these industries. There is closure of traditional and satellite industries, rundown of engineering practices, decentralization of key industries in areas like electronics, processing and machine engineering to more competitive locations outside the countries. Others are obsolescence of many processes used by industries in these areas, reduction in defense spending which led to insecurity in most developing nations, erratic power supply among others.

Solutions and Way forward

There is need to expanding the knowledge base by rebalancing the research and development portfolio, re–establishing research as a priority for industry, strengthening the links among industries and research institutions home and abroad, rebuilding and rehabilitating the infrastructures for engineering research with modern laboratories with state of the earth equipments, enhancing the diversity of world class engineering (like America, United Kingdom, Canada, China, India, etc). Other are enhancing the flow of graduate scientists and engineers across various countries, firms, building stronger interest in engineering careers among the younger ones by conduction seminars, workshops, etc. at the grass root, implementing more strategic immigration policy partnership among the leading nations in the world, interdisciplinary character among the existing engineering cadre, education by incentives and scholarships to interested applicants in engineering profession. Others include reviving the power sector to prevent the local industries and multinationals from migrating to another countries in the sub-region where there is uninterrupted power supply, and so on and so forth.

Regulation of Engineering

In order to become a professional engineer in countries like Canada, you must be licensed in the provincial/territorial jurisdiction in which you are employed. The license is a permit to practice engineering. It is a privilege that obliges those who hold a license to hold the public interest paramount, maintain skills and competencies, and obey a code of ethics. These measures help to ensure that Canadians can continue to live in safe, prosperous and sustainable communities (Infrastructure Canada, 2012).

Encouraging Engineering Business

Canada is globally recognized for its engineering services and is the fifth largest exporter of engineering services in the world with 30 percent of its work performed at the international level (Infrastructure Canada, 2012).

Promoting Engineering Excellence

Engineering learned societies forms an essential link between research and engineering practice, between our universities and consulting and construction companies. Engineering organizations in countries like Canada ensures that practicing engineers remain up to date with the latest developments in their fields of expertise. Engineers are constantly striving to build more durable and less expensive infrastructure. The learned societies contribute to this ongoing pursuit of excellence and all citizens in the nation and the world at large benefit from this commitment to the betterment of the engineering profession.

Technical Capacity Building Plans

Having identified the role played by engineering professions nationally and internationally, there is need to evaluate the technical capacity building plans and plan ahead. There is need to examine the engineering programmes currently producing graduates and to know how many of these prospective engineers are graduated each year, and to know if this is consistent with other similar nations noting that one third of graduates in engineering is normal for nations seeking to develop quickly. Quality assurance systems like accreditation are currently in place for the engineering programmes and do this reference to internationally recognized standards. There is need for the assessment of technical capacity plan in the areas of the quantity of engineering graduates whether it is sufficient for current and future needs of the nation, the current quality assurance system need to be checked whether it is adequate for nation purposes and appropriate for mutual recognition agreements in the global engineering field. Most importantly is the need to enhance current engineering programmes to global quality vis a vis laboratory upgrades, faculty/school development, computers, library, ict centers, etc. Also crucial is the needs (i. e. needs assessment) by the authorities whether the quantity of well-prepared engineering graduates is insufficient for current and future needs and what is needed to increase the flow such as additional schools or programmes, increased size for current programmes, more financial aid for the institutions and students (scholarships, grants,, etc.) the quality of programmes and their graduates whether it is below global norms for competitiveness, and what remedial measures are needed (e.g. develop an accreditation system or improving the existing ones). There is need for adequate plans to meet any need for increased quantity of well-prepared engineering graduates, to meet any need for increased quality assurance of engineering programmes, for retention of well-educated engineering and other graduates in the nation's public service and for professional development of those graduates to make excellent policy decisions. Also of importance is in the area of funding to accomplish needed quantity and quality enhancements and the available sources of funding like government, development banks, industry, tuition, etc. Finally is the leadership of all the stakeholders in the engineering professions which includes the time line for execution of the plans and evaluation/assessment mechanism which will track the progress and review results (Royal Academy of Engineering, 2015; South Pacific Engineers' Association, 2012; Maria et al. 2012; John, 2017; James, 2008; UNESCO Report, 2007; Ernesto e al., 2017; Osborne and Kumar, 2017; Raza, 2008).

Conclusion

This paper has examined the role of engineering professions in the economic development of a any nation The ingredients were thoroughly, exhaustively and objectively defined and discussed. The possible solutions and way forward suggested will help to further boost the economic generation, regional integration and enhancing job opportunities within and outside the nation. Finally, the technical capacity building plans, if fully implemented, will strengthen the engineering profession and eventually act as catalyst to the growth of the profession.

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