

Laboratory Business in Nigeria and Economic Considerations

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Abstract:

In Nigeria, there is a realization both in government and private sectors, that laboratories should be run as business ventures in line with relevant economic laws and principles. The Nigerian clinical laboratory services market for instance was valued at USD 527.68 million in 2021 and is projected to reach USD 695.11 million by 2027 registering a CAGR of nearly 4.7% during the forecast period, 2022 - 2027. The laboratory business could be a sole proprietorship, partnership, cooperative, or limited liability company. The major roles of a laboratory include sampling, method validation, equipment, raw material testing, in-process control, and specification, finished product testing, product development, and market surveillance. They are influenced by the laws of self-interest, competition, and supply and demand. The five basic economic principles governing investments in laboratory business in Nigeria include; opportunity cost, marginal principle, law of diminishing returns, principle of voluntary returns, and real nominal principle. The challenges facing laboratory business in Nigeria include lack of government funding, Staffing shortages, poor management training, and internal conflict. The lack of government funding for analytic laboratories has been responsible for the rejection of Nigeria's export produce and most consumer goods from Nigeria and Africa extract. The continent of Africa contributes less than nine percent to global laboratory activities, and this is one of the reasons you begin to see that various rejected products come from the African region. The government of Nigeria should be tasked to subsidize the procurement of the necessary equipment and facilities or provide financial incentives so that laboratory services locally and for export from Nigeria could attract premium prices at their destinations. The Nigerian law provides that no product like food, drugs,

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medical devices, cosmetics, water, chemicals, or consumer products, should be marketed or consumed without the certification of a public analyst, for objectivity, economic consideration, and safety.

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1. Introduction

A Laboratory abbreviated as 'Lab' or 'Labo' is an organized facility, room or building that provides the required and regulated conditions in which scientific experiments, research analyses are carried out with reliability and precision (Olatunji, 2015). It originated from the latin word *Laboratorium* /*laborare*. 'Laborare' means to labor or perform hard work (English) or travailler (French). A laboratory is a facility that provides controlled conditions in which scientific or technological research, experiments, and measurements may be performed. Laboratories are found in a variety of settings like: schools, universities, privately owned research institutions, corporate research and testing facilities like ones found at pharmaceutical and petrochemical companies, government regulatory and forensic investigation centers, physicians' offices, clinics, hospitals, regional and national referral centers, and even occasionally personal residences (Carlson, 2013).

Business is also known as an enterprise or a firm, an organization involved in the trade of goods and services to consumers. A business, whether simple, complex, private, or public is created to produce competitive goods and services at competitive prices. The business could be a sole proprietorship, partnership, cooperative or limited liability company. A good laboratory personnel must ensure a conducive climate for a successful and sustainable laboratory business (OECD,1997).

The importance and relevance of laboratories in global technological research and development cannot be over-emphasized. Despite the underlying notion of the lab as a confined space for experts, the term "laboratory" is also increasingly applied to workshop spaces such as Living Labs, Fab Labs, or Hackerspaces, in which people meet to work on societal problems or make prototypes, working collaboratively or sharing resources (Bruno, 1987). This development is inspired by new, participatory approaches to science and innovation and relies on user-centered design methods and concepts like Open innovation or User innovation (Hippel, 1986). One distinctive feature of work in Open Labs is the phenomenon of translation, driven by the different backgrounds and levels of expertise of the people involved (Fritzsche, 2018). The earliest laboratory according to the present evidence is the home laboratory of Pythagoras of Samos, the well-known Greek philosopher and scientist. This laboratory was created when Pythagoras experimented with tones of sound and the vibration of string. In the painting of Louis Pasteur by Albert Edelfelt in 1885, Louis Pasteur is shown comparing a note in his left hand with a bottle filled with a solid in his right hand, and not wearing any personal protective equipment (Schummer,

2007). Researching in teams started in the 19th century, and many new kinds of equipment were developed in the 20th century. A 16th-century underground alchemical laboratory owned by Rudolf was accidentally discovered in the year 2002. The laboratory is called *Speculum Alchemiae* and is preserved as a museum in Prague (Lowe, 2015). Laboratory equipment refers to the various tools and equipment used by scientists working in a laboratory. Laboratory equipment is generally used to either perform an experiment or to take measurements and gather data. Larger or more sophisticated equipment is generally called a scientific instrument.

The classical equipment includes tools such as Bunsen burners and microscopes as well as specialty equipment such as conditioning chambers, spectrophotometers and calorimeters. The title of laboratory is also used for certain other facilities where the processes or equipment used are similar to those in scientific laboratories, for example film laboratory (darkroom), computer laboratory etc.

A multidirectional cycle of laboratory business representing a continuing sequence of stages, tasks or events among governments, industries and institutions can be illustrated as:

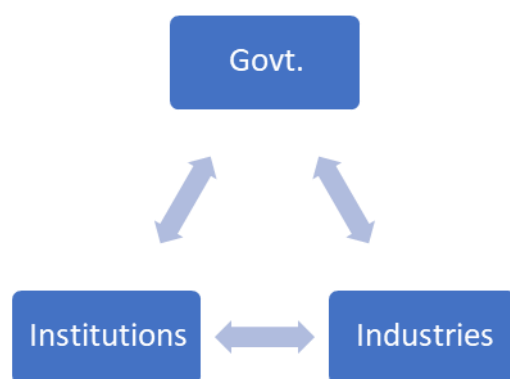


Fig. Laboratory business cycle

Laboratory is a fulcrum of major scientific and technological breakthroughs in fields such as biology, chemistry, basic sciences, translational sciences, agriculture, medicine and environmental sciences. Resources of a laboratory are those assets owned/available to it that can be used to achieve its objectives and include people, money, materials, equipment, facility, technology, information and network (Salami,2015). Depending on the size of the laboratory (Fig.2), and scope of its activity, the following subsystems of the laboratory are easily recognizable; administrative/staff function, technical/analytical, support, library/IT function, function, finance/procurement function and documentation/innovation management function.



Fig.2 Size and components of a laboratory

Characteristics of good laboratory. A good laboratory must have:

- Realistic Mission statement of the laboratory direction and strategy.
- Achievable Goals and Objectives with broad targets, objectives and tactics to be adopted to reach the stated goals.
- Specific and Directional Financial marketing and action plan. Each of these plans covers a specific aspect of the laboratory's strategy and direction
- Operational, Functional and right equipment
- Appropriate Personnel, Well-trained and knowledgeable personnel
- Ethical, Good laboratory practice (GLP)
- Timely and Dependable Adequate quality control.

2. In-house laboratory in the industry

In-house laboratory refers to a laboratory that provides basic and essential laboratory testing/services within an organization. The use of an in-house laboratory in the industry is a vital key to a successful and comprehensive quality control. The state-of-the-art quality control laboratory is essential to run technology-driven research/investigations with meaningful and substantial impact in the attainment of the objectives and goals of the industry. Organization of laboratories is an area of focus in sociology. Scientists consider how their work should be organized, which could be based on themes, teams, projects or fields expertise (Vinck,2010). Work is divided, not only between different jobs of the laboratory such as the researchers, engineers and technicians, but also in terms of autonomy (should the work be individual or in groups). For example, one research group has a schedule where they conduct research on their own topic of

interest for one day of the week, but for the rest they work on a given group project (Herper, 1992). Finance management is yet another organizational issue.

The laboratory itself is a historically dated organizational model. It came about due to the observation that the quality of work of researchers who collaborate is overall greater than a researcher working in isolation. From the 1950s, the laboratory has evolved from being an educational tool used by teachers to attract the top students into research, into an organizational model allowing a high level of scientific productivity. Some forms of organization in laboratories include their size, the division of labour and coordination mechanisms. Their size varies from a handful of researches to several hundred. The division of labor: occurs between designers and operatives; researchers, engineers, and technicians; theoreticians and experimenters; senior researchers, junior researchers and students; those who publish, those who sign the publications and the others; and between specialties. (Chesbrough, 2003). The coordination mechanisms include the formalization of objectives and tasks; the standardization of procedures (protocols, project management, quality management, knowledge management), the validation of publications and cross-cutting activities (number and type of seminars).

A systematic approach to managing the entire lifecycle of laboratory instrumentation, from procurement to decommissioning, is a good business practice for smooth laboratory operation. Doing things right the first time will help save time, money, and resources and avoid preventable instrument failures. A systematic approach conveys confidence to auditors during laboratory inspections. Most importantly, a systematic approach to make sure an instrument is functioning properly and adequately according to the intended requirements is one of the most important factors in ensuring the quality and reliability of data generated by the instrument (Buraimoh, 2015). The reliability of the laboratory analyst is one of the three critical determinants of the reliability of analytical data generated from analysis (Hubber, 1999). The different technical competence levels of the laboratory analysts can be defined in terms of awareness, developing, competent, expert and master. Awareness is the introductory level, shadowing or working under close supervision and becoming familiar with core requirements of role/function, supporting processes and documentation (Hubber, 1998). Developing stage is the core training period and working towards competence by repeatedly undertaking specific tasks with gradually increasing range (Freeman, 1995). Those deemed competent will generally work without direct supervision and may undertake training/supervision of other staff. Expert level is likely to be required/attained by relatively few technical staff who specialize in a particular aspect and demonstrate ability to keep up to date in area of expertise. Master represents the highest level of technical excellence after extensive business experience and may be accompanied by formal higher-level academic/professional study. The educational background of the researchers, the intellectual process involved in their work, and

laboratory history contribute to the organizational form of a laboratory. Other forms of organization include social organization.

3. Major Roles of in-house laboratory in the industry

This includes, sampling, method validation, equipment, raw material testing, in process control and specification, finished product testing, product development and market surveillance. Sampling is the process of taking representative portion of a whole lot or batch. Improper sampling leads to erroneous results. The sequence of the process is sampling of raw materials, packaging materials and finished product for analysis.

Information regarding the validation of methods should be carefully evaluated for completeness, accuracy and reliability. If a compendia method exists, but the firm chooses to use alternative method instead, they must compare the two and demonstrate that in-house method is equivalent or superior to the official methods. Laboratory equipment usage, maintenance, calibration logs, repair records and maintenance of standard operating procedure should be examined.

The safety and efficacy of the finished product is largely dependent on the purity and quality of the bulk active substance. Evaluation of the test result from the in- process test performed in the production area or laboratory for conformance with established testing protocols, analytical methods and specifications. The laboratory assures safety and efficacy of the product. In carrying out this function, the finished product must be analyzed to ensure that the product conform to developed specification and regulatory requirements. Methods are developed to ensure that product is present in the quantity expected and that it is free from other substances etc. when the product is launched, each batch is tested by the quality control laboratories to ensure it meets all specifications. monitors product during its shelf-life. This is achieved through stability testing representative batches throughout their expiration period. The product disposition at release must meet all requirement throughout its shelf.

4. Running a Laboratory Like a Business

In Nigeria, there is a realization both in government and private sectors, that laboratories should be run as business ventures in line with relevant economic laws and principles. The Federal Government has set up modeling laboratory and economic intelligence desk at the Ministry of Finance, Budget and National Planning (Planning Arm) to test proposed new policies before implementation (Agba, 2021). The Nigerian Minister of State, Budget and National planning, while inaugurating the Modeling Laboratory and Economic Intelligence Desk said it was established as a macroeconomic analysis department to serve as a clinical laboratory or wind tunnel. According to him, this is where the technical officers of the ministry are expected to test proposed new policies before implementation; to study economic questions, test the cause and effect of macroeconomic problems. According to the honorable minister the data obtained from data generating agencies

would be used in the laboratory to estimate the effects of public policies and test their validity. Furthermore, it would be a place where officers would conduct a range of in-house empirical research activities, use macroeconomic models to observe and examine behaviours of economic agents for a given policy change. He also said it would serve as an avenue for young officers to develop a scientific attitude and approach in addressing economic questions and knowledge in economic method that are useful in National Planning. This project has the support of UNDP, International Monetary Fund, IMF, World Bank, GIZ, European Union and Central Bank of Nigeria, CBN, among others.

The Nigerian clinical laboratory services market was valued at USD 527.68 million in 2021 and is projected to reach USD 695.11 million by 2027 registering a Compound Annual Growth Rate, CAGR of nearly 4.7% during the forecast period, 2022 - 2027.

The clinical laboratory market was affected by the COVID-19 pandemic. However, the COVID diagnostic services positively impacted the market, as the number of cases was rising daily, and there was high demand for COVID diagnostic services in Nigeria. According to an article published in the International Journal of Infectious Diseases, 2020, the incidence rate of COVID-19 was growing steadily in Nigeria during the pandemic (Ohia *et al.*, 2020). The Government of Nigeria is continuously focusing on remote diagnostics, case management, and expanding telemedicine solutions, which may fulfill the unmet needs during the pandemic.

The Nigerian Clinical laboratory market is driven by the rising incidences of chronic diseases, the increasing demand for accurate disease diagnosis, and the government's focus on public-private partnerships. According to the data published on the Global Health Data Exchange 2020, Nigeria's top causes of death are malaria, lower respiratory infections, HIV/AIDS, diarrheal diseases, cancer, meningitis, stroke, and tuberculosis (Nwafor *et al.*, 2020). The number of malaria cases was around 58, 143, 458; additionally, the number of tuberculosis cases was 288, 258, and the number of cases for diarrheal diseases was around 244, 501, 556 according to World Health Organization Report 2021, for Nigeria. Thus, the prevalence of infectious diseases is rising in the country, augmenting the demand for diagnostic services for the better management of diseases.

In addition, the Nigerian government, donor agencies, and NGOs are also making collaborative efforts to raise awareness among individuals. In December 2021, the government announced its diagnostic arm's launch with diagnostic laboratories fitted with state-of-the-art technology that will offer healthcare providers and patients access to world-class, cost-effective, speedy, reliable, and advanced molecular diagnostics. However, the lack of adequately trained laboratory staff restrains the market's growth.

4.1 The four major business organization forms of laboratory business in Nigeria

Business organization is the single-most important choice to make regarding setting your laboratory company in Nigeria (Rifkind, 2015). What form laboratory business adopts will affect a multitude of factors, such as how you are taxed, your legal liability, costs of formation and operational costs many of which will decide your company's future. There are 4 main types of laboratory business organization: sole proprietorship, partnership, corporation, and Limited Liability Company, or LLC.

Sole Proprietorship is the simplest and most common form of business owned and run by someone for their own benefit. The business existence is entirely dependent on the owner's decisions, so when the owner dies, so does the business. Advantages of sole proprietorship are as follows; all profits are subject to the owner, there is very little regulation for proprietorships, owners have total flexibility when running the business and very few requirements for starting- often only a business license. Disadvantages of sole proprietorship shows that owner is 100% liable for business debts, equity is limited to the owner's personal resources, ownership of proprietorship is difficult to transfer and no distinction between personal and business income.

Partnership come in two types: general and limited. In general partnerships, both owners invest their money, property, labor, etc. to the business and are both 100% liable for business debts. In other words, even if you invest a little into a general partnership, you are still potentially responsible for all its debt. General partnerships do not require a formal agreement—partnerships can be verbal or even implied between the two business owners.

Limited partnerships require a formal agreement between the partners. They must also file a certificate of partnership with the state. Limited partnerships allow partners to limit their own liability for business debts according to their portion of ownership or investment. Advantages of partnerships includes; shared resources that provides more capital for the business and each partner shares the total profits of the company. Other advantages include similar flexibility and simple design of a proprietorship and inexpensive to establish a business partnership, formal or informal. Disadvantages of partnership include; 100% responsibility for debts and losses by each partner, ends when any partner decides to end it and selling the business is difficult requires finding new partner.

Corporations are, for tax purposes, and separate entities are considered a legal person. This means, among other things, that the profits generated by a corporation are taxed as the "personal income" of the company. Then, any income distributed to the shareholders as dividends or profits are taxed again as the personal income of the owners. Advantages of a corporation includes limiting liability

of the owner to debts or losses, personal assets cannot be seized to pay for business debts, profits and losses belong to the corporation and that it can be transferred to new owners fairly easily. The disadvantages include the facts that corporate operations are costly, establishing a corporation is costly and with some exceptions, corporate income is taxed twice apart from complex paperwork to start a corporate business requires,

Similar to a limited partnership, a Limited Liability Company provides owners with limited liability while providing some of the income advantages of a partnership. Essentially, the advantages are that it limits liability to the company owners for debts or losses and the profits of the LLC are shared by the owners without double-taxation. Some disadvantages are that ownership is limited by certain state laws and beginning an LLC has high costs due to legal and filing fees. Agreements must be comprehensive and complex in this type of business.

4.2. Basic economic principles behind laboratory business in Nigeria

There are five basic principles of economics that explain the way laboratory business handles money and decides which investments are worthwhile which include : Opportunity cost, marginal principle, law of diminishing returns, principle of voluntary returns and real/nominal principle (Loveland, 2019). While the marginal principle definition might explain the very fundamentals of turning a profit, the real/nominal principle can teach one how to understand the actual worth of a dollar. Our society thrives on the five basic economic principles that can determine the success of business generally and laboratory business in particular. The more you understand the way our economy works, the better you can get ahead of the curve and make the best financial choices for you. Basically, the world has unlimited wants but very limited means, so there's always a choice that has to be made. We give up one thing to have another but must calculate the value and cost to find which option will be most fruitful. Before we get into any marginal principle examples, opportunity cost is one of the most basic economic concepts on the map. In short, the marginal principle concept definition is very basic and what we deal with every single day when running a business for example a laboratory. There is increase in the level of an activity as long as its marginal benefit exceeds its marginal cost. In other words, it wouldn't be a very wise business decision to spend more money than you're taking in if you don't have an overarching plan for profitability. An example of marginal principle is if a laboratory may choose to keep expanding their business as long as they see increased revenue, but they see that revenue has started to drastically shrink, they will, in turn, scale down or close altogether. The law of diminishing returns also goes by a couple of other names such as the principle of diminishing marginal productivity. This principle of economics shows that if one output of production is increased while keeping the others fixed, production will see an overall increase, but the rate of the increase gradually decreases.

The law of diminishing returns is something every business considers when they're ramping up and planning to expand, and it's often the same reason we hear about layoffs and restructuring within companies that may still be profitable but aren't showing as much profit as anticipated. The number of sales must justify the cost of raw materials, payroll and other manufacturing costs. The principle of voluntary returns is a principle of economics that promotes a free exchange of goods and services between buyers and sellers in a marketplace. This particular principle is used highly in international trade but can be relevant in laboratory business. Basically, we import the products we don't specialize in and sell off the ones we do. Sometimes, those things are deeply intertwined. The key part of this principle is that this exchange is voluntary as individuals get the best rate and both parties are happy with the exchange. The real/nominal principle is one of the fundamentals of economics. Basically, it states that people aren't interested in the face (nominal) value of money. They're interested in the actual (real) value of money. The real value is how much goods money can buy and the key to understanding how much money is actually worth in the scheme of real society. This is specifically important when factoring in exchange rates and inflation or the value in regard to other goods. A successful laboratory business thrives on these five Principles.

Running a laboratory like a business entail; managing and motivating knowledge workers, managing and maintaining a budget. The primary personal values that motivate knowledge workers include the following: Advancement (promotion and recognition for achievement), autonomy (being largely self-directed in one's work), challenge (solving difficult problems), job security, work-personal life balance and altruism (contributing to the welfare of others). Setting the budget and monitoring expenditure to ensure that budget limits are observed while the minimum required for achieving the laboratory goals are allocated and disbursed. Whether small, medium or big firm there is need to have a thorough understanding of organization budgeting procedures and time table for achieving the set goals.

The laboratory (business) must develop a formal and systematic product development portfolio management to; align project with business strategy, contain high-value-to-the business projects and to ensure a balance of project types: long term/short term, innovative projects, late-stage commercialization projects and customer service projects. Additionally, it must prioritize projects, limit the number of projects to avoid product development pipeline gridlock and accelerate new products to market and strike a balance between number of projects and available resources.

4.3 Maintaining Good Laboratory Practices (GLP)

Good Laboratory Practice (GLP) embodies a set of principles that provides a framework within which laboratory studies are planned, performed, monitored, recorded, reported and archived. These

studies are undertaken to generate data by which the hazards and risks to users, consumers and third parties, including the environment, can be assessed for pharmaceuticals (only preclinical studies), agrochemicals, cosmetics, food additives, feed additives and contaminants, novel foods, biocides, detergents etc. GLP helps assure regulatory authorities that the data submitted are a true reflection of the results obtained during the study and can therefore be relied upon when making risk/safety assessments. Webster et al., 2005.



Good laboratory practice refers to the use of a set of detailed mandatory specific operation procedures in basic and applied research, data acquisition and reporting (Juanita,2000).

In a broader sense, GLP is the use of standardized testing and reporting procedures so that result obtained in one laboratory at different times may be compared to those obtained at other laboratories. Aside from this, it is also a good practice to evaluate and document an alternate course of action to be taken in the event of sudden breakdown of critical equipment, measuring instruments, loss of critical plant systems and reference standards in a laboratory (Salami, 2015). This is to prevent a sudden total collapse of activities. This type of planning is called Business continuity plans. An alarm system is built into the system and triggers action when such occurrence arises. A system audit is required to determine the current state of an organization (Jalaoso, 2015). Adequate knowledge of the systems within the set up and the art of auditing are prerequisites for a value-adding audit. The three elements of quality cost in a laboratory industry are prevention,

appraisal and failure costs. Analysis has shown that well managed increase in prevention cost leads to tremendous reduction in appraisal and failure cost.

Many technical organizations have established standardized testing and reporting methods for various areas of research and development in Nigeria and globally. Examples are: ASTM international (the American society for testing materials), National Association of Corrosion Engineers, Society of Petroleum Engineers, Standard Organization of Nigeria (SON), National Agency for Food, Drugs, Administration Control, NAFDAC and World Health Organisation, WHO.

It is the responsibility of the laboratory manager to ensure that instructions (manual) on performing the testing methods are readily available and laboratory personnel are properly trained in the application of standardized testing methods. Laboratory managers are also responsible for ensuring that the testing equipment and reagents specified in the standardized testing methods are available. Major goals of GLP are to help in obtaining: reliable results, reproducible data, auditable record and ethically recognized output internationally.

4.4. Writing a Laboratory Proposal

A well written lab proposal will introduce research plans to an audience; sometimes, this audience is a teacher who will be grading lab work, while at other times it is a group who will provide funding or support for the proposed research. The Key aspects of a laboratory proposal include an intriguing introduction, description of method and qualification. Any lab proposal should ideally begin with a strong introduction that piques the reader's interest in your project. The hypothesis and the relevance in today's world should be explained and concluded with a concise statement of what you hope to accomplish in the laboratory. The proposal should be continued with a description of the experiment you would like to perform and the equipment required for the method of testing intended to be used. The body of your proposal should explain what you want to do, how you plan to do it and when it will be done.

A good laboratory proposal will describe the qualification of the person conducting the laboratory work and include any course your colleagues have done to prepare for the experiment you are proposing. The proposal will end with a strong conclusion that reiterates the main part of your plan and their significance.

4.5. Crucial factors for using the testing Laboratory

In Nigeria, a Public Analyst is statutorily mandated by law to regulate the analysis of consumer and health related products like food, drugs, medical devices, cosmetics, water, chemicals, consumer

products, and the environment with regards to pollution and impact assessment. The Nigerian law clearly provides that no product should be marketed or consumed without the certification of a public analyst, section 14 (1) and (2), IPAN Act CAP 116LFN 2004 formerly (Decree 100 of 1992). The advantages of using Public Analyst or Testing Laboratory are for Objectivity, Economic Consideration and Safety

The independent offsite testing laboratory focuses on the testing procedure to ensure accurate results. Third party testing by an independent laboratory is a common advertising claim that guarantees the test result are objective and free from the influence, guidance or control of interested parties. Economic consideration plays a central role in the decision of many types and especially smaller businesses, to utilize an outside laboratory to conduct quality and safety test. Laboratory activities are rife with such “hidden costs” including corporate or upper management salaries and benefits, liability insurance, office supplies, etc. Many companies engaged in producing potentially hazardous materials prefer to utilize an outside testing firm to minimize the danger of in-house exposure to hazardous agents as hazards are present in many laboratories. Laboratory hazards might include [poisons](#); [infectious agents](#); [flammable](#), [explosive](#), or [radioactive](#) materials; moving machinery; extreme temperatures; lasers, strong magnetic fields or high voltage. Therefore, safety precautions are vitally important (Otto, 2021). Rules exist to minimize the individual's risk, and safety equipment is used to protect the lab users from injury or to assist in responding to an emergency (Cossairt & Quinn, 2019). The Occupational Safety and Health Administration (OSHA) in the United States, recognizing the unique characteristics of the laboratory workplace, has tailored a standard for occupational exposure to hazardous chemicals in laboratories. This standard is often referred to as the "Laboratory Standard". Under this standard, a laboratory is required to produce a Chemical Hygiene Plan (CHP) which addresses the specific hazards found in its location, and its approach to them. In determining the proper Chemical Hygiene Plan for a particular business or laboratory, it is necessary to understand the requirements of the standard, evaluation of the current safety, health and environmental practices and assessment of the hazards. The CHP must be reviewed annually. Many schools and businesses employ safety, health, and environmental specialists, such as a Chemical Hygiene Officer (CHO) to develop, manage, and evaluate their CHP. Additionally, third party review is also used to provide an objective "outside view" which provides a fresh look at areas and problems that may be taken for granted or overlooked due to habit. Training is critical to the ongoing safe operation of the laboratory facility. Educators, staff and management must be engaged in working to reduce the likelihood of accidents, injuries and potential litigation. Efforts are made to ensure laboratory safety videos are both relevant and engaging (Micheal et al., 2007).

5. Challenges of Laboratory Business in Nigeria

The challenges facing laboratory business in Nigeria include, lack of government funding, Staffing shortages, poor management training, and internal conflict. The Institute of Public Analysts of Nigeria, (IPAN) has identified lack of government funding of analytic laboratories as been responsible for rejection of Nigeria's export produce during the group's 30th Mandatory Continuous Professional Development (MCPD) Workshop for its members. This development was a major contributor to the high rate of rejection of most consumer goods from Nigeria and Africa extract The continent of Africa contributes less than nine percent to the global laboratory activities, and this is one of the reasons you begin to see that various rejected products come from the African region because even the nine percent we are talking about are actually owned by laboratories that are offshore and they carry out activities for us here (Ogunmoyela, 2022). Global competitiveness of laboratories is going to be the way by which we would avoid international rejection of products that we have and encourage the significant roles for the laboratory sector in Nigeria. On its part the government should be tasked to subsidise the procurement of the necessary equipment and facilities or provide finance incentives so that laboratory services locally and for export from Nigeria could attract premium prices at their destinations. Most labs in Nigeria are short-staffed. As top-performing members of the workforce approach retirement, new labs face the challenge of finding new, highly experienced staff that they can afford. As a result, most labs are forced to operate with staff shortages and mid- to low-level expertise at the onset. Staffing shortages cause other problems, such as overworked employees and inefficiencies. However, medical lab start-ups that use clinical/medical laboratory consulting and recruiting experts from the onset can avoid the staffing challenges of starting a medical laboratory business. Medical laboratory personnel often transit into management roles without receiving formal managerial training. As a result, many medical laboratory businesses end up being run by individuals who have a medical background but aren't necessarily sure of how to be good business managers. Unskilled managers face many issues in communication, delegation, and conflict resolution. These issues tend to overrun the good aspects of the core business in the long term, leading to failure. Considering laboratories are high-stress environments with close-knit teams, they tend to be more prone to internal conflict between coworkers. For a start-up, internal conflict can bring down the business faster than usual if coworkers focus on tearing each other down. Given the importance of teamwork in the eventual success of a lab, it's understandable that internal conflict tends to lower the morale of medical laboratories.

6. Conclusion

Economic laws are true in themselves as such, the fundamental economic laws that govern laboratory business do not require empirical verification. One can ignore and violate the fundamental laws of economics but one cannot change them (Mueller, 2022). Consumption is the objective of economic activity, and production is its means. Therefore, the consumers are the final de facto owners of the production apparatus in a capitalist economy. In laboratory business, valuation is subjective and varies with the individual's situation. The same physical good has different values to different persons. Utility is subjective, individual, situational and marginal. Production has costs and value is subjective. The output per hour determines the worker's wage rate per hour. In a free labor market, businesses will hire additional workers as long as their marginal productivity is higher than the wage rate. Competition among the various laboratory firms will drive up the wage rate to the point where it matches productivity. Expenditure is not only income, but also represents costs. Spending counts as costs for the buyer and income for the seller. Income equals costs. The mechanism of the fiscal multiplier implies that costs rise with income. In as much as income multiplies, costs multiply as well. Labor, in combination with the other factors of production, creates products, but the value of the product depends on its utility. Utility depends on subjective individual valuation. In competitive capitalism, economic profit is the extra bonus that those businesses earn that fix allocative errors. In an evenly rotating economy with no change, there would be neither profit nor loss and all companies would earn the same rate of interest. In a growing economy, however, change takes place and anticipating changes is the source of economic profits. Business that does well in forecasting future demand earn high rates of profit and will grow, A set of seven fundamental notions that reflect the study of economics and how the economy operates are; scarcity, subjectivity, inequality, competition, imperfection, ignorance and complexity (Orley, 2023). The implication of the rules of economics is that we have limited resources and unlimited wants, while prices depend upon preferences. Competitive laboratory markets are more efficient and important while information is a scarce good.

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References

- Agba, C. (2021). Laboratory testing of Nigerian Economic Policies. *Nigerian National Petroleum Company (NNPC) monthly Oil and Gas report*.15(1).
- Bruno, L. (1987). *Science in action: How to follow scientists and engineers through society*. Cambridge: Harvard University Press.

- Buraimoh, A. (2009). Validation procedures: Application to equipment, method of analysis and personnel. *Paper presented at Mandatory Continuous Training Workshop, theme: Quality Assurance in Laboratory business, @ Lagos airport hotel, Ikeja, Lagos Nigeria.*
- Carlson, A. (2013). Top 8 Tools for Building a Personal Prototyping Laboratory". EE Times.
- Chesbrough, H.W. (2003). *Open Innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business School Press.
- Fritzsche, A. (2018). Corporate Foresight in Open Laboratories - A Translational Approach. *Technology Analysis & Strategic Management*. **30** (6): 646–652.
- Harper, R. H.R (1992). *Looking at Ourselves: An Examination of the Social Organisation of Two Research Laboratories*. Cambridge: Reprinted as Rank Xerox Technical Report EPC–92–108. pp. 330–337.
- Hippel, E. V. (1986). Lead users: a source of novel product concepts. *Management Science* **32**, 791–805.
- Jolaoso, D. (2015). Systems audit in manufacturing industries-food,water,drugs and cosmetics. Your laboratory, your laboratory, *paper presented at the 21st Mandatory training workshop organized by Institute of Public Analysts of Nigeria (IPAN)*. Ilorin, Nigeria.
- Juanita M.H. (2000). The importance of the laboratory to the pharmaceutical business. *Journal of automated methods and management in Chemistry*. **22**:2, 47-52.
- Loveland, M. (2019). The five basic Principles of Economics. *Bizfuent* <https://bizfluent.com/info-8458957>.
- Lowe, D. (2015). Laboratory history: The chemistry chronicles". *Nature*. **521** (7553): 422. Bibcode:2015Natur. 521..422L. doi:10.1038/521422a.
- Michael L. M; Jeffrey P. F; Shirley L (2007). Creating Customized, Relevant, and Engaging Laboratory Safety Videos. *Journal of Chemical Education*. **84** (10): 1727. doi:10.1021/ed084p1727.
- Mueller, A. P. (2016). Ten fundamental laws of Economics. Austrian Economics Overview Monetary Theory. Mises Institute, <https://mises.org>.
- Nwafor, C.D, Ochu C.L, Elimian, K.(2020).Nigeria Public Health response to the COVID-19 pandemic. *Journal of Global Health, ncbi.nlm.nih.gov.2*(3).
- OECD, Organization for Economic Co-operation and Development, Principles of Good Laboratory Practice (as revised in 1997). *OECD Environmental Health and Safety Publications* (OECD) 1. 1998.
- Ogunmoyela, O. (2022). Laboratory analysis: A necessary quality assurance measure for acceptance of agro-allied products. *A keynote address presented at the 30th Mandatory Continuous Professional Development (MCPD). Workshop, IPAN*. Akure, Nigeria.
- Ohia, C, Bakarey A.S & Ahmed. T(2020).COVID-19 and Nigeria; putting the realities in context. *International Journal of Infectious disease 2020-Elsevier.2*(1),21-30.
- Olatunji, G. A. (2015). Your laboratory, your laboratory. *Keynote paper presented at the 21st Mandatory training workshop organized by Institute of Public Analysts of Nigeria (IPAN)*. Ilorin, Nigeria.
- Orley, A & Amos, R(2023).Seven rules of economics. *Advanced programmed learning system, http://www.AmosWEB.com*.
- Otto, T. (2021). Safety for Particle Accelerators". *Particle Acceleration and Detection*. doi:10.1007/978-3-030-57031-6. ISBN 978-3-030-57030-9. ISSN 1611-1052.
- Rifkind, F. (2015). The four major business organizations forum. *Business law* <https://www.rifkindpatrick.com>
- Salami, F. (2015). Management of resources: Application to laboratory. Your laboratory, your laboratory, *paper presented at the 21st Mandatory training workshop organized by Institute of Public Analysts of Nigeria (IPAN)*. Ilorin, Nigeria.
- Schummer, J; Spector, T. I (2007). The Visual Image of Chemistry: Perspectives from the History of Art and Science". *Hyle: International Journal for Philosophy of Chemistry* (1): 3–41.

- Vinck, D. (2010). *The sociology of scientific work*. The Lypiatts: Edward Elgar Publishing Limited. pp. 83, 97–100.
- Webster, Gregory K.; Kott, L; Maloney, T (2005). "JALA Tutorial: Considerations When Implementing Automated Methods into GxP Laboratories". *Journal of the Association for Laboratory Automation (Elsevier)* 10 (3): 182–191.

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