Measuring and Managing User Innovation in Emerging Economies: A Case Study of South-West Nigeria

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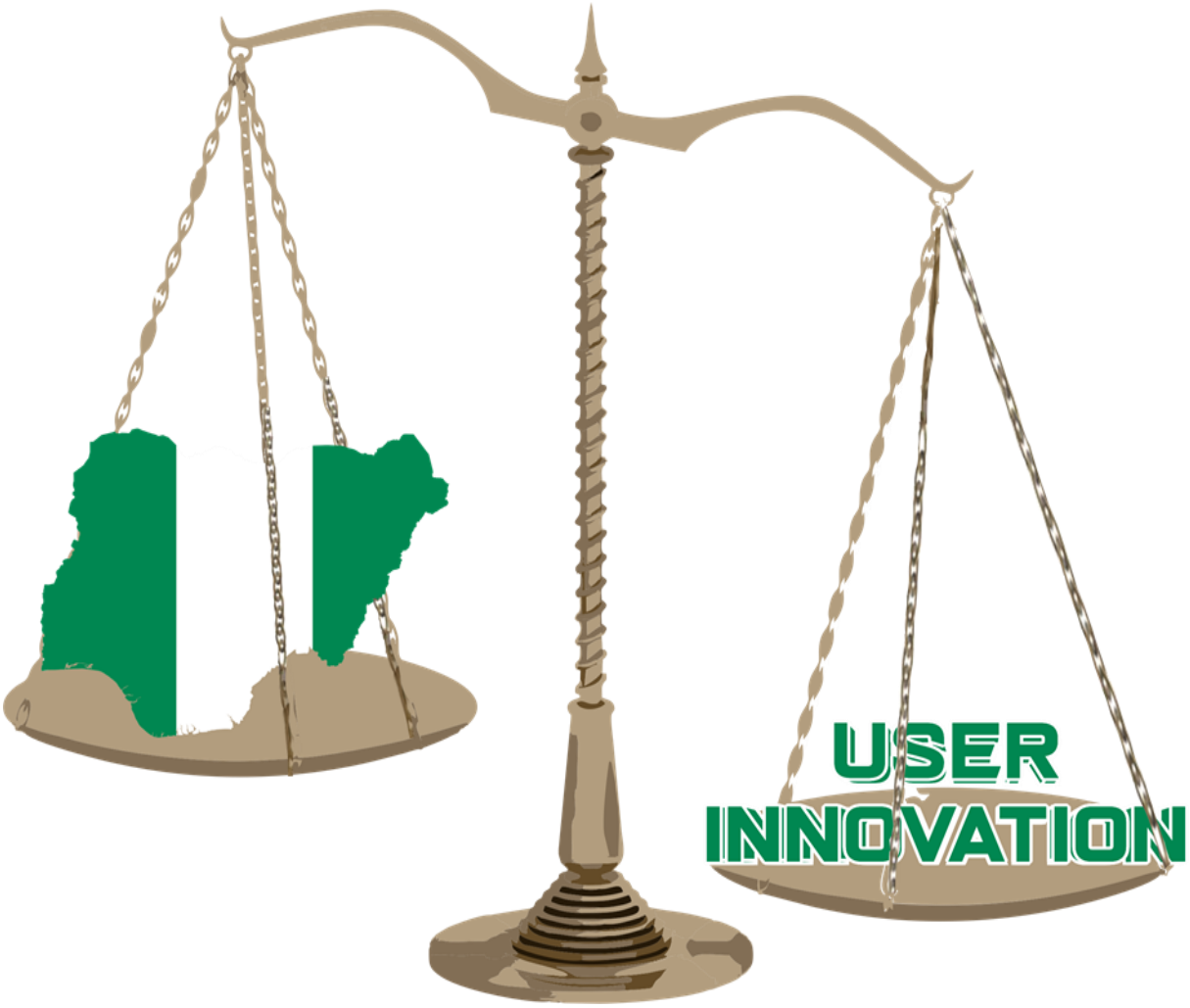
A Case Study of South-West Nigeria



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A thesis presented

By

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To

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Abstract

Contrary to traditional assumptions, the origin of most product innovation has been revealed to be the users whose needs were unmet by existing commercial products. These users engage in the act of innovation either in an incremental or radical form. Moreover, since most user innovation outputs are distributed through an open peer-to-peer distribution mechanism, user innovation was identified to possess tremendous social wealth and as a potent source of information spillover, which is beneficial to manufacturing firms and other service providers alike. Despite its gross importance in the innovation space, up until now, nothing is known about the state of user innovation in the emerging economy. Therefore, the goal of this doctoral thesis was to explore the prevalence and incidence rate of user innovation from the perspective of an emerging economy. The main focus of this study was on Nigeria. The thesis was conducted using quantitative research methodology involving administration of survey questionnaire, and qualitative research methodology involving personal and telephone interviews, as well as through participants' observation.

This thesis commences with a basic introduction to the research topic, outlining the four premises on which the study was based. An in-depth literature review is presented in chapter two. The reader is introduced to specific areas such as the origin, definition, variations, benefits, chronology, and diffusion of user innovation. This chapter also includes a description of the user innovation model, and a preview of the state of innovation in Nigeria, from the pre-colonial era to the post-colonial era. Chapter three contains the research methodologies used for this study; detailing the research questions, research approach, and the limitations experienced in each phase of the research. Chapter four presents the findings and discussion of the first phase of the research, which was to measure user innovation among Nigerian higher education students. Chapter five presents the findings and discussion of the second phase, which was to measure user innovation among Nigerian Small Medium Enterprises. Chapter six presents the findings and discussion of the survey on the contributions of private innovation incubators in the Nigerian innovation space. Chapter seven provides prognostic information on how user innovation can be adequately managed in emerging economies. The last chapter summarizes this research work, providing its implication as well as an outlook on areas to be considered for future research. The appendices provide additional statistical results and the survey questionnaires used for this work.

It is hoped that this thesis will be of use to students and researchers interested in knowing about the state of user innovation in Nigeria, especially from the angle of the emerging economic. In addition, this thesis could also be used by manufacturers looking for ways to maximize their innovation process. Lastly, this thesis could also be utilized as well as by those interested in discovering how innovation activities can be managed.

Kurzfassung

Entgegen den traditionellen Annahmen wurde festgestellt, dass der Ursprung der meisten Produktinnovationen bei den Anwendern liegt, deren Bedürfnisse von bestehenden kommerziellen Produkten nicht gedeckt wurden. Es wurde festgestellt, dass diese Benutzer sich entweder inkrementell oder radikal an Innovationen beteiligen. Da die meisten Benutzerinnovationsergebnisse über einen offenen Peer-to-Peer-Verteilungsmechanismus verteilt werden, wurde festgestellt, dass Benutzerinnovationen über einen enormen sozialen Wohlstand und eine potenzielle Quelle von Informationsüberflutung verfügen, die sowohl für produzierende Unternehmen als auch für andere Dienstleister von Vorteil ist. Über den Stand der Nutzerinnovation in der aufstrebenden Wirtschaft ist trotz der großen Bedeutung für den Innovationsraum bislang nichts bekannt. Ziel dieser Doktorarbeit ist es daher, die Verbreitung und Inzidenz von Nutzerinnovationen aus der Perspektive einer aufstrebenden Volkswirtschaft zu untersuchen. Der Schwerpunkt dieser Studie liegt auf Nigeria. Die Arbeit wird sowohl mit einer quantitativen Forschungsmethode durch Fragebogen als auch mit einer qualitativen Forschungsmethode durch persönliche und telefonische Befragung sowie durch Beobachtung der Teilnehmer durchgeführt.

Diese Arbeit beginnt mit einer grundlegenden Einführung in das Forschungsthema und beschreibt die vier Prämissen, an denen die Studie durchgeführt wurde. Eine ausführliche Literaturübersicht wird in Kapitel 2 vorgestellt. Der Leser wird in bestimmte Bereiche wie Ursprung, Definition, Variationen, Vorteile, Chronologie und Verbreitung von Benutzerinnovationen eingeführt. Dieses Kapitel enthält auch eine Beschreibung des Benutzerinnovationsmodells und eine Vorschau auf den Innovationsstand in Nigeria aus der Vorkolonialzeit, der Kolonialzeit und der Nachkolonialzeit. Kapitel drei enthält die für diese Studie verwendeten Forschungsmethoden, in denen die Forschungsfragen, der Forschungsansatz und die in den einzelnen Phasen der Forschung festgestellten Einschränkungen aufgeführt sind. In Kapitel 4 werden die Ergebnisse und die Diskussion der ersten Phase der Studie vorgestellt, in der die Nutzerinnovation bei nigerianischen Hochschulstudenten gemessen werden soll. In Kapitel 5 werden die Ergebnisse und die Diskussion der zweiten Phase vorgestellt, in der die Nutzerinnovation bei nigerianischen kleinen und mittleren Unternehmen gemessen werden soll. In Kapitel 6 werden die Ergebnisse und die Diskussion der Umfrage zu den Beiträgen privater Innovationsinkubatoren im nigerianischen Innovationsraum vorgestellt. Kapitel sieben enthält prognostische Informationen darüber, wie Benutzerinnovationen in aufstrebenden Volkswirtschaften angemessen gehandhabt werden können. Das letzte Kapitel fasst diese Forschungsarbeit zusammen und gibt einen Ausblick auf die Bereiche, die für die zukünftige Forschung in Betracht gezogen werden müssen. Die Anhänge enthalten zusätzliche statistische Ergebnisse und die für diese Arbeit verwendeten Fragebögen.

Es besteht die Hoffnung, dass diese These Studenten und Forschern von Nutzen sein wird, die sich für den Stand der Nutzerinnovation interessieren, insbesondere unter dem Gesichtspunkt der aufstrebenden Wirtschaft. Darüber hinaus könnte diese These auch von Herstellern verwendet werden, die nach Wegen suchen, um ihren Innovationsprozess zu maximieren. Schließlich könnte diese These auch von Interessierten genutzt werden, um herauszufinden, wie Innovationsaktivitäten verwaltet werden können.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ACE	Awojobi Clinic Eruwa
ARSPON	Association of Rural Surgical Practitioners of Nigeria
BIC	Business Innovation Centres
CAD	Computer Aided Design
CNC	Computer Numerical Control
CPI	Corporate Private Incubator
DFW	Digital Fabrication Workshop
DIWO	Do It with Others
DIY	Do It Yourself
EAT-SET	Emergency Auto Transfusion Set
FDM	Fused deposition machine
FME	Federal Ministry of Education
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GE	General Electric
GFI	Government-Funded Incubator
GII	Global Innovation Index
GPL	General Public License
HND	Higher National Diploma
ICT	Information and Communication Technology
IE	Innovation Efficiency
IIS-I	Innovation Input Sub-Index
IOS-I	Innovation Output Sub-Index
IPI	Independent Private Incubator
IPR	Intellectual Property Right
MIT	Massachusetts Institute of Technology
NACETEM	National Centre for Technology Management
NBS	National Bureau of Statistics
NIS	National Innovation System
NPD	New Product Development
NSD	New Service Development
NUC	National Universities Commission
OAPI	African Intellectual Property Organization
OECD	Organisation for Economic Co-operation and Development
OPAC	Online Public Access Catalogue
PI	Private Incubator
R&D	Research and Development
SPSS	Standard Package for Social Scientist
SME	Small and Medium Enterprise
SMEDAN	Small and Medium Enterprises Development Agency of Nigeria

STE	Science, Technology and Engineering
STEM	Science, Technology, Engineering and Mathematics
SUI	Student User Innovator
TMCM	Traditional Manufacturer-centric Model
UBI	University Business Incubators
UCIM	User-centric Innovation Model
UIM	User Innovation Model
UIS	UNESCO Institute of Statistics
UK	United Kingdom
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEF	World Economic Forum
WIPO	World Intellectual Property Organization

1 Introduction: Why Measure Innovation?

Based on an adage that says "*What gets measured gets done,*" measuring innovation is a vital step to assess the contribution of innovation both on the macro-level and micro-level. The importance of measuring innovation is to understand the problem the innovation metrics should solve, so as to design and implement a suitable innovation measurement framework (Richtner et al., 2017). As indicated by Davila et al. (2012), "Innovation requires measurement and incentives to deliver sustained, high yields." A key to successful innovation is a periodic innovation diagnosis of the overall innovation system in a company or nation to uncover the phases of innovation that requires attention (Manoochehri, 2010; Davila et al., 2012; Kuczmarski, 2001; Edison et al., 2013). The best way to conduct these diagnosis is by measuring the state of innovation in the organization or country. In this study, the innovation measurement is conducted from the standpoint of the micro-level, which without a doubt has an accumulative effect on the macro-level (OECD 1997a; 1997b).

After having highlighted the importance of measuring innovation in the paragraph above, there is an increasing amount of research that stipulates that users (which include individuals or firms), contrary to traditional beliefs, play a vital role in the innovation processes. This new body of knowledge indicates that in the user-oriented innovation approach, users engage in innovation activities due to the unsuitability of commercial products or services to meet their urgent needs. Therefore, users either create a new product or modify a commercial product to meet their urgent needs. Which means in order to appropriately measure innovation, the preliminary step should be to measure user innovation. This is the motive behind this research study. In addition, this study is the first attempt to carry out in-depth measurement of the user innovation activities of an emerging economy. Moreover, this study was conducted using Nigeria as the prefatory case study.

Based on the background knowledge of the author about the implications of inadequate technological or innovation encouraging infrastructure in Nigeria, the study will also, as a prognostic approach, attempt to explore approaches through which user innovation activities

can be adequately cultivated. Therefore, this study sets out to bridge the gap in recognizing the contributions of users in the innovation ecosystem from four different premises:

1. Like existing studies conducted by Flowers et al, (2010) and Mendonca (2009), the first perspective of this study will be to uncover the prevalence and incidence rate of user innovation among the individual consumers. According to literature, lead-users are discovered to engage more in innovation ahead of other users (Schreier & Prügl, 2008; Urban and von Hippel, 1988; von Hippel, 1988; Olson & Bakke, 2001; Herstatt, 1991; Brem & Voigt, 2007; Prügl, 2006); hence playing a key role in the innovation process.
2. The second perspective of the study will be to uncover the prevalence and incidence rate of user innovation among firms in Nigeria. However, in this study, specific focus will be given to the small medium enterprises (SMEs), since it is well documented in literature that SMEs play a critical role in the economic development of a nation (Adelowo et al., 2012; Hall et al., 2009; Etuk et al., 2014; Abubakar et al., 2012; Aina, 2007; Apulu & Ige, 2011).
3. The third perspective on which this study was conducted is to explore the contributions of innovation incubators in the Nigerian Innovation ecosystem. The motive behind this is because Nigeria is known to be plagued with infrastructural deficiencies, and inadequate R&D investment. Therefore, the author concluded that measuring the contribution of the private innovation incubators would be an ideal basis to highlight the significance of providing an adequate innovation encouraging avenue. This will serve as a preamble to the prognostic approach with which this study predicts user innovation activities can be managed.
4. Lastly, the final perspective of this thesis is to provide a prognostic approach through which user innovation can be cultivated.

The structure of this thesis will be presented in the next section.

1.1 Thesis Structure

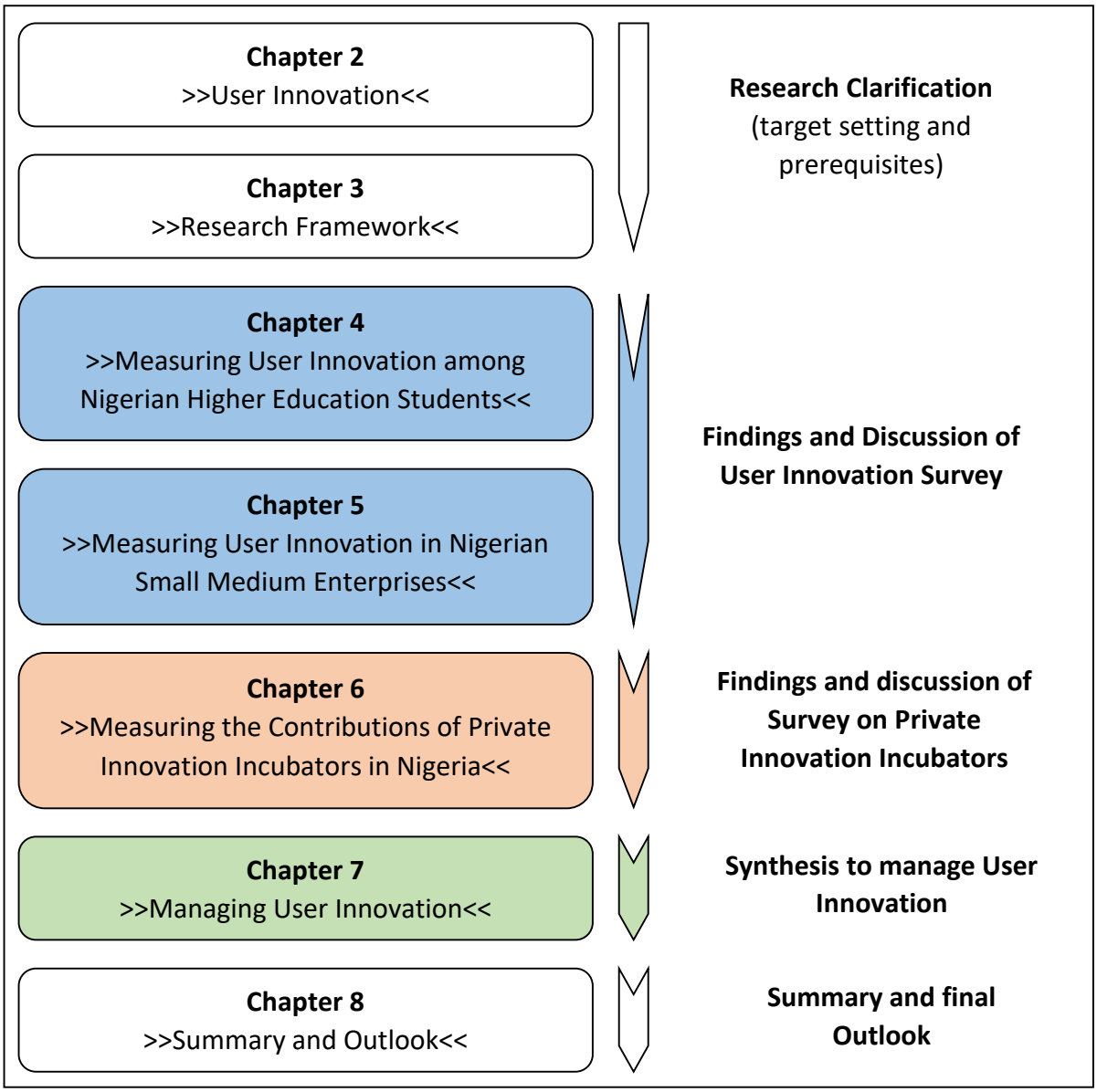

Figure 1-1: Chapter Outline

2 User Innovation

Synopsis

This chapter outlines the theoretical background of user innovation, providing information about the origin of the term and its definitions. In addition, an outline of the Lead-User theory is also stated, while also presenting an illustration of the user innovation model, which is significant in identifying the likely avenues through which the user innovation output can be adequately utilized. In this theoretical background, a critical review of the state of innovation in Nigeria was also highlighted, detailing the state of user innovation in three significant eras in Nigerian history, such as the state of user innovation during pre-colonial Nigeria, colonial Nigeria and post-colonial Nigeria.

2.1 Origin, Terms and Definitions

Though it has been long traditionally assumed that the origin of product innovation can be traced to producers, there is a wealth of literature on the topic of user innovation that reveals that contrary to traditional beliefs, users are the principal driving force of many commercialized products in various industries (von Hippel, 1976; 1979; 1988; 2005; 2009; Raasch et al., 2008; Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b; Foxall, 1986; Rothwell, 1986; Lee, 1996; Füller et al., 2013; Morrison et al., 2000; Franke & Shah 2003; Franke & von Hippel 2003; Lüthje et al., 2005; Shah & Tripsas, 2016; Henkel & von Hippel, 2005). According to von Hippel (2009), the concept of user innovation was first observed by Adam Smith as far back as 1776, where he explored the significance of early machinery inventions that enabled several tasks to be accomplished faster and easier. In his exposition, von Hippel also made the discovery that a significant amount of early manufacturing machines had their origin in the works of the common labour workforce. These labour men were originally employed by the then manufacturers to accomplish specific tasks. Howbeit, in a quest to execute their given routine tasks with greater ease, they invented machineries to perform the assigned tasks. Therefore, the origin of user innovation can be explored from two views: 1. A socially motivated activity where users innovate to solve their immediate need, rather than accomplish enhanced economic value (von Hippel, 2005; 2009; De Jong & von

Hippel 2009a; 2009b), and 2. Economically motivated activity, where users expect a high benefit from their innovative activities (Morrison et al., 2000; Schmookler, 1966; 1972; Shah & Tripsas, 2016).

It is worth highlighting that the concept of user innovation transcends the equipment manufacturing industry; evidences of user innovation were also claimed in some basic consumer products, processes, and services. Lüthje & Herstatt (2004) provided the following anecdotal instances of user innovation in consumer goods (1) 'TipEx', a fast drying white liquid used to correct errors in writing or typing, is claimed to have been invented by a secretary towards the end of the 1950s, (2) 'Gatorade', athletes' energy replenishing drink, is claimed to be developed by the trainer of a college football team. (3) Lastly, other products such as protein shampoos and the baking recipes for ready-mixed cakes are also purported to be first developed by users. From these examples, it is evident that being faced with recurrent and impending needs propelled these users to find innovative ways to solve their problems. The next section presents more detailed information about the user innovation concept.

2.2 Understanding the User Innovation Paradox

It is natural to expect that a sizable percentage of some consumers' needs will be unmet by the 'one size fits all' approach used in mass producing commodities. This approach, which is mostly based on a market push strategy, is a strategy assumed to meet the basic needs of a large segment of a niche-market to stimulate enough interest and generate great profit from the consumers' market, rather than a demand-pull. User Innovation, a ubiquitous innovation, occurs where users, in an attempt to meet their impending or unsolved needs, create a new product or modify existing products with the sole purpose of solving these needs. It is worth buttressing that the term 'users', as referred to in this study, concerns consumers with specific needs and who expect to directly benefit (either socially or economically) from using a product or service they developed (von Hippel, 2005; 2009; Flowers et al, 2010; De Jong & von Hippel, 2009a; 2009b; Gault & von Hippel, 2009). These are otherwise referred to as user innovators, and can be classified into two types: 1. a User firm, or 2. as an individual user (von Hippel, 2005; 2009; Gault, 2012; Flowers et al., 2010).

However, there are slight distinctions between a user firm and an individual user. User firms are firms who develop or modify products or process technologies to serve their urgent in-house needs; thereby improving the efficiency of their production system which could inadvertently result in favourable financial output (De Jong & von Hippel, 2009a; Flowers et al., 2009; 2010; Lee, 1996). On the other hand, individual users create or modify products in order to cater for their unaddressed needs by commercial off-the-shelf products without expecting a financial return from their innovative exploits (De Jong & von Hippel, 2009a; Flowers et al., 2010; von Hippel, 1988; 2005; 2009). However, as will be seen later in this paper, some individual users might identify a prospective opportunity to generate income from their innovative activities. Therefore, seek a commercialization route other than the social route.

In addition, despite the organizational boundaries mostly viewed to exist between users and manufacturers (Block et al. 2016), there is significant amount of literature that proves that these two realms are not entirely disjointed (Schweisfurth & Raasch, 2015; Porter, 1985; Priem et al., 2012; Schumpeter, 1926). This claim is also supported by von Hippel (2009), that a manufacturer, who expects to benefit from the sales of a product or service, could also double as a user innovator. In this case, product manufacturers naturally expect to benefit from the sales of products, but in specific instances, a manufacturer might have to develop some process or products in-house to aid their product development process. In this instance, the manufacturer could be considered both as an individual user or a user firm. Therefore, in light of this discovery, this study considers an interaction between three key players (user, manufacturer, and educational institution) as significant to the concept of user innovation. However, to increase the chances of the success of this interaction, manufacturers are advised not to use a transactional approach that seeks to pick technologies or ideas in order to quickly commercialize them, but to use an inclusive approach that involves all parties from the start to the end of the production system (Dorf et al., 2011; Wright, 2008; Thursby & Thursby, 2004). A schematic representation of the proposed interaction is presented in Figure 2.1 below.

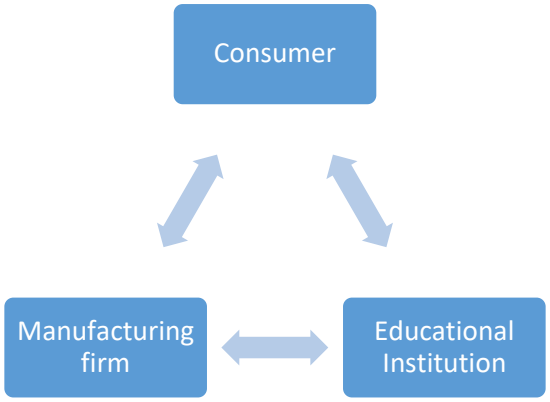

Figure 2-1: User-Manufacturer-Institution Interaction. Source: Author

Figure 2.1 purports that user innovation can be tremendously enhanced by a user-manufacturer-institution interaction. That is, a direct interaction between the production companies, institutions and customers. Since users have been identified as a rich source of innovation for manufacturers, educational institutions, due to their cutting-edge research and technological innovation abilities, are envisioned to have competent users that would be a more unique source of innovation (Flowers et al., 2010; Dorf et al., 2011; Shah & Tripsas, 2016; Branscomb et al., 1999; von Hippel, 1988). A typical example of this situation was presented by Schillings, (2010). In this example, the situation of a company that manufactures a powerful instant adhesive was presented. After several unsuccessful collaborative research attempts to innovate a tissue adhesive, based on the instant adhesive process, to replace surgical applications in a faster and durable manner, the companies shelved the proposed product development process as '*far too risky*' to be accomplished. However, after an unexpected and vital input from an academic professor, the project was successfully accomplished. This particular example buttresses the significance of an interaction between all the players in the user innovation system.

Moreover, the benefit of such interaction between user, producer and educational institution will generate a significant learning opportunity for all parties involved. (Lee, 1996; Teubal, 1979;) These technological learning processes determine modifications and improvements and are a unique source of innovation over a long period of time (Lee, 1996). Several other benefits accrue to the establishment of a mutual and long-term symbiotic relationship among all parties, which results in a unique service response or support for user innovators, as well

as unique reward opportunities for the other parties (Lee, 1996; Patel and Pavitt, 1990; Pavitt, 1988; Pavitt and Patel, 1988).

Lastly, in order to create a stronger interaction between these parties, this study proposes two tested methodologies: (1) the utilization of the lead-user research method which involves a joint product development agreement between the users (lead-users) and manufacturers, and (2) the provision of a user innovation toolkit, which was proposed as a means for manufacturers to satisfy users' heterogeneous needs. These two concepts will be discussed later in this chapter. Having highlighted all these information, the succeeding section will present a more rigorous review of the questions *'What is User Innovation, and who should be considered as a User Innovator?'*

2.2.1 User Innovation defined

Firstly, one point worth highlighting before proceeding is that user innovation is a shift in perception of the significance of users in the innovation process. This is contrary to the traditional perception that mostly considered product manufacturers as the major source of innovation. This shift in perception is invigorated by the technological advancements being experienced presently, especially in 3D printing and other open source technologies. Secondly, user innovation is an adequate means for product and service providers to accurately respond to user needs, thereby maintaining their competitive advantage in the market place (von Hippel & Katz, 2002; Franke & von Hippel, 2003). Since manufacturers have been highlighted by existing studies as the major beneficiary of user innovation attempts (Flowers et al., 2010; von Hippel, 1976; 1988; 2005; 2009; von Hippel & Euchner, 2013; Baldwin et al., 2006; Herstatt & von Hippel, 1992; De Jong & von Hippel, 2009a; 2009b; Bogers et al., 2010), and these studies only defined user innovation without taking cognizance of the significance of manufacturers' contribution to ease the innovation process of users by providing user innovation toolkits as suggested by (Svensson & Hartmann, 2018; von Hippel & Katz, 2002; Franke & von Hippel, 2003), this study therefore defines user innovation as the innovation efforts of users (either intermediate or consumer users) with or without manufacturers' involvement in an attempt to solve their unmet needs. According to Flowers et al. (2009), user innovation can be defined using the following variables:

1) *User Process Innovation:* This refers to the radical or incremental innovation of existing production process (or process technologies) without any intention of commercialization. This type of user innovation is more evident among user firms than individual users.
2) *User Product Innovation:* This refers to the radical or incremental product or service innovation efforts engaged by users for commercialization purpose (Flowers et al., 2009).
3) *User Involvement:* These are firms that engage their users during their user innovation activities.

For the sake of clarity, a more detailed definition of who a user innovator will also be provided below.

2.2.2 Who is a User Innovator?

Users are a rich source of radical innovation which must be involved in the innovation process in order for manufacturers to enhance their innovation capability for radical innovation (Lettl et al., 2006; Chesbrough, 2006). According to Luthje et al., (2002), user innovators mostly rely on their expedient needs and their access to local information (that is, information already available to the innovator or that can be generated locally during the development of the innovation) in order to develop their innovation.

In addition, user innovators have been defined as firms or individual consumers that expect to benefit from using a product or service that was self-developed or self-modified (von Hippel, 2005; 2009; 1988; 1976; Flowers et al., 2010; von Hippel & Jin, 2008). However, these definitions failed to take cognizance of the possibilities that exists when the user attempts to generate financial income for their innovation activities either through licensing or new business venture. As identified by Lettl et al. (2006), Shah & Tripsas (2016), and Block et al. (2016), a user can also play an entrepreneurial role by attempting to commercialize the developed product. Therefore, a user innovator in this study will simply be referred to as a user firm or individual user who radically or incrementally innovate to meet its unsatisfied or

heterogeneous needs, and expects to benefit from their innovation activities. These benefits could be in the form of direct usage or through licensing or new business venture. As would be seen in later section, the user innovator could choose any technology diffusion form based on its objectives.

In addition, there are scores of literature that indicated a variation of users and the roles played by each individual users (Bogers et al., 2010; von Hippel 2005; 2009; Schweisfurth & Raasch, 2015; Morrison et al., 2000; Gault, 2012; Stockstrom et al., 2016). These variations will be explored in the succeeding section.

2.3 Variations and Roles of User Innovators

In furtherance of the work done so far, to concretize the significance of user innovators in the innovation process, it is vital for the variations between the user innovators be explored. This section presents the findings from literature about the types of user innovators, their focus, and contribution to user innovation. From literature, there are two variations of users, which are consumer users and intermediate users (Bogers et al., 2010; von Hippel, 2005; 2009). Intermediate users are firms that uses purchased equipment to produce goods and services, while consumer users are individual users of consumer goods (Bogers et al., 2010; von Hippel, 2005; 2009). In addition, these two variations are referred to above as user firms (intermediate users) and individual users (consumer users).

Moreover, from literatures it was gathered that users play different roles in the innovation process (Bogers et al., 2010; von Hippel 2009; De Jong & von Hippel, 2009a; 2009b; Morrison et al., 2000; Gault, 2012; Stockstrom et al., 2016; Schweisfurth & Raasch, 2015; Urban & von Hippel, 1988; Schillings, 2010; Herstatt & von Hippel, 1992; Block et al., 2016). These roles are: lead-users, users as collaborators, and users as informant to products development. Amongst all these roles, the lead-users have been identified as the major player in the user innovation process (von Hippel, 2005, 2009; Morrison et al., 2000; Gault, 2012; Stockstrom et al., 2016; Schweisfurth & Raasch, 2015; Urban & von Hippel, 1988; Schillings, 2010; Herstatt & von Hippel, 1992).

Lead-users are therefore defined as consumers who experiences a particular need ahead of the general market, and are predicted to disproportionately benefit from the solutions ahead of the general marketplace (Schillings, 2010; Morrison et al., 2000; von Hippel, 1988; Urban & von Hippel, 1988; 2009; De Jong & von Hippel, 2009a; Herstatt & von Hippel, 1992; Olson & Bakke, 2001; 2004; Lilien et al., 2002; Schweisfurth & Raasch, 2015; Herstatt, 1991; Schreier & Prügl, 2008; Lüthje & Herstatt, 2004; Bilgram et al., 2008; Franke et al., 2006; Shah & Tripsas, 2016; Eisenberg, 2011; Marchi et al., 2011). Therefore, based on this definition, it is expected that lead-users will engage more in radical innovation ahead of other users. Hence, a highly rich source of breakthrough innovations.

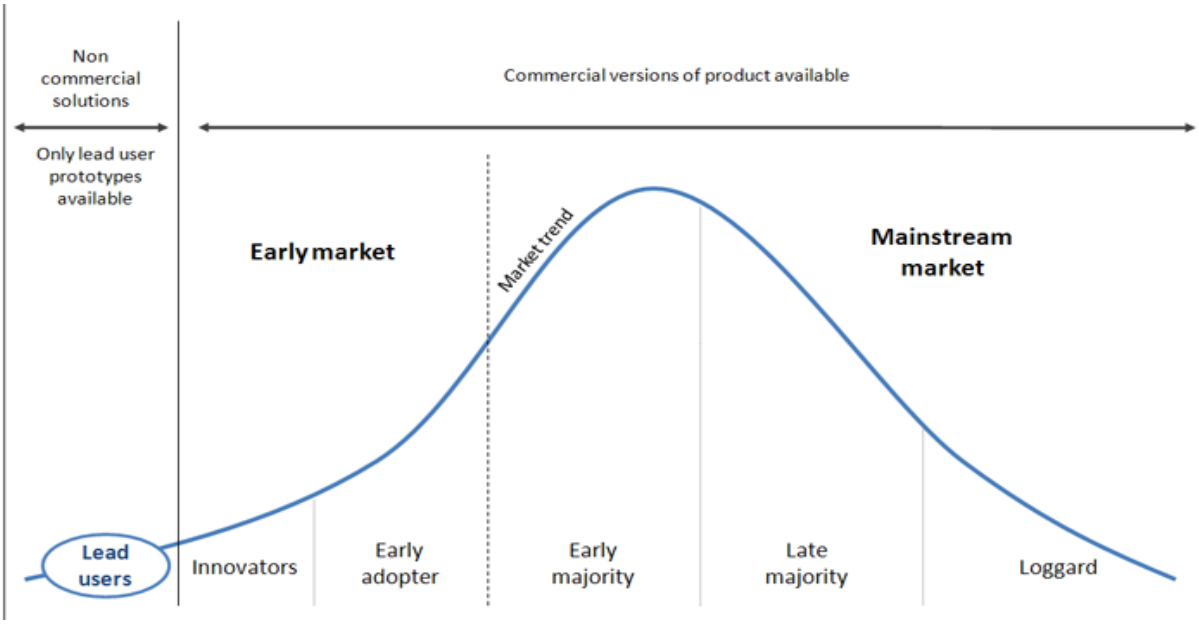

Figure 2-2: Lead User. Source: https://strategies4innovation.wordpress.com/2009/10/29/les-lead-users-quest-ce-que-cest/

In addition, according to literatures product innovation developed by lead-users are often appraised stronger and highly profitable for manufacturers than the ones solely developed by the manufacturers (Shah & Tripsas, 2016; Urban & von Hippel, 1988; von Hippel et al., 1999; von Hippel, 1986; 2005; 2009). Moreover, von Hippel (2009) further hypothesized that '*the higher the intensity of lead-user characteristics portrayed by an innovator, the greater the commercial attractiveness of the product innovation developed by the lead-user*'. Theoretically speaking, this means that the lead-userness of user innovators is proportional to the likelihood of developing a commercially attractive user innovation (Franke et al., 2006; Schreier & Prügl, 2008). A detailed theoretical implication of lead-user will be presented in the following subsection.

2.3.1 The Role of Lead-User

From the preceding section, lead-users were identified as the major key role player in the user innovation process (see figure 2.2). Therefore, it is significant to explore it a little bit further through literature review. One thing clear is that lead-user theory explains in details the significance of lead-user innovation in the innovation process and how they can be harnessed for commercial advantage. The lead-user theory suggests that identified lead-users be firmly integrated into the organizational efforts during new product development (NPD) using the lead-user method that will be highlighted in the succeeding section below (Schreier & Prügl, 2008; Urban and von Hippel, 1988; von Hippel, 1988; Olson & Bakke, 2001; Herstatt, 1991; Brem & Voigt, 2007; Prügl, 2006). During this integration process, the manufacturer elicits information from the lead-user about their needs and possible solutions developed, with the intent of deriving potential products concepts. The derived products are then developed in collaboration with the lead-users.

The lead-user theory is dependent on two components derived from its definition above. The first component is the *high expected benefits* of the lead-user, which was a derivative of the research on the economics of innovation. Moreover, Franke et al., (2006) also hypothesized that the greater the benefit an entity expects to attain from an impending innovation need, the greater the entity's investment in achieving the solution. Therefore, the basic intention of Component 1 is to serve as an indicator of the likelihood of innovation (Franke et al., 2006). The second component is *ahead of the general marketplace* trend because the innovation developed by users residing at a location in a marketplace was envisioned to have a tremendous impact on its commercial attractiveness (Franke et al., 2006; Urban and von Hippel, 1988; von Hippel, 1988). These two components are significant since lead-users has been identified to experience the general needs of the marketplace months or years ahead of the market (Schillings, 2010). Which if properly harnessed, gives the manufacturer a great competitive advantage in the market.

In order for the manufacturers to effectively harness the benefits of the lead-user theory, Herstatt & von Hippel (1991) proposed the lead-user research method which helps

manufacturers to uncover the need and solution information that are significant to develop concepts for new products and services. This research method will be briefly discussed in the following section.

2.3.2 Lead-User Research Method

As indicated in the preceding section, the lead-user research method is a user-centric product concept that assists manufacturers acquire detailed information about the need and solution that will be useful in the development of new concepts for the development of new products and services (Herstatt & vin Hippel, 1991, Eisenberg, 2011; von Hippel et al., 1999; Churchill et al., 2009; Urban & von Hippel, 1988). This research method is conducted in the initial phases of the innovation project so as to identify strong market opportunities as indicated by the lead-users, and it involves four major steps (Herstatt & von Hippel, 1991; Urban & von Hippel, 1988; Eisenberg, 2011; von Hippel et al., 1999; Churchill et al., 2009):

[1]. **Specify Lead-User Indicators**: The indicators to specify the lead-user are based on the following indicators:

   a. Identify the trends and Users' needs: in this phase, the underlying trends on which the lead-users have a leading position must first be specified before the lead-users can be identified. This can be achieved by conducting a survey of experts, that is people with expert knowledge in the field of the target product.
   b. Highlight measures of potential benefits: in order to measure the expected benefits from solving a need, a definition of the variable measure of the 'high expected benefits' must be stated. According to Urban & von Hippel (1988) the following are three measures are suitable for defining the variables of expected benefits. First, the evidence of user product development or product modification. Second, user dissatisfaction with the existing products, processes, or services. Lastly, the speed of adoption of innovations.

[2]. **Identify Lead-User Group**. To identify the lead user group, Urban & von Hippel (1988) suggested the use of a cluster analysis of lead-user indicators to uncover the subgroup of lead-users. While Bilgram et al. (2008), suggested three distinct search criteria.

a. Screening method. This tests any person within the user population for the presence of relevant criteria that pertains to the specific purpose.
b. Pyramiding or networking method. This method is significant in identifying significant numbers of lead-users in analogous markets based on highlighted references from users in the target market. It starts from a small number of users and climbs the pyramid through recommendations.
c. Broadcasting method: in this method, the formulated problem is distributed to a large group of potential lead-users external to the organization's boundary. However, this research method has been identified to be inefficient in identifying lead-users.

[3]. **Generate Product Concept with Lead-Users**: this occurs once the lead-user group has been effectively identified, then the internal workforce of the company establishes a collaborative network with the identified lead-user to develop product concepts valuable to both parties by deriving useful information from lead-users based on their interactive experience with new products concepts of the company's commercial interests (Urban & von Hippel, 1988; Bilgram et al., 2008; Herstatt & von Hippel, 1991). As indicated in the section 2.2 above, in order to increase the chances of success, company are advised to use an inclusive approach instead of a transactional approach.

[4]. **Test Lead-User Product Concept**. Here the elicited product concepts are further elaborated to know whether they will also be valuable to other users in the target market (Urban & von Hippel, 1988; Herstatt & von Hippel, 1991).

Moreover, the lead-user research method has been well explored in Europe (Eisenberg, 2011). Once again, just like the spatial literature that exists on the state of user innovation in emerging economies, little is known about the state and role of the lead-user method in emerging economies. Though it is beyond the objectives of this research study to identify the role of each user in the user innovation process, conducting additional studies into exploring the role of lead-users in emerging economies will be a contribution to the body of knowledge. However, a foreseeable problem with this study is due to the fact that most emerging economies are based on importation of goods and rarely manufacture. Howbeit, in the service industry this might be very significant. But it will still be great to conduct a broad research to

explore the state of lead-userness of the innovators on both service and manufacturing industries.

2.4 What drives Users to Innovate or modify products?

Apart from the novelty and complexities of the users' needs and the dissatisfaction derived from the purchase of an off-shelf product to meet their needs, several other factors serves as a determinant of the reason why users innovate than to purchase.

1. Other reasons why users innovate such as agency costs, that is, costs incurred to ensure that the expectations of the principal are met (von Hippel, 2009; Bogers et al., 2010). In addition, some literatures also revealed that users tend to innovate due to the stickiness of knowledge or information concerning user's needs (Bogers et al. 2010; von Hippel, 1994; Ogawa, 1998).
2. In addition to the factors stated in this section, this study also suggests that some users will innovate due to the suitability or capability of their environment to spur innovation. For example, in the case where a user has the necessary innovation toolkit (von Hippel & Katz, 2002; Franke & von Hippel, 2003) or access to innovation initiatives that provides tools and suitable environment needed for the user innovation activities.
3. Another factor suggested in this thesis is the risk appetite or the risk averseness level of the innovator. As the innovation process is expected to be cost and energy-incursive, some users might be reluctant to expend the necessary commitments needed by the project.
4. As has been adequately highlighted in this chapter, user innovators can proceed to self-commercialize their product innovation. Therefore, another factor that can drive user to innovate is the expected innovation-related benefits, which could be in the form of financial returns or simply in the form of user gaining psychological incentives from the innovation process (Lüthje & Herstatt, 2004; von Hippel, 2009; Bogers et al., 2010), or the direct psychological benefits gained from using the new self-developed or modified product that perfectly meets the users' needs (Schreier & Prügl, 2008; von Hippel, 2005; 2009; Flowers et al., 2010).

5. Lastly, Flowers et al., (2010) also indicated that due to the novelty of the user needs and the insignificant amount of potential market for producers to venture into addressing for such needs. While the exact reason why users modify existing products can be purported to be solely based only on the former reason of an unmet users' need. This will be well detailed in the section that focuses on the user innovation model.

2.5 Benefits of User Innovation

From these numerous literatures, it is obvious that user innovation is quite beneficial to both users, manufacturers, and the global populace as a whole. Some of these benefits are tabulated in Table 2.1 below.

Table 2-1: Benefits of User Innovation

Benefit	Explanation	Reference
User Innovation produces more benefits beyond the capabilities of the user innovator	Depending on the form of user innovation engaged, that is whether creation of new product or modification of existing products, user innovation could provide strings of benefits such as financial incomes through licencing or royalties for the user innovator.	Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b; von Hippel & Finkelstein, 1979; Hyysalo & Usenyuk, 2015; Baldwin & von Hippel, 2011
Information spillovers	By sharing their innovation or modifications with others, this results in product and operational efficiency for the manufacturer, as well as a reduced research and development expenditure	Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b; Chesborough, 2006; Benkler, 2006; Morrison et al., 2000; von Hippel & Finkelstein, 1979
Revenue generation opportunities for user innovators	As will be seen in the proposed UIM users could also patent their products. Therefore, through the license, users can generate sizable income from their innovative activities	Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b; Shah & Tripsas, 2016
Increase in Social Efficiency	By freely diffusing the information about their innovation, user innovation is known to generate significant impact on social welfare	Flowers et al., 2010; von Hippel, 2009; Morrison et al., 2000; Svensson & Hartmann, 2018; Henkel & von Hippel, 2005; von Hippel & Katz, 2002
Enhanced reputation	By freely revealing their products, user innovators ends up well known in a bigger sphere than they would if the product	Flowers et al., 2010; Weber, 2004; Harhoff et al., 2003; Allen, 1983; Lerner & Tirole, 2002; de Jong & von Hippel, 2009a; Benkler, 2006
Increase in product impact or utilization rate	User innovation improves the interaction rate of other users with the product innovation	Flowers et al., 2010; Weber, 2004; Harhoff et al., 2003; Raymond, 2001; Schillings, 2010; De Jong & von Hippel, 2009a; Chesborough, 2006; Fuller et al., 2013
Improved product development	By revealing their product freely elicit reciprocity from other users, thereby enhancing the initial product developed by the user. Also the stickiness of user information could lead to the development of new product offerings.	Flowers et al., 2010; Weber, 2004; Harhoff et al., 2003; Raymond, 1999; Schillings, 2010; De Jong & von Hippel, 2009a; Chesborough, 2006; Benkler, 2006; Fuller et al., 2013
Increased access to valuable feedback	By freely diffusing their innovation, user innovators receives valuable feedback from other users that results into the improvement of the initial product.	de Jong & von Hippel, 2009a; Raymond, 1999; Harhoff et al., 2003; De Jong & von Hippel, 2009; Chesborough, 2006; Benkler, 2006

New business venture	User innovation could lead to the creation of new business enterprises led by the user innovators themselves	Flowers et al., 2010; Schillings, 2010; De Jong & von Hippel, 2009a; Shah & Tripsas, 2016
Low cost and simplicity	Most products created by user innovators have been identified to be affordable, as most are done with frugality omitting the complexities of commercial products	Schillings, 2010; De Jong & von Hippel, 2009a; 2009b; Morrison et al., 2000; von Hippel, 2009; Franke & Shah, 2003; Lakhani & von Hippel, 2003; Slaughter, 1993; Lüthje et al., 2002; Svensson & Hartmann, 2018
Derivation of valuable private benefits	Apart from financial income, other benefits such as sense of accomplishment or sense of ownership are other benefits that could emanate from user innovation.	De Jong & von Hippel, 2009a; Teece, 1986; Lakhani & Wolf, 2005; Baldwin & Clark, 2006

Source: Compiled by Author

2.6 Chronological Instances of User innovated products

The concept of user innovation was first observed in the technology manufacturing field in 1776. The earliest instance was explored and identified during the earliest development of lathe and milling machines in the US machine tool industry (Rosenberg, 1976; von Hippel, 2009). However, these earlier studies did not take cognizance of the role of individual users, hence, only focused on the role of user firms. The earliest instances of cases where individual users innovated machining tools that were later commercialized are indicated in gun manufacturing, textile manufacturing and fabric sewing machine manufacturing industries (von Hippel, 2005; 2009). In addition, Schillings, (2010), noted another significant instance of innovation by users, with the example of the small Laser sailboat, which was developed by three former Olympic sailors in 1970s. Laser sailboat was developed due to their need for a boat that provides easy transportability, affordability, durability, simplicity, high performance. More quantitative references of the chronological cases of user innovation were further explored, this cases are presented as thus.

- Enos (1962) indicated that majority of the technologies used in the oil refining field were first conceived and developed by user firms (von Hippel, 2005; 2009; Bogers et al., 2010).
- Hollander (1965) identified instances of user innovation in the chemical industry (Bogers et al., 2010).
- Freeman (1968) discovered that machineries used in chemical production processes were mostly developed by user firms (von Hippel, 2005; 2009 Bogers et al., 2010).

- Von Hippel & Finkelstein (1979) identified some instances of user innovation in the medical equipment field
- Pavitt (1984) identified that a significant amount of invention by British firms were developed in-house by user innovators.
- Foxall & Tierney (1984) identified an instance in the industrial machinery production (Bogers et al., 2010).
- Voss (1985) identified instances of user innovation in application software development (Bogers et al., 2010).
- Von Hippel (1988) also identified that 80 percent of most scientific instruments and 67% innovations in semiconductor processing resulted as the exploits from users (von Hippel, 2005; 2009).
- Urban & von Hippel (1988) identified instances of user innovation in the Printed circuit CAD Software field
- Herstatt & von Hippel (1992) identified instances of user innovation in Pipe Hanger hardware
- Ogawa (1998) discovered instances of user innovation in the technologies used in convenience stores (Bogers et al., 2010).
- Arundel & Sonntag (1999) also identified that twenty-six advanced manufacturing technologies used in Canadian manufacturing plants are instances of the exploits of user innovators.
- Shah (2000) also discovered that most commercialized equipment innovation in at least four sporting fields were developed by individual users (von Hippel, 2005; 2009; Shah & Tripsas, 2016). Some of these product inventions were identified as modifications made by users (Fisher, 2009; Franke et al. 2006; von Hippel, 2005; Baldwin et al., 2006; Fuller et al., 2007; Shah, 2005; Bogers et al., 2010).
- Morrison, Roberts, and von Hippel (2000) identified an instance of 26% user innovation in the Online Public Access Catalog (OPAC) library information systems, in this case, significant modifications were made on the library information systems.
- Lüthje (2003) also identified instances of user innovation in the Medical surgery equipment field (Bogers et al., 2010).

- Franke & von Hippel (2003) identified an instance of user innovation in the development of the Apache security software (Bogers et al., 2010; von Hippel & Jin, 2008).
- Oliveira & von Hippel (2009) discovered instances of user innovation in the commercial banking sector (Bogers et al., 2010).

In addition to the instances highlighted above, it has also been discovered that user innovated products are often of a high quality orientation (von Hippel & Jin, 2008). This will be explored by presenting a case study of a popular instance that signifies the contribution of user innovation.

2.6.1 Instance of User Innovation today: A Case Study of RepRap 3D printer

In this present age, a typical example of the contribution of users' innovative activities can be well observed in 3D printing technology (Rayna et al., 2015), which up until early 2000 was very expensive for an average user and still very much controlled by producer firms. However, in 2005, Adrian Bowyer, a university professor at Bath University in the United Kingdom after identifying an unmet need for a low-cost and small-scale fused deposition machine (FDM) 3D printer incrementally innovated a self-reproducible open source 3D printer called *'RepRap'* which stands for Replicating Rapid-prototyper (Jones et al., 2011; Sells et al., 2010; Bradshaw et al., 2010; Pearce et al., 2010). After the development of this machine, just as claimed by existing literatures that user innovator prefers to share their innovation-related information freely, the development blueprint of RepRap was freely diffused online under the GNU General Public Licence, which revolutionized the 3D printing world and led to the sporadic growth of desktop 3D printing technologies, as well as the spin-off of other low-cost or self-assembled or self-developed 3D printers such as Makerbot, Ultimakers, Tarantula, Hangprinter and other variations among others.

The social welfare impact of RepRap was highlighted with respect to reusing waste polymers to fabricate feedstock from waste plastic which was identified to possess both economic and environmental impact (Zhong & Pearce, 2018), recycling of waste plastic as filaments for RepRap (Braanker et al., 2010; Petersen et al., 2017; Baechler et al., 2013; Pearce et al., 2010;

Kreiger & Pearce, 2013). In addition, Kreiger & Pearce (2013) conducted a comparative study of the environmental impact of RepRap to industrial 3D printers by comparing the embodied energy and emissions. Their findings revealed that RepRap has a lower environmental impact than the industrial 3D printers. This instance also confirms the User-Manufacturer-Institution interaction proposed in section 2.2 above.

2.7 Diffusion of User Innovation

Gault, (2012), in his report indicated that according to the OSLO manual, for any innovation to be considered as a user innovation, there must have a direct link to the market. Which is true in its due sense, based on the usage of the word innovation, an invention that has generated an economic value in the marketplace (Dorf et al., 2011; Füller et al., 2013; Roberts, 2007; McGourty et al., 1996; Hansen & Wakonen, 1997; NACETEM, 2010a), rather than invention. In addition, majority of the literature on this subject matter revealed that most user innovators tend to share their product or process innovation with other users without expecting any financial returns for their innovative activities instead of protecting them (Shah & Tripsas, 2016, von Hippel, 1988; 2005; 2009; Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b). In addition, Flowers et al., (2010), reported that 25% of user firms in the UK shared their process innovations with manufacturers and other users without charging the recipients. Which means that the free peer-to-peer sharing of information in itself is a good means of diffusing the innovation to the market (Füller et al., 2013).

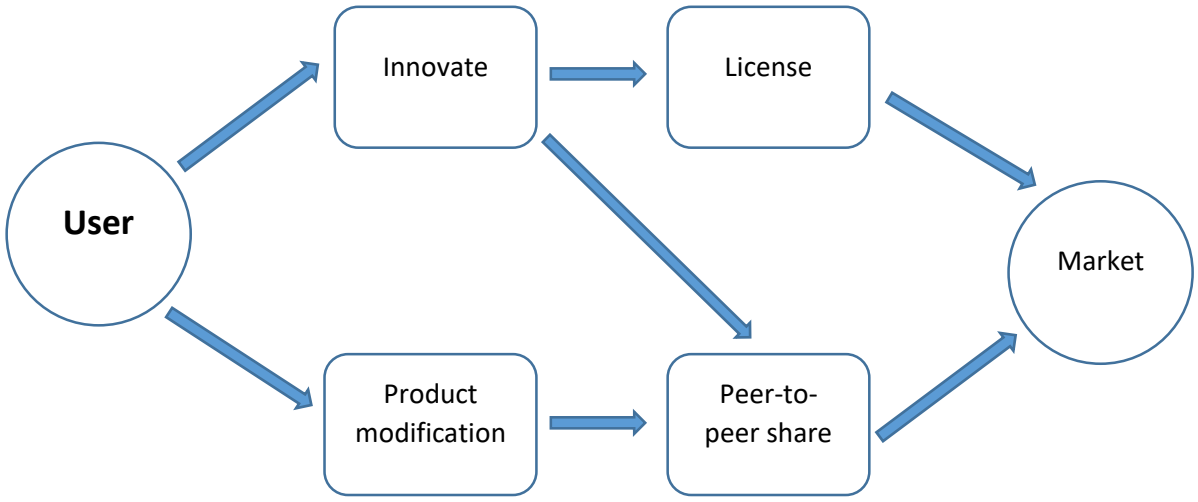

Figure 2-3: Diffusion of User Innovation. Source: Author

However, despite these well-established claims of a free peer-to-peer diffusion of innovation, Morrision et al., (2000) identified the existence of an 'informal information trading' between user innovators, even among direct rivals. This informal information trade is said to be important if the information received has a positive profit association to both parties (Morrision et al., 2000). This indirectly points to the possibilities of user innovators making direct profits from their innovation expeditions. Moreover, some research studies also indicated some instances where user innovators in the medical equipment, stereo components, ice harvesting products, and some sporting equipment commercialized their inventions by establishing a new business venture to capture the economic value from their inventions rather than share it freely with others (Shah & Tripsas, 2016; Langlois & Robinson, 1992; Utterback, 1994; Shah, 2005; Haefliger et al., 2010; Winston Smith & Shah, 2011; Lettl et al., 2006). In theory, this shows that whatever is expected to happen to an average innovation expeditions engaged by producers, can also be applied on user innovation. However, most choose to share than commercialize. All these factors were thoroughly considered and represented in Figure 2.3.

In the figure above represents the diffusion method of user innovation to the market. Depending on the severity of the users' needs, a user can either initiate NPD or modify an off-the-shelf product. When a user initiate NPD, then there are two possible routes to the market for the user innovator. 1. To protect the innovation through IPR and copyright, and sell the license to manufacturers, or 2. To share the innovation with other users or manufacturers without any financial expectations. While, due to the protective mechanisms that is assumed to exist on the off-the-shelf products, the only possible route for modified product to the market is by freely revealing the innovation to other users or manufacturers. This user innovation diffusion method will be further invigorated in the proposed User Innovation Model (UIM) that will be presented in the later section.

2.8 Why do they freely reveal their innovations?

Several factors encourage users to freely share their innovation with others and manufacturers, some of which includes:

- The orientation of the user towards enhancing social efficiency (Flowers et al., 2010; von Hippel 1988; 2005; 2009; Henkel & von Hippel, 2005). A typical example is the surge in open source innovation. There are lots of user innovators who after experiencing a problem, decided to solve and also freely reveal it to other interested users on open source platforms such as github, instructables, thingiverse, yeggi, openbuilds etc. For example, the case of Torbjörn Ludvigsen, who observed the need for a frameless and unrestricted 3D printer designed the Hangprinter, a self-reproducible 3D printer hanging from the ceiling, and shared the new design with the global space. Out of which several variations and improvements have been made by other developers all over the world.
- Users might freely reveal their innovation due to the difficulty in obtaining an effective intellectual property protection. This has been identified as weak in most fields with the exception of the pharmaceutical and chemical field (Lüthje et al, 2002), as well as costly with uncertain outcomes (Harhoff et al, 2002; Lüthje et al, 2002). Henkel & von Hippel (2005) makes a related point that an increase tendency towards a stronger intellectual property protection will have a negative effect on user innovation activities. However, due to the debility of these studies, which were conducted more than a decade ago, it is relevant for new research studies to be conducted to ascertain the validity of these claims.
- Users might also freely reveal their invention if the envisioned returns of commercializing the invention does not fall within the acceptable profit margin of both users and manufacturers (Shah & Tripsas, 2016; Franke & von Hippel, 2003; Lüthje et al, 2002). For example, an incremental user innovation with a relative small value compared to the overall value of the existing product might not provide an acceptable profit margin for both users and manufacturers to venture into introducing it to the market (Shah & Tripsas, 2016).
- In addition, complexities in achieving safety certification of their innovation might force user innovators to freely reveal their inventions. For example, LaserDuo, the biggest known open source laser cutter in the world, during an internship program at OpenLab Hamburg encountered a major complication with the aforementioned reason. After an intense one-month internship effort to replicate the machine at the OpenLab Hamburg facility, failed to pass the safety standard in place at the OpenLab

Hamburg facility. Hence, the machine is not permitted for public usage, and usage by laboratory members had to be done with lots of safety gears in place. From observation, it was elicited that this complexity could specifically lure the inventor to freely reveal their invention to other users willing to take the risk and thereby perfect the product.

2.9 User Innovation Model (UIM)

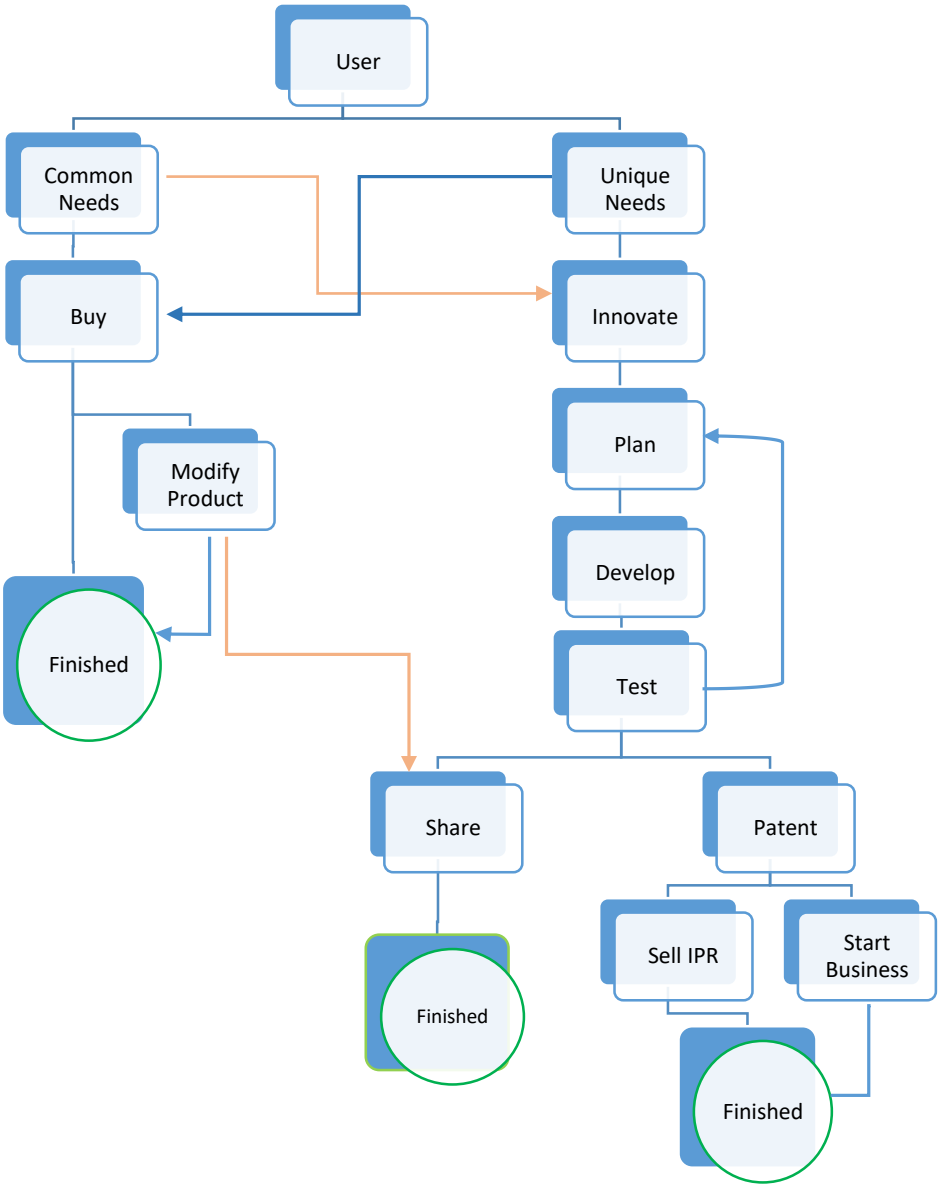

Figure 2-4: User Innovation Model. Source: Author

As long as there are unsatisfied users' needs or users with unique needs, user innovation (UI) will continue to be in existence. However, what cannot be assured is whether most User

innovator would share their products or not. It is worth emphasizing that this model assumed that the user has enough skills and experience in developing or modifying the product. From existing research, von Hippel (2005) proposed a user innovation model which is based on the user's decision to either 'Innovate or Buy'. In this model he stated that '*users with unique needs are better of innovating than buying a product*'. He further stated that some '*users may decide to innovate irrespective whether their needs are common or unique, rather than buy an existing solution'*. This factors were put into consideration and depicted in Figure 2.4. In the UI model below, a differentiation is made between the Unique needs and Common needs. Unique needs are users' needs that can only be solved by User-centric Innovation Model (UCIM) rather than the Traditional Manufacturer-centric Model (TMCM). While Common needs are users' needs that can be solved by the UCIM and /or TMCM depending on the user's approach. TMCM is a model where products and services are developed by manufacturers in a closed way using several protective means such as patents, copyrights, trade secrets, which prevent imitators from having a free ride on their innovation (von Hippel, 2009). While UCIM is a model where products and services are developed by users or in collaboration with users or by simply using users as sources of information for development (Gault, 2012; Stockstrom et al., 2016; Schweisfurth & Raasch, 2015).

The model is based on some decisions made by the consumer at specific milestones on their common need or Unique need. As depicted in the Figure 2.4, a user with a particular need decides on the criticality of the need, and makes a decision whether to buy or to innovate. The decision to buy or innovate can be taken at any point when analysing the type of needs. After the decision has been made, for example, if an innovate decision was made, the user then begins with a plan on how to accomplish the objectives. As indicated in the findings of von Hippel & Katz (2002), it is very vital for user innovation toolkits enable users to fully utilize the complete trial-and-error cycles when creating their designs. Based on this finding, the next step proposed in UIM is the development process which will encompass both the conceptual design and prototyping phase of the innovation process. After which the user conducts a test on the product to assess whether it meets their expectations, if the design fails to meet the user's expectation, he or she can refer back to the planning phase to modify the conceptual design, then proceed with the process. At the end, after the user is satisfied with product

developed, the user can now decide whether to reveal the product freely with others or to patent the product.

Therefore, if a patent decision was made, the user after filing the IPR, could decide to start a new business from the product or simply sell the IPR to a producer that has enough capabilities to mass produce the product (Shah & Tripsas, 2016; Flowers et al., 2010; Hienerth, 2006). However, user entrepreneurs, according to literatures are highlighted to face low opportunity costs, thereby exhibiting characters such as high risk taking, willingness to experiment, and a high potential to explore commercial opportunities (Haefliger et al., 2010; Shah & Tripsas, 2016). Shah & Tripsas, (2016) predicted several situations where some users might prefer to sell their licenses to manufacturer or even become a User Entrepreneur. These are,

1. Situations where the user's projected a negative profit margin, but the manufacturer's estimated a positive margin from the user innovation. A probable reason for this differential estimation in profit margins might be due to entry barriers such as large start-up costs, difficulty in gaining access to suppliers or distributors, negative innovation politics, stringent government regulations, brand loyalty, insufficient human capitals, export-oriented traditional monopolistic industries, and many more. So in this situation, it might be useful for the user to rather sell its license to a well-established manufacturer with enough capabilities to compete in the niche market.
2. Situations where both user and manufacturer projected a positive profit margin, however due to its already established status in the niche market, the manufacturer envisions a better financial returns than the that expected by the user. In this situation, the user innovation could reach a wider number of consumers as well as achieve a higher profit margin better than that of the user entrepreneur. Therefore, the user might prefer to license the innovation rather that enter the market.
3. Situations where the user, after identifying a positive profit margin and potential opportunities in the untapped niche market, doggedly enters the market irrespective of the entry barriers. Haefliger et al., (2010) buttressed this fact by indicating that user entrepreneurs have an advantage over manufacturers, because of their embeddedness in a community of users with similar needs, who play a key role by

providing early access to vital feedback and relevant information to aid a positive commercialization process.

4. In addition, just like the third point above, a user might choose to commercialize its innovation if the manufacturer estimated the potential opportunity and hence the value of licensing the innovation lower than the expected value of the user. In this situation, a user might find it more attractive to take the product to the market itself than going through the manufacturer.
5. Lastly, in this study, in the case of user firms, a user might choose to commercialize its innovation so as to maintain a good competitive advantage in the market.

Moreover, if a 'Buy' decision was made, upon the purchase of the product, the user verifies whether his or her need was met by the product. If not, then the user can either modify the product to suit their needs, after which the product can either be shared with others or just kept for the users use only. Considering the claim by Gault, (2012), to be considered as UI, the innovation must have a connection to the market. With respect to this claim, the UIM covers that by providing two extra steps after the patent phase, by creating two extra links one which leads to the user innovator starting a business venture from their invention, or selling the IPR to producers for an agreed amount. However, when a modification is made on existing product, to avoid a breach of IPR, we foresee no direct link to the market by the consumer, other than for them to reveal it openly, except permitted by the producer (Fisher, 2009). Despite the highlighted limitations with the 'Buy' option, the potentials of UI are a testament to the significance of UI on an economic scale, thereby confirming the findings from existing research on the subject. Later in the studies, this model will be further tested some of the objectives of this research studies.

2.10 Factors that could enhance user Innovation in the present age

If user innovations were able to thrive for decades, with limited technological capabilities as compared to today, even before the subject became popular. How much more now considering the following factors: the improved technological abilities of users, the improved technological capabilities of firms big and small, the availability of affordable developmental component most importantly the Chinese cheap production model, the evolution and

embeddedness of digital fabrication platforms with strong community empowerment initiatives such as FabLabs, Makerspaces, hackerspaces, Repair cafes, Techshops etc. in addition, this study also posits that the formalization of more open source platforms such as Github, Instructables, Hackster.io, Thingiverse, Openbuilds, among others will contribute more to the enhancement of the user innovation paradigm. In that these platforms promotes effective collaborations where user innovators can freely share their product or process inventions, get feedback and also learn about other project important to each user. How much more now that major industrial giants are showing support and embracing the open innovation models, for example, Autodesk and 3D Systems released some of their computer-aided design (CAD) software for free for beginners and intermediate users.

All these claims were confirmed by that the steady improvement experienced in user innovation is due to the improving technological intelligence and design capabilities of users, and also through the improving competence of users to pool and correlate their innovation-related efforts through the Internet (Flowers et al., 2010; Rayna et al., 2015). Therefore, this section will look at some other factors that could further enhance the user innovation process. However, it is worth knowing that most of these factors are reliant on the involvement of government and other policy makers.

1. Increase governmental support by reviewing the intellectual property right (IPR) laws so as to normalize the playing field for both user innovators and producer innovators alike, improving user innovation measurement, and by improving infrastructural facilities to reduce the cost of collaborative user innovation (von Hippel & Jin, 2008; von Hippel, 2005). This is vital as intellectual property rights has been identified as a major inhibitor of innovation, how much more user innovation (Henkel & von Hippel, 2005; von Hippel, 2005; Strandburg, 2008; Gangopadhyay & Mondal, 2012; Brüggemann et al., 2016; Fan et al., 2013; Chesbrough, 2003). Baldwin & von Hippel, (2011) claimed that government policies tend to focus and favour producer firms, due to traditional belief that producer firms are the progenitor of most innovation. However, existing literature highlighted in this study has proven this claim to be erroneous. In addition, Sweet & Maggio (2015) also highlighted that only developed countries with an above–average measures of development reap the dividend of IPR. Therefore, for user innovation to be further

enhanced, it is vital for existing governmental policies to be reviewed, and measures that encourages innovation should be implemented, especially in the context of a developing country.

2. As indicated by von Hippel (2005), for user innovation to thrive, controls placed over distribution channels that could be used by user innovators willing to freely share their innovation-related information should be removed or lightened.
3. As stated in the first point, existing government policies are only favourable to manufacturing firms. In addition, it has also been recorded in many countries that most producers receive direct benefits from government for their innovative activities through R&D subsidies and tax credits (von Hippel, 2005). Therefore, the innovative activities done by users should also receive some sort of rewards, since their efforts has a direct impact on the social welfare of the economy.
4. Support from private organizations that benefit directly from the users' innovation activities in the form of donations, subsidies, remuneration and recognition for every valuable information gathered from the lead-users, and provision of more innovation toolkits.
5. In the quest to strengthen their user innovative capacities, hence ensure sustainability, emerging economies can no longer rely solely on the acquisition of foreign technologies and R&D (Kim & Jung 1998, Desai et al 2002). Therefore, it is pertinent to have in place an initiation of governmental policies that advances indigenous knowledge and technologies, supports innovative efforts of local user innovators, as well as reduce the overreliance on exogenous technologies that makes it too difficult for endogenous technology to compete in their local market.

2.11 How to Measure User Innovation?

The concept of user innovation can be explored from the context of user firms and individual user. From online search, it was discovered that only 5 attempts have been made to measure the incidence rate of user innovation, and all these studies were conducted on the developed country and majority of the study was conducted from Europe's context. This section lists the metrics from these existing literature that should be considered when conducting a study to measure user innovation. These metrics are tabulated in Table 2.2.

Table 2-2: Metric of User Innovation

Existing Literature	Focus (User or Individual firms)	Modification	NPD	Source of funds	Innovation expenditure	Firm size	Gender	Age	Qualification	Collaboration	Information Sharing	IPR	Support from Government	Business creation	Adoption	Compensation
Flower et al., 2009	User firms	X	X			X				X	X	X	X			
De Jong and von Hippel 2009a	User firms	X	X		X	X		X		X	X				X	X
Schaan 2010	User firms	X	X	X	X					X	X	X				
Flowers et al 2010	User firms and Individual users	X	X		X	X	X	X	X	X	X	X			X	
Mendonca 2012	Individual users	X	X	X	X		X		X	X	X	X		X	X	

Source: compiled by Author

- Flowers et al., (2009) measured user innovation in European user firms by focusing on the prevalence of user process innovator (a firm that has introduced new or improved processes either through customization of processes developed by other companies or individuals), user product modifier (a firm that has improved products for its customers through customization of processes developed by other companies or individuals) and user involver (a firm that has participated in online discussion forums, freely revealed products or services to other users, and involves users in its in-house innovation activities).
- De Jong and von Hippel (2009a) conducted a study to measure user innovation in the Netherlands by focusing on the type of user innovation, firm size collaboration with producer or user, innovation expenditure, willingness to share, application of IPR, adoption of innovation, compensation received from adopter.
- Schaan (2010) measured user innovation in Canadian user firms by focusing on the technology acquisition or adoption methods, to discover whether they have modified existing technologies or developed a novel technology, sources of funds, whether they have collaborated with other firms and types of cooperation, whether they have shared their innovation with others, adoption of their innovation process, application of IPR

- Flowers et al., (2010) while measuring the incidence of user innovation in both the UK user firms and individual users, focused on the types of user innovation, the collaborative activities between the firm and the user and inter-firm collaboration, as well as the innovation expenditure, the application of IPR, the willingness to share their innovation, the adoption of the innovation by other users, the gender of the individual users, their age, and the firm size.
- Mendonca (2012) measured user innovation in Portugal by focusing on the incidence rate of user innovator among highly-educated individual users, using factors such as the types of innovation, gender, sources of funds, collaboration with others, application of IPR, successful implementation of the innovation, and business creation after the innovation process.

From Table 2.2, it is evident that irrespective of the focus of the study on measuring user innovation, the types of user innovation, that is whether they modified existing product or developed a new product, the collaboration activities between the users and the firm and the inter-firm activities are the most used metrics. Moreover, with regards to the metrics used in measuring the prevalence of user innovation by user firms, from the table above it can be observed that, coupled with the information divulged earlier, other critical factors to consider are the innovation expenditure, firm size and the application of IPR. While in the measurement of individual user innovation, the other important factors to consider are innovation expenditure, gender, qualification, application of IPR, and the adoption rate of the innovation. To know the state of user innovation in Nigeria, which has been predicted to be minimal due to inadequate innovation encouraging infrastructures and support, it is vital to first explore the innovative activities employed in the country, as well as the basic factors that limits the surge of innovation in Nigeria. This will be presented in the succeeding section.

2.12 Creativity and Innovation in Nigeria

Through in-depth literature review, this thesis has laid adequate emphasis on the significance of user innovation to the advancement of any economy. However, since the major objective of this research is to quantify the prevalence rate of user innovation in emerging economies, by using Nigeria has the basis for this ground-breaking study, it is highly important to first

uncover the level of creativity and innovation in Nigeria before delving into the objectives of the research project.

Radwan & Pellegrini (2010) based on Michael Porter's stages of national competitive development, claimed that Nigeria is at the factor-driven stage of development, which tend to rely solely on their possession of natural resources and unskilled labour in an attempt to advance to the investment-driven stage which focuses on the transference of technology and investment in human and physical capital, hence preparing them for the next innovation stage. However, it is envisioned in this thesis that Nigeria's stance as the strongest economy in Africa should one way or the other have a positive effect in advancing Nigeria up the stage of development. Therefore, through literature review, this research work will attempt to provide some summaries with respect to the state of innovation in Nigeria.

Moreover, exploring Nigeria's present innovativeness without looking at the ancient indigenous level of creativity will only but produce a one-sided or incomplete information. As indicated by NACETEM (2010a), to combat the sustainability problems ravaging the African continent, both past and present governments have attempted the utilization of ranges of foreign (exogenous) technologies which spans from agriculture and food processing to mining and industrial facilities to communication and transportation to name a few. However, these efforts have not yielded the overall expected results in terms of achieving the required balance between social and economic development, and the cultural and ecological integration of the expected developments. This is mostly due to the fact that indigenous technology development has been wrongfully affirmed as a regressive paradigm shift, rather than progressive. Hence, the inadequate focus on the significance of indigenous technology resulted in the government's inability to accomplish their envisioned sustainability. Therefore, this subsection will be providing retrospective and current glimpses of the state of innovation in Nigeria.

2.12.1 Innovation in Pre-Colonial Nigeria

If the latent state of technological development in Nigeria is the only determinant of the innovative activities engaged by Nigerians, one would easily conclude that innovation and its

related activities was introduced to Nigeria by the colonial invaders. However, there are evidences that reveals that innovation however minuscule was not new in ancient Nigeria. This is evident in the ancient monumental architectural designs and artefacts used in pre-colonial era. Uwaifo & Uddin (2009) asserted that before the advent of colonialism, local artisans in pre-colonial Nigeria were involved in many aspects of industrial and practical arts. Examples were drawn from the local technologies utilized in making intricate farming apparatus and weapons. Another typical example of such ancient indigenous innovative activities is the Iron mining and smelting processes used by the ancient Nok culture in northern Nigeria which dates as far back as 500BC (Yusuf, 2012; Onipede, 2010; Olaoye, 1992). It is worth emphasizing that the term process as used here also covers the indigenous technologies used in the ancient innovation process. Other examples include:

- Ancient textile manufacturing process used in pre-colonial Nigeria, which includes weaving, spinning and dyeing, ginning and carding process (Onipede, 2010; Onimode, 1982; NACETEM, 2010a).
- Leather tanning process in Northern Nigeria (NACETEM, 2010a)
- Bronze smelting and casting process in ancient Benin
- Clay pot production process (NACETEM, 2010a).
- Iron mining in old Oyo empire (Onipede, 2010; Stride & Ifeka, 1975)
- Ancient carving and art decorative process
- Ancient iron smelting and smithing process (Yusuf, 2012; Onipede, 2010; Olaoye, 1992; Aliyu et al., 2008; Jaggar, 1973; Okafor, 1997; Anozie, 1979).

2.12.2 State of Innovation in Colonial occupied Nigeria

In as much as the introduction of exogenous technologies in the colonial occupied Nigeria, should not be asserted as the sole factor responsible for the latent technology development. There are evidences that reveals that the introduction of exogenous technologies by the colonial masters stultified the indigenous innovative activities in Nigeria (Akaninwor, 2008; Onipede, 2010; NACETEM, 2010a; Uwaifo & Uddin, 2009; Yusuf, 2012; Lloyd, 1953; Mukhtar, 1990). In addition, in order to protect their interest, the colonial invaders were reported to use sanctimonious prohibitions, persecutions and other policies to discourage local artisans

from advancing their product development processes (Akaninwor, 2008; Yusuf, 2012; Aliyu et al., 2008; Cline-Cole, 1994; Jaggar, 1973, Emeagwali, 1997), which could have tremendously benefited from the available knowledge and intercourse with the colonial invaders. Other perpetration on the indigenous innovative activities in colonial occupied Nigeria was recorded in the theft of ancient artefacts such as the Benin bronzes and ivories, Ife sculptures (Uwaifo & Uddin, 2009; Kiwara-Wilson, 2012). Without doubt, these attempts had a devastating effect on the technological advancement of the then and current Nigeria, in that it abruptly terminated the transcendental transference of essential indigenous knowledge pertaining to the Nigerian culture which could be beneficial in promoting a sustainable economic and environment culture.

2.12.3 State of Innovation in Post-Colonial Nigeria

In post-colonial Nigeria, due to over-reliance on foreign technologies which is still very predominant today, NACETEM (2010a) uncovered the existence of what was termed the 'massive importation syndrome', which resulted in a general sense of inferiority in the local artisans' community where foreign technologies are seen to be superior. Therefore, propagating negative ideas about indigenous technologies, hence the country's inability to achieve sustainability. In addition, local artisans are marginalised during policy formulation and implementation processes which leads more to the degeneration of indigenous technologies (NACETEM, 2010a; Uwaifo & Uddin, 2010).

For example, Yusuf (2012) asserted that restrictions on the importation of metals in early post-colonial Nigeria resulted in growth in the local blacksmithing craft as well as the advancement in technological innovation through the introduction of coldsmithing. Yusuf (2012) also identified that the oversaturation of foreign goods in colonial occupied and early post-colonial Nigeria also created an opportunity for local blacksmiths and artisans to provide cheaper products to users through the imitation of foreign products. However, this ventures were also inhibited by the unavailability of local resources. The next section provides information about Nigeria's innovation system, by providing a 10-year review of the country's stance on two key global innovation indicators, that is the global innovation index and the world competitiveness report.

2.12.4 National Innovation System: 10 Year Review of the Global Innovation Index

In this third industrial revolution era, there is no better roadmap to competitiveness, growth, sustainable development, infrastructural development, social welfare and economic opulence like innovation. In a bid to manage the technological innovation process Chris Freeman (1987), Giovanni Dosi et al. (1988), and Bengt Ake Lundvall (1992) initiated in the late 1980s the National Innovation System (NIS) as a global metric used to assess the innovation performance of a country. NIS is defined as a set of procedures and processes that determines how information, knowledge and new technologies are created, acquired, diffused and utilized with individuals and distinct institutions (Oyewale, 2010; Radwan & Pellegrini, 2010; Kayal, 2008; OECD, 1997a; 1999; 2002; Freeman, 1987; 1995; Dosi et al., 1988; Lundvall, 1992; Godin, 2009; Nelson, 1993; Metcalfe, 1995; Lalkaka, 2002a). Therefore, in order for an economy to effectively benefit from its innovative performance, there must be synergy between all the elements of NIS, such as firms, research institutions, universities and the social institutions such as values, norms, materials, money, and legal frameworks (Smith, 1997; Oyewale, 2010; Groenewegen & Van der Steen, 2006; Freeman, 1987; 1995; Dosi et al., 1988; Lundvall, 1992; Godin, 2009; Nelson, 1993). This synergy represents collaboration, information/knowledge exchange, materials/equipment sharing and finance among the Education and Research institutions, Industrial Production, Finance, and Public Policy and Regulation Elements.

The benefits of the NIS according to Edquist (2006), includes, NIS places innovation and learning processes at the center of focus; NIS adopts a holistic and interdisciplinary perspective; NIS employs historical and evolutionary perspectives; NIS emphasizes interdependence and non-linearity; NIS encompass both product and process innovations and their subcategories; lastly, NIS lays more emphasis on the role of institutions as one of the key determinants of innovation.

2.12.4.1 Global Innovation Index: 10-Year review of Nigeria

To better understand the state of Nigeria's innovation system, a review of the country's trend on the GII will be presented in this thesis. The Global Innovation Index (GII), first developed in

2007, aims to illustrate the degree of a nation's response-readiness to the challenge of innovation Dutta & Caulkin (2007), by measuring the innovation capabilities and output of individual nation based on the evaluation of two sub-indices which are: The Innovation Input Sub-Index (IIS-I); and the Innovation Output Sub-Index (IOS-I). the average of the IIS-I and IOS-I are then used to derive each country's overall GII score, which is then used to show the innovative performance of the country for the particular year in study. These sub-indices are constructed around seven key pillars, five of which are used to capture the activities that enable innovation in the national economy, these are mainly used to measure the IIS-I. While the remaining two pillars are used to capture the actual evidence of innovation output, and are used to measure the IOS-I. From these values will the innovation score which determines the innovativeness of the country for the year in review be calculated. The Five IIS-I pillars are: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication. Lastly, the two IOS-I pillars are: (6) Knowledge and technology outputs and (7) Creative outputs.

Figures 2.5 and 2.6 shows how Nigeria has fared since the inception of GII. The graph depicts the numbers of countries against the year. From the illustration, it can be observed that Nigeria's innovativeness is always below average. The highest ranking recorded was in 2008, where Nigeria was ranked 70th in the world out of the 130 countries evaluated. After which a steady decline in its innovativeness has been experienced. From the current GII rankings, Nigeria was ranked 116 out of the ranked 126 countries.

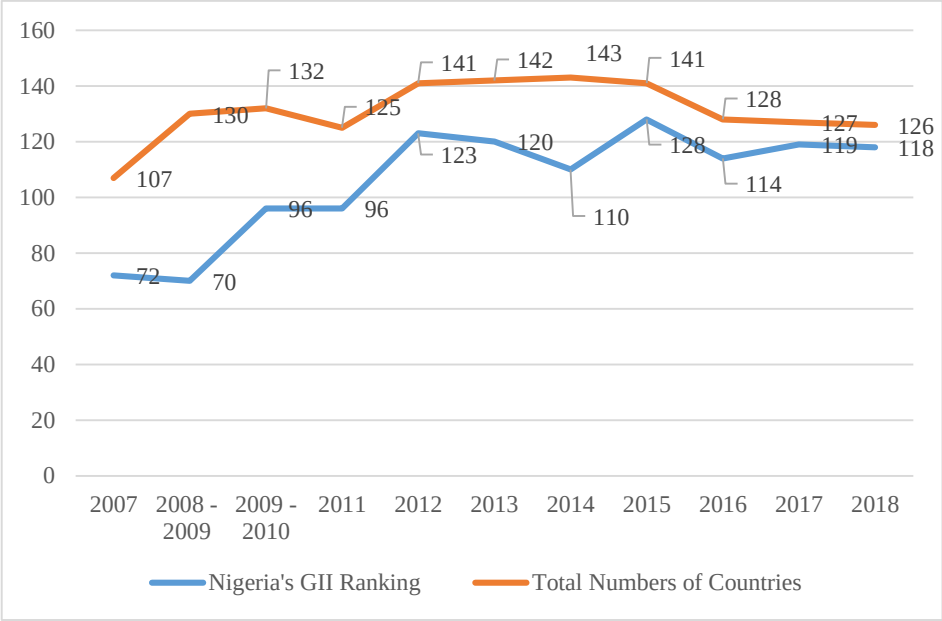

Figure 2-5: Nigeria's rank on the GII from 2008 – 2018. Source: Computed by Author

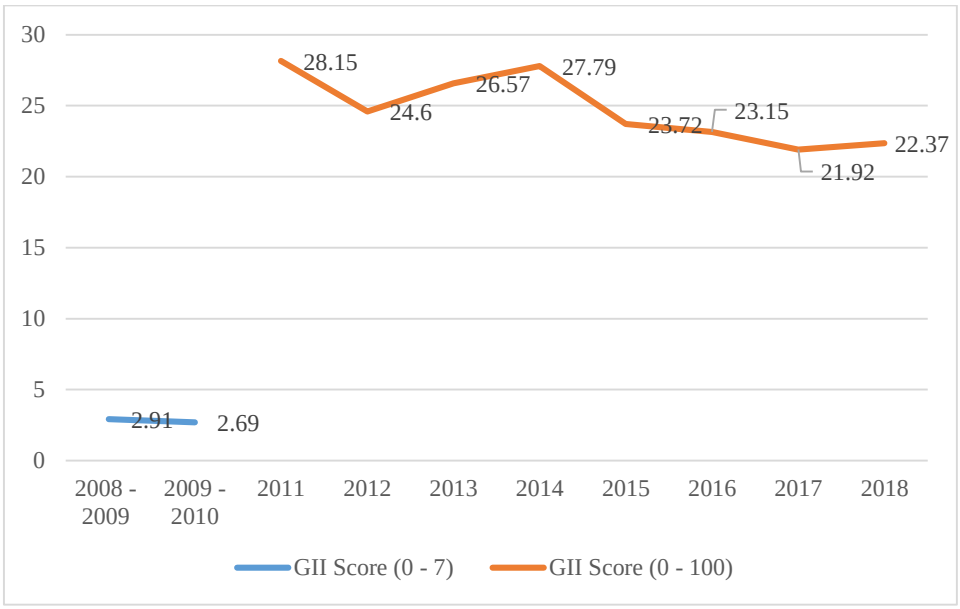

Figure 2-6: Nigeria's score on the GII from 2008 – 2018. Source: Computed by Author

From the thorough analysis of the 2018 GII report (Cornell et al., 2018) (See Appendix II for summary), a lack of interaction between the elements of Nigeria's innovation system was observed. Which could be liable for the regressive growth experienced. From the latest GII ranking, with respect to IIS-I, Nigeria was ranked 116 with a score of 29.85, while with respect to the IOS-I Nigeria was ranked 115 with a score of 14.89. Therefore, with a value of 29.85 for IIS-I, and 14.89 for IOS-I, the GII score for 2018 is calculated as thus

$$\text{GII} = \frac{(\text{IIS}-\text{I})+(IOS-I)}{2} \qquad (1)$$

$$\text{GII} = \frac{(29.85)+(14.89)}{2}$$

$$\therefore \text{GII} = 22.37$$

While the innovation Efficiency is calculated using this formula:

$$\text{IE} = \frac{(IOS-I)}{(\text{IIS}-\text{I})} \qquad (2)$$

$$\text{IE} = \frac{14.89}{29.85}$$

$$\therefore \text{IE} = 0.4988 \approx 0.50$$

In addition, by taking a microscopic look at each pillar of innovations to acquire a better understanding of the stance, with respect to the five pillars that determines the IIS-I and the two pillars that determines the IOS-I, the following discoveries were made:

1. it was discovered that inefficiency with governmental institutions such as destabilized political environment, unstandardized regulatory environment, and irregular business environment plays a key role in the country's lack of innovation performance, as Nigeria was ranked 119 out of the 126 countries. This basically correlates to the unsuitability of governmental policies identified to inhibit the user innovation activities (Henkel & von Hippel, 2005; von Hippel, 2005; Strandburg, 2008; Gangopadhyay & Mondal, 2012; Brüggemann et al., 2016; Fan et al., 2013; Chesbrough, 2003; Baldwin & von Hippel, 2011). This can be ascertained considering the on-going insurgency in Northern Nigeria that has had somewhat of a negative effect on the country's GDP expenditure as more funds required to bolster other NIS elements are channelled to combat the insurgency.
2. With respect to the human capital which gauges the country's expenditure on education, tertiary enrolment, numbers of graduate in Science, Technology, and Engineering (STE) and the gross expenditure on R&D (GERD), Nigeria was ranked 116. Factors such as incessant strike actions from tertiary institution lecturers, inadequate R&D support from government, and constant security issues to some teachers especially in the Northern part of Nigeria are definite evidences of this latent ranking.
3. With respect to the infrastructure pillar that measures the access and usage of information and communication technologies (ICTs), availability of general infrastructure such as the country's electricity production capabilities and gross capital

formation, and ecological sustainability which includes their environmental performance, Nigeria was ranked 114.

4. With respect to the market sophistication which measures the market conditions such as ease of getting credit and other supports needed, investment potentials, trade, intensity of local competition, and the domestic market scale, Nigeria was ranked 95, and this was actually identified as the core strength of Nigeria. This is purported to be the positive contributions of the innovative activities engaged by private firms in the Nigeria's service industry.
5. The last pillar of the IIS-I is the business sophistication, which captures and measures how conducive firms within the country are to innovation activity. This focuses on factors such as firm's ability to attract, acquire, train, and retain knowledge workers, innovation collaboration between firms and university/industry research facilities, and the knowledge absorptive capacity of firms through licensing of intellectual property rights, technology importation, and the technology management practices of the firms. From the GII 2018, it was discovered that Nigeria was ranked 103. One thing worth highlighting here is the High technology importation activities engaged by firms in Nigeria, GII indicated this factor as one of the key strengths of Nigeria. This attests to the '*massive importation syndrome*' highlighted by NACETEM (2010a) which was stipulated to have a derogatory effect on the advancement of indigenous technology in the country.
6. With regards to the IOS-I, the first pillar listed in the knowledge and technology outputs. This pillar entails all the variables conceived to be responsible for high invention and innovation rate. This includes knowledge creation which entails factors such as patent application both local and international, scientific and technical publications, knowledge impact which include growth rate of GDP, numbers of software spending, percentage of high technology and medium high technology development, and lastly methods used to diffuse knowledge. With regards to this knowledge and technology outputs, Nigeria was ranked 119, which shows that the country technological development activities are dormant. Possible reasons could be factors such as the negative effect of the high importation of foreign product which makes it extremely difficult for indigenous technologies to compete in their local market.

7. The last pillar of GII and IOS-I is the creative output, which quantifies the role of creativity in the innovation process. This gauges the intangible assets through the quantification of local trademark and industrial design applications, the contributions of ICTs as a business or organization enabler, as well as the rate of creative goods and services such as the exportation of creative and cultural artefacts, local film production, creation of mobile apps, and the online creativity engaged in the country within a calendar year. With regards to this, Nigeria was ranked 99, and two key factors were identified as the key strength of Nigeria's creativity expedition. These are the utilization of ICTs as business enabler and the production of local feature films.

From this emphasis, some of the limitations to Nigeria's innovativeness has been revealed. In addition to the information presented here, the succeeding section will provide other limitations to Nigeria's innovation system.

2.13 Factors limiting innovation in Nigeria?

After having emphasized the state of Nigeria innovation system, most of the factors limiting the country's innovation system are well documented. However, this section will formally list them The following are factors inhibiting innovation in Nigeria

- Undervaluation of indigenous knowledge and indigenous knowledge system. Indigenous knowledge is a unique form of knowledge relating to a particular culture, society and community (NACETEM, 2010a). These abilities are accumulated through years of experience, indigenous research and developments, and transcendental transmission from one generation to another (Brower, 1993; NACETEM, 2010a; Siyanbola et al., 2012). As revealed by NACETEM (2010a), the incapacitation of indigenous knowledge negatively affects the growth of grassroots innovation and evolution of alternative development model.
- Another factor is the disjunction between the four key elements within the national innovation system (NIS), namely: Education and Research, Industrial Production, Finance, and Public Policy and Regulation (Oyewale, 2010;) which inadvertently affect the technology transference process.

- Moreover, as identified in the 2015 global innovation index (GII), for an effective innovative capacity to be built, the human capitals of the society must be well developed and retained. However, Nigeria is foremost on the receiving end of the incessant effect of 'Brain Drain', with majority of the home-grown professional population either seeking employment abroad or ended up working abroad (Mba & Ekeopara 2012; Adefusika 2010; Easterly & Nyarko 2008).
- In addition, the inadequate infrastructural abilities of the country are also one of the critical inhibiting factors of innovation
- Inadequate governmental support through the provision of innovation encouraging policies and platforms, and adequate R&D expenditure.

Much emphasis has been laid on the state of innovation in Nigeria, the next section will attempt to provide a glimpse of user innovation in Nigeria, by providing 2 case studies that indicate the user innovative activities recorded in Nigeria.

2.14 Review of User Innovation in Nigeria: A Case Study of the Ancient South-Westerners

After having established in the preceding section that innovation is not novel in pre-colonial Nigeria, and was definitely not introduced by the British colonial expeditions. Therefore, since this thesis is about exploring the rate of user innovation in Nigeria, it is even more significant to highlight whether the concept of user innovation can be established in the pre-colonial Nigeria. This will be done by reviewing the book titled '*The History of the Yoruba People*' written by Samuel Johnson (1966). According to this literature, Johnson (1966:117) highlighted that the ancient trades and professions of the ancient Yorubas are: Agriculture, weaving, iron-smelting, tanning and leather working, carving on wood etcetera. Moreover, he further revealed that most of the then indigenous technologies and processes used for these trades were of '*home manufacture*'. Especially, he highlighted that agricultural equipment, articles of iron and steel which ranges from weapons of war to pins and needles used for sewing, to the processes and technologies used in leatherworks, as well as the musical instruments were all home manufactured by the users (Johnson, 1966). This statements

affirms that user innovation though not well explored was existent in the ancient Yoruba country.

Moreover, another significant factor revealed is that most of this equipment and apparatus were mostly used for commercial purposes. Which confirms that there was actually an ancient innovation strategy engaged by the ancient Yoruba people to commercialize their inventions. In confirmation of the negative effect of colonialism as indicated in the preceding section, Johnson (1966:120) also indicated that the ancient smithery got a backlash of the unilateral business relationship with the British colonial expeditions, as cheaper iron rods soon replaced the local iron production network, hence to the demise of the industry and the transference of this piece of significant knowledge in the then Yoruba country.

Lastly, Johnson (1966) made another significant revelation by indicating a significant piece of information with regards to the benefits of innovation to the local populace. He indicated that in the ancient Yoruba, learning how to build a particular technology needed for trade and commerce contributed significantly to their maintenance and repair of these technologies when needed. Though there were no record of the willingness of the ancient Yoruba user innovators to freely reveal or share their inventions with others. However, traces of their openness can be perceived through the form of training and apprenticeship employed. As new apprentices were adequately infused with the required knowledge and skills by their masters. However, a high level of secrecy was recorded by Johnson (1966: 122) in the medical field of the ancient Yoruba country, and the transference of knowledge about a particular medical innovation was kept secret within the family of the inventor and transferred strictly in a trans-linear manner from father to son or other close relatives. All these vividly points to the possibilities now engaged in the present world about intellectual property rights, knowledge management, and innovation management.

3 Research Framework

Synopsis

This chapter provides information about the research methodology used to conduct this study. This includes the objectives of this research as well as the approaches used to conduct the study. In addition, this research questions which will be used to steer the study are provided. Lastly, the limitations of each phase of the studies are also stated.

3.1 Introduction

Many theoretical works, empirical studies and project experiences have indicated the significance of user innovation in the innovation output whether at the micro, meso, and macro level. However, all these empirical studies that focused on the metrics of the notion of user innovation and its significance thereof have been conducted from the perspective of the first world countries such as Netherland, United Kingdom, Canada, Portugal (De Jong & von Hippel, 2009a; 2009b; Flowers et al., 2009; 2010; Mendonca 2012; Schaan, 2010). Despite the proposal of several methods to promote a proper management of user innovation through the suggestion of user innovation toolkits (von Hippel 2005; 2009), there is only one empirical study done to manage the concept of user innovation (Svensson & Hartmann, 2018). Therefore, the absence of information on the presence of user innovation in emerging economies is the major reason why this study was embarked on. The sections detail the phases of the thesis, the research questions this thesis answers, and the research approaches used to answer these questions.

3.2 Research objectives

Before proceeding further, it is worth highlighting that this research study was designed to provide information with regards to user innovation however with a direct link to the elements of NIS firms, research institutions, universities listed in the preceding section. In order to effectuate a quality research study, the objectives of the research are divided into four phases:

Phase 1. measure the prevalence and incident rate of user innovation within the Nigerian higher institution students;

Phase 2. measure the prevalence and incident rate of user innovation within Nigerian SMEs;

Phase 3. explore the contribution of Private innovation incubators to Nigeria's innovation ecosystem;

Furthermore, after having conducted adequate measures on the subject of user innovation, just like the medical field, diagnosis or prognosis without treatment is nothing but a waste of time. Therefore, the preceding phase will attempt to proffer means that can help to promote and encourage user innovation in an emerging economy.

Phase 4. propose a framework for managing user innovation activities in Nigeria through the introduction and qualitative review of digital fabrication initiatives such as FabLab and Makerspaces.

Focusing on each specific research objective, the research approach used are explained in the succeeding sections.

3.3 Research Methodology for Measuring User Among Nigerian Higher Education Students

With regards to the incidence of user innovation according to educational accomplishments, Flowers et al., (2010), uncovered that degree or post graduate degree holders are the biggest contributors to user innovation in the United Kingdom (UK). Their overall contribution was identified as a value of 11.8%. This is followed by college students, who were identified to contribute a value of 9.5%, followed by innovators who signified possessing additional qualification, whose overall user innovation value stands at 8.7%. Then secondary education certificate holders contributed a total of 6.4%. Lastly, user innovators with qualifications below secondary school level contributed an overall value of 4.9% user innovation. This signifies that education plays a significant role in the volume of user innovation or user innovators. However, it is worth noting that the user innovators focused on here are definitely

individual user innovators. Therefore, it can be concluded from these statistics that, the higher the educational accomplishment of the innovators, the higher the volume of user innovation expected to be released to the market. This hypothesis will be further tested in this section.

Therefore, the second phase of this study will focus on uncovering information on the state of user innovation in the higher education sphere in Nigeria. The following are the objectives of this phase:

a) quantify the rate of user innovation in the Nigerian higher education sphere, which will henceforth be referred to as student user innovator (SUIs);
b) to identify the factors that encourage SUIs innovate;
c) to study the role of gender classification on user innovation in Nigeria;
d) to identify the types of products or inventions developed by SUIs;
e) Lastly, to highlight commercialization process of the user innovations by SUIs.

These objectives will be attempted with the following research questions and hypotheses which will provide a suitable avenue to uncover the state of the student user innovation.

RQ 1. How prevalent is user innovation among Nigerian higher institution students?

In addition, as indicated by Flowers et al. (2010) SUIs like other user innovators, innovate mainly to meet their unmet needs. However, since existing literatures only refers to the state of user innovation in developed countries, this finding may not hold in the emerging economies. Therefore, in order to identify the factors that encourage SUIs to innovate in Nigeria, the research question below will be employed to provide a suitable avenue to identify the factors that enables SUIs to innovate.

RQ 2. Why do users innovate in the Nigerian Higher education sphere? Is it the same as the motives of user innovators in existing studies?

Moreover, this study assumes that due to the academic exposure and knowledge acquisition, the academic level of each SUIs would have a significant effect on the user innovation activities engaged in by the SUIs. That is, 100 level SUIs are not expected to be more innovative that the 200 level SUIs, and so on and so forth. Therefore, in order to test this assumption, the following research question will be used.

RQ 3. Does academic achievement have any effect on the innovative abilities of SUIs?

Lastly, various literatures have identified mixed results with regards to the effect of gender on the innovation. Mendonca (2012) discovered that in Portugal, there are more female user innovators than male user innovators, while Flowers et al (2010) discovered that in the UK, Male are more engaged in user innovation activities than the female user innovators. Therefore, this study will attempt to uncover the role gender plays in user innovation activities in the Nigerian higher education sphere. This will be done by the following research question.

RQ 4. What is the effect of gender on the user innovation activities of higher education students in Nigeria?

3.3.1 Research approach

To conduct the study in this phase, a quantitative research methodology was employed. Questionnaires were distributed to students enrolled in science and engineering related degree programs. The major reason why science and engineering students were the target is due to financial implications, as well as what the assumptions that students in the science and engineering fields, due to the relativeness of their course to innovation, will be more innovative than other students in other fields. This assumption was also supported by the findings made by Halbinger (2018) that indicates that majority of innovators are from a technical field.

Moreover, the major reason why this study only focused on South west Nigeria, and on science and engineering related field is partly due to financial implications. other factor such as the size (in terms of population), the commercial capability, and per capita influence of two South

western states (Lagos and Oyo state) on Nigeria. Presently, from online search, we discovered that there are about 462 higher education institutions in Nigeria, which includes universities, polytechnics, colleges of education, and technical colleges. Out of which 162 (35.1%) are in the south west region. This gives us the confidence to proceed with our study. Moreover, this study also assumed that due to their academic orientation, most innovation in any emerging economies would come from science and engineering fields. This survey was conducted for a period of 6 months from November 2017 till April 2018.

In addition, the questionnaire was designed around four major factors (See Table 3.1 below) indicative of who should be considered as a user innovator as uncovered in entrepreneurship and innovation literatures. These questions are tabulated below.

Table 3-1: List of Factors and Survey Questions (SUIs)

Factors	*Questions*
User Innovator	• Have you developed or modified any invention/equipment/technology for your personal use or for the usage of others? • Why did you develop or modify the product? • To the best of your knowledge, how novel is your product?
Product Commercialization	• When was the product developed or modified? • How long did it take you to develop or modify the products (in weeks)? • Did you (or do you plan to) commercialize your invention? • To the best of your knowledge has your invention been adopted or utilized by others? • Did you file for Intellectual Property Rights for your product? • To the best of your knowledge, has your invention been adopted or utilized by others? • Have you started (or trying to start) a business from your product? • To what extent was the product successful?
Technology Transfer	• Did you or are you willing to share the knowledge about your invention with others? • What are your reasons for sharing your inventions?
Types of Product	RQ1. What type of product did you create or modify?

Source: Author

Moreover, the critical criterion for participating in the survey is based on whether the respondent have developed or modified existing products prior to completing the questionnaire. At the end of the survey period, we collected data from 2869 students, out of which only 304 respondents fit the criteria of the research. The responses of the respondents were analysed using Statistical Package for Social Sciences (SPSS), and will be presented through descriptive statistics in chapter 4.

3.3.2 Limitation of Phase

Being a maiden study in the context of an emerging economy, the findings of this study have to be seen in light of some limitations which restricted a broader research study that would have covered the entire country as well as every faculty. Some of the limitations experienced when conducting the survey for this phase includes limited access to data through restriction of the survey to only students in Science, Technology and Engineering field as well as to the South-West region of Nigeria. This was as a result of insufficient funds. Moreover, after identifying the respondents, conducting an additional qualitative interview with the respondents would have provided a more significant study. However, due to the unavailability of the contact details (such as email address and phone number) of the respondents. It was impossible to contact the respondents to gather more information, especially with regards to the issue of missing data which will be described in the paragraph below.

In addition, other limitations include issues of missing data, as some respondents failed to provide responses to some data that would have aided a better analysis of the study. However, during the data cleaning it was discovered that deleting such respondents would greatly affect the data analysis, as all these respondents met the critical requirements for the study phase which is to identify whether they have created or modified products to either meet their needs or those of others. Therefore, this study hopes to provide a suitable direction for future studies, and hopes that future research would consider these limitations and provide a more regiment study that covers the entire country as well as the faculty. state of user

3.4 Research Methodology for Measuring User Innovation Among Nigerian SMEs

SMEs, though faced with numerous resource constraints, play an important role in an economic and technological development (Rosenbusch et al., 2011; Acs & Audretsch, 1988; Osotimehin et al., 2012; Aremu & Adeyemi, 2011). There exists considerable amount of literatures that indicated the crucial role played by SMEs with respects to innovativeness. Some of which includes the superiority of SMEs in terms of utilizing different forms of innovation than large firms, hence the major source of innovation (Rothwell, 1978; Vossen,

1998; Lee et al., 2010). Secondly, due to their reliance on alliances or networks as a means to expand their technological competences, SMEs effectively utilises external forms of innovations than large firm (Lee et al., 2010; Edwards et al., 2005; Rothwell, 1991). Lastly, SMEs were suggested to play a disproportionately large part in major inventions made in the 20th century (Rothwell, 1978; Prakke, 1974).

Moreover, literatures on innovation has proven that the size of a firm does have an effect on the firm's innovative output (Coad et al., 2016; Van Praag & Versloot, 2007; Hansen, 1992). In addition, with regards to user innovations, Flowers et al., (2009 & 2010) indicated that the size of the firm have a significant effect on the incidence of their user innovation activities. That is, larger firms tend to be more involved in user innovation activities than small firms. However, this study only focuses on SMEs which are not expected to have more than 250 employees according to the structural definition of SMEs (Rosenbusch et al., 2011; Murphy, 2002; Hall et al., 2009). However, despite their economic potentials, Nigerian SMEs were identified to have performed below expectations due to the presence of the following critical resource constraints: access to finance, inadequate infrastructure, inconsistent government policies and bureaucracy, environmental factors, poor management, multiple taxes and levies, unfair competition, inadequate access to modern technology, unavailability of localized raw materials, and marketing problems (Osotimehin et al., 2012; Agwu & Emeti, 2014; Onugu, 2005; Aremu & Adeyemi, 2011). Therefore, in order to adequately uncover the contributions of the Nigerian SMEs to the user innovation concept, the following objectives would be the focus of this phase:

a) To uncover the state and type of user innovation in the Nigerian SMEs. It is worth noting here that this phase only focuses on the state of User product innovation and user involvement.
b) To identify the effect of the firm size on their user innovation activities. Thereby ascertaining the findings of Flowers et al., 2009 & 2010
c) To identify the effect of the age of firm on the user innovation activities of the Nigerian SMEs.
d) To uncover the source of information for the user firms.
e) To uncover the commercialization rate of this user innovation.

f) Lastly, this study will also attempt to derive the information about the novelty of the innovation and the willingness of the user firms to share their innovations.

According to Flowers et al. (2009), user firms, being the progenitor of new products, processes and services, and also the initiator of new organizational methods, should be termed as 'super-innovators'. Therefore, it is vital to first and foremost uncover their prevalent rate in the Nigerian SMEs, as well as to uncover the type of user innovation involved by the SMEs. In order to do that, the research questions will be tested to proffer an answer to the first objective of this phase.

RQ 5. How prevalent is user innovation within Nigerian small and medium enterprises (SMEs)?

RQ 6. What kind of user innovation (Product or Service) is predominant in Nigerian SMEs?

In addition, existing research identified that the size of a firm does have an effect on the firm's innovative output (Coad et al., 2016; Van Praag & Versloot, 2007; Hansen, 1992). Moreover, with regards to the notion of user innovation, various literature identified that larger firms have the tendency to be involved in user innovation activities than smaller firms (Flowers et al., 2009; 2010; De Jong & von Hippel, 2009b; De Jong & Flowers, 2018). The reason for this result was identified as the high level capabilities and resource availability possessed by larger firms, which enables them to tackle challenges faced internally. Therefore, with the research question below, an attempt will be made to uncover the effect the firm size has on the user innovation activities engaged by the Nigerian SMEs.

RQ 7. What effect does the size of the firm have on the user innovation activities of Nigerian SMEs?

In addition, De Jong & von Hippel (2009b) and De Jong & Flowers (2018) also indicated that the bigger the firm size, the bigger likelihood of the SMEs to report an involvement in user process innovation. This was explained as the antecedent effect of number of employees on the sales quota of the SMEs, that is the greater the amount of processing done, the greater

the return obtained from the specified process innovation (Klepper, 1996). One critical limitation of this phase is the omission to study the effect of the number of graduate employees of the SMEs on their user innovation abilities. Therefore, it is important for future research to study the effect of the graduate employees in the SMEs to their user innovation endeavours. That is, does academic achievement of employees have any effect on the innovative abilities of SMEs? This was not covered in the data gathering phase.

Moreover, according to literatures (Baldwin & Johnson, 1999; Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992), the age of a firm is posited, due to the inertia effect, to have a negative effect on the firm's innovation activities. That is, older firms are posited to be less innovative as the younger firms. However, there are no literature to uncover whether this notion holds the same for user firms. Therefore, this study will attempt to uncover the effect of age on the user innovation activities of Nigerian SMEs.

RQ 8. What effect does the age of the firm have on the user innovation activities of Nigerian SMEs?

As indicated in earlier section, users, without the exception of user firms, were ascertained to innovate in response to their local need which was unmet by existing commercial products. Though not intended for commercial purpose, these user innovations still find their ways to the commercial market. Therefore, it is worth ascertaining whether this fact also holds for the Nigerian SMEs. This will be attempted through the following research question.

RQ 9. Why do users innovate in the Nigerian Small and Medium Enterprises (SMEs)? Is it the same as the motives of user innovators in existing studies?

Lastly, as indicated in the introductory section above, SMEs utilises external sources of innovations than large firm due to their reliance on alliances or networks as a means to expand their technological competences (Lee et al., 2010; Edwards et al., 2005; Rothwell, 1991). Therefore, this following research question will attempt to uncover the major sources of information used by the user firms in the Nigerian SMEs.

RQ 10. What is the predominant sources of information used by the User firms in the Nigerian SMEs?

3.4.1 Research approach

To conduct this study, a quantitative research methodology was employed. Questionnaires were distributed to SMEs in South west Nigeria, this survey was conducted for a period of 4 months from September 2018 to December 2018. The justification behind the focus of the study on the South West Nigeria is based on those provided in phase 2 above. Such as the size (in terms of population), the commercial capability, and per capita influence of two South western states (Lagos and Oyo state) on Nigeria. This assertion was confirmed true by reviewing the 2016 database derived from the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN). From the database review, it was discovered that as at 2016 there were a total of 3264 registered SMEs in Nigeria. Nigeria as we know it is subdivided into 6 geo-political zones, which are: North central (NC), North east (NE), North west (NW), South east (SE), South south (SS), and South west (SW).

As can be seen in Figure 3.1, the SW region has more SMEs (29%) than other geo-political zones in Nigeria. Moreover, probing further, it was discovered that Lagos and Oyo state due to their commercial capability, human capital, and some other factors have a combined value of 723 SMEs, which constitutes 22% of the total SMEs in Nigeria, and significantly more than other geo-political zones except NW which stands at 24%. This discovery asserts the assumptions stipulated in this study, thus giving us the confidence to proceed with our study. However, it is also worth noting here that the surveyed SMEs are manufacturers or service providers which spans from agriculture to laundry and dry cleaning services, to consultancy and sales.

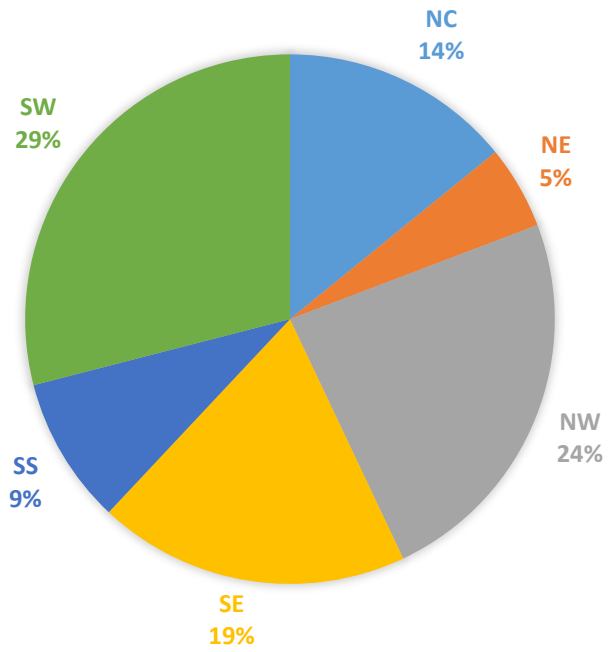

Figure 3-1: Geographical Distribution of SMEs in the SMEDAN 2016 database. Source: Author

In addition, the questionnaire was designed specifically to elicit information about the user innovation activities of the user firm within the past three years. This information is designed around seven factors indicative of who should be considered as a user firm as uncovered in user innovation literatures. These questions are tabulated below (See Appendix V for the questionnaire).

Table 3-2: List of Factors and Survey Questions (SMEs)

Factors	*Questions*
User firm	• During the past three years, did your enterprise introduce new or modified products/services • Who developed or modified these products or services? • Were any of the developed or modified product/service new to your firm? • Were any of the developed or modified product/service new to your market?
Firm Age	• When was your firm established?
Firm Size	• What is the total number of employees within your enterprise?
Product Development and Support	• Did you collaborate or receive any assistance while developing or modifying the products or services? • Please give the estimate of resources (finance and time) invested to develop or modify the products/services?
Product Commercialization	• Has your firm generated a revenue turnover from the developed or modified products/services?? • What is the average monthly revenue turnover from the new or modified products/services? • To the best of your knowledge has your invention been adopted or utilized by others? • Did you file for Intellectual Property Rights for your products or services?

	• To the best of your knowledge, has your invention been adopted or utilized by others? • What factors are important to the successfulness of your innovation (Question 21)? • Has your innovation been adopted by other firms?
Technology Transfer	• Are you willing to share the knowledge about your innovation? • Did you receive any compensation from the producer firm for transferring or sharing your invention (Question 26)?
Types of Product	• What type of product did you create or modify?

Source: Author

To conduct the survey, a total of 365 SMEs were randomly selected from a cross section of 18000 firms (which includes SMEs) spread across Nigeria. This list was obtained from the National Bureau of Statistics (NBS). However, as indicated in section 3, the focus area of this study is the SW geo-political zone of Nigeria, covering sectors such as Services, Manufacturing, Processing, Oil & Gas, Educational etc. During the data cleaning process, two criteria were considered. These are based on whether the respondents have created new products or services or modified existing products or services in the past three years, and who created or modified the products. Therefore, respondents who did not meet these prerequisite were removed. After data cleaning, a total of 249 SMEs were identified fitting the objectives of this research phase. The responses to the questionnaires were analyzed using the statistical package for social sciences (SPSS). These findings will be presented using descriptive statistics in chapter 5.

3.4.2 Limitation of Phase

The empirical results reported in this should be considered in the light of some limitations. The major limitation of this study is the indirect approach used during the data gathering phase to identify the incidence of user innovation activities among the Nigerian SME firms. Unlike previous studies which directly asked whether the survey participants have created or modified a new product or service for their own use, this study posited that due to the infrastructural issues in Nigeria, user innovation activities would be minimal. Therefore, the survey questionnaires were designed to identify some forms of user innovation activities among the SMEs.

In addition, similar to some of the limitations listed in section 3.4.2, this phase also experienced some limitations with regards to the method used to collect the data, hence restricting the quantitative survey to the South-West region of Nigeria. Despite the criticality of these limitations, this study provides evidences of the activities of user innovation among Nigerian SME firms which was deemed vital for future studies.

3.5 Research Methodology used to explore the contribution of Private innovation incubators

In order to accomplish the main objective of this phase, which is to quantify the state of user innovation in Nigeria, it is highly significant to first acquire adequate information about the state of innovation as well as the limitations to the innovativeness in Nigeria. Therefore, the first phase of this study will focus on exploring the contribution of private innovation incubators to the innovation ecosystem in Nigeria. The objective of this phase are:

1. To investigate the contribution of the PIs to Nigeria's innovation ecosystem
2. To uncover the effect of the firm's age on their innovative activities
3. To study the effect of the firm size on their innovative activities
4. To study the effect of graduate employees on their innovative activities
5. To examine the factors affecting PIs, as an industrial policy in Nigeria
6. Lastly, to explore the numbers of user innovators supported by the PIs.

This will be attempted by the following research questions:

RQ 11. What is the contribution of private innovation incubators to Nigeria's innovativeness?

RQ 12. What is the effect of the firm's age on their innovative activities?

RQ 13. What is the effect of firm size on the innovative activities of Nigeria's private innovation incubators?

RQ 14. What is the effect of the number of graduate employees on the innovative activities of Nigeria's private innovation incubators?

Being the first phase of the research work, and in the absence of adequate literature that focuses on the significance of private innovator incubators in the Nigerian innovation space, this study was conducted through a qualitative literature review. However, there are ample literatures on the significance of the national technology business incubators (NTBI) launched by the government. Hence to indicate the difference between this phaseal study and the existing studies on NTBI, the NTBIs are referred to as government-funded incubators (GFIs) while the innovation incubators in focus are hence referred to as private innovation incubators (PIs). However, though private, some could be financed by the government as will be revealed later in the analysis phase of this study.

3.5.1 The Data Collection Process

According to the objectives of the study stated in section 3.2, the samples for this study were drawn from a list we compiled and regularly updated during the information gathering phase which spanned between 2 years from 2015 and 2017. This was done through several internet searches of keywords such as 'Innovation Incubators in Nigeria', 'Private Innovation incubators in Nigeria', and 'Business Innovation Incubator in Nigeria', and also through referrals from known PIs. From this, we were able to compile data for 27 PIs as of the last quarter of 2017. Which we deemed as relevant for the purpose of this study. With each region (i.e. Northern, South-West, South-South, Eastern) in Nigeria having at least one innovation incubator. However, during the survey process, the first obvious observation we made was that Abuja and Lagos, being the financial and commercial capitals of Nigeria, comprise up to two-third of the total numbers of PIs in Nigeria.

To collect the data, we employed a research design that covers a qualitative study of selected PIs. The qualitative research approach was more suitable given the significance of collecting suitable data for deep understanding and local contextualization of the research topic (Van Maanen, 1979; Miles & Huberman, 1994; Welman et al., 2005). This data was collected during a structured open-ended face-to-face interviews with key staff members of the responding PIs such as the founder, co-founder, or manager. During the interview process, we visited some PIs in Lagos, Ibadan, and Abuja. In addition, we also employed telephone interviews to

gather information from some PIs in other regions in Nigeria. In total, the interview process was conducted for a period of 10 months (from April 2017 to January 2018). The length of the interviews was typically between 60 and 90 minutes, out of which we collected 14 responses from the 27 PIs, which statistically correlates to 52% of the population. Out of the 14 respondents, 3 are CPIs while the remaining 11 are IPIs. The data was collected by audio recording, which was later carefully transcribed and coded by RQDA, a qualitative data analysis based on R package. Then we further analysed the coded data by SPSS statistical analysis software.

These interviews had four major goals:

a. to gain insight about the PI's background by covering characteristics such as firm's age, size, the skill level of the workforce by measuring the number of graduates, strategy, sources of funds, and the type of organization;
b. to map the value proposition offered to tenants in terms of infrastructure, support services provided, and access to networks, this will be attempted by exploring the focus of the PIs;
c. to gain insight into the overall contribution of the PI by measuring its innovative output;
d. lastly, to measure the relational capabilities of the PIs, that is, whether they have collaborated with other firms and universities, and the nature of the collaboration.

The information collected was purposive in determining information that pertains to the tangible and intangible inputs, innovation process, and the innovation output. In addition, with this data, we will attempt to uncover the effect of the age of the PIs, their size, and the numbers of graduate employed on the innovation input, process, and output. This will be detailed in discussion section below. The findings of this analysis are thoroughly discussed in chapter 6.

3.5.2 How to measure the innovativeness of PI?

Since Innovation incubators could majorly be termed as a service industry than manufacturing industry, therefore, we focus on metrics of service innovation which has been indicated to include the Non-R&D expenditures (Evangelista & Sirilli 1995; OECD, 1997b; 2010b), which includes the transformation process of innovation.

Using the innovation dashboard, which encompasses a set of measures that displays a variety of performance criteria from an organizational perspective (Manoochehri, 2010), we will attempt to measure the state of the art of innovation of the PIs in Nigeria. The benefits of the innovation dashboard allow an organization to monitor the organization's performance along different aspects of innovation (Manoochehri, 2010). The dashboard includes various metrics which focuses on the input, process, and output metrics, these metrics include:

1. Input Metrics: Inputs are the tangible and intangible resources, such as people, capital, equipment, office space, time, talent, motivation and company culture, devoted to the innovation effort (Davila et al., 2012; Adam et al., 2006; Stone et al., 2008). According to Manoochehri (2010), the two most vital input to ensure the success of innovation projects are the allocation of financial resources and assignment of key people. Therefore, this study will attempt to uncover the state of these input metrics in the Nigerian PIs. This will be achieved by exploring the sources of finance for these PIs and also their size and numbers of graduate workers.
2. Process Metrics: these are real-time measures of the transformation that occurs from input to output (Davila et al., 2012). As time is the most critical factor during the innovation process (Manoochehri, 2010), in this study, we will explore the time taken for the innovation incubator to break even (revenue generation and the innovation strategy).
3. Output Metrics: the outputs are the results of the innovation effort (Davila et al., 2012). It elicits the outcomes of the innovation efforts. It shows the R&D performance of the organization, the number of patents filed, publications. Number of products, innovation return on investment (ROI) and qualitative change accrued to the innovation effort (Stone et al., 2008; Davila et al., 2012; Manoochehri, 2010; Kleinknecht et al., 2002). Like the input metrics, we will also attempt to explore the state of the PIs in Nigeria using information such as the number of start-ups launched,

the number of products, and patents application. Manoochehri (2010) indicated that the main purpose of the output metrics is to uncover the percentage of revenue generated from new products; percentage of profit from new products; and the percentage of revenue growth from new products.

3.5.3 Limitation of phase

This study is not without limitations, which provides opportunities for future research. The first major limitation to this study was due to the improper documentation or database of the total number of PIs. However, we were able to collate sizable information from the internet and through referrals by visited PIs. Secondly, another limitation to the study is due to inadequate data to conduct an in-depth measurement of the innovativeness of the PIs. This was due to the reluctance of some respondents to disclose vital information such as annual returns, total R&D expenditure, and returns based on R&D expenditure. Which from our observation could be due to the competition we perceived existed between the PIs. Lastly, another notable limitation is the lack of focus on the tenants of the PIs to elicit information with regards to correlate the suitability of the PI's value proposition to their value expectations. However, irrespective of these limitations, we are sure that this work could help instigate the need for an in-depth research study on this topic. The next section provides the results of our survey.

3.6 Research Methodology for Managing User Innovation

Just like in the medical field, after a prognosis, there is need for a prescriptive measure to suppress the identified health condition. In this study, the first three phases were the prognostic measures engaged to quantify the prevalent rate of innovation and user innovation in Nigeria. Considering Nigeria's underwhelming stance in the global innovation sphere, there is need to suggest means by which user innovation can be spurred. In addition, von Hippel and Katz (2002) suggested that for user innovation to thrive, there is need for private firms that benefit from the user innovation to provide innovation toolkits for the user innovators. Therefore, this phase will be suggesting digital fabrication workshops (such as FabLabs, Makerspaces, Tech hubs and so on) as one of this viable toolkits to manage and encourage

more user innovation activities in emerging economies. This will be done by reviewing the research question below.

RQ 16. What effect would digital fabrication technique have on user innovation activities in emerging economies? If so, what are the significant implications of using digital fabrication in managing user innovation?

The research methodology used for this phase is a qualitative approach through literature review of existing studies, and a case study review of GreenLab microfactory.

4 Measuring User Innovation among Nigeria Higher Education Students

Synopsis

In a bid to create adequate value, it is no longer surprising to consider users as a viable source of innovation, from which some critical commercial products are adopted. Existing study on this subject matter has been thoroughly explored from the context of a developed country. Thereby leaving a huge chasm between the knowledge of user innovation in emerging economies. In order to bridge this gap, this phase will attempt to explore the state of user innovation in Nigeria, by laying specific focus on the higher education students. Using a quantitative research approach, this research study identified 304 user innovators. Among many other things, this study discovered that user innovators in Nigeria mostly innovated to meet their underserved needs. Moreover, a high male dominance was observed in the user innovation activities in Nigeria. Lastly, we also discovered that female user innovators focus more on products related to household and health/medical equipment.

4.1 Introduction

Despite the numerous choices of mass produced products available to consumers nowadays, Users, in a bid to meet their underserved or otherwise unsatisfied needs, innovate (von Hippel, 2005). This particular form of innovation can be presumed as an adequate means of value creation (Prahalad & Ramaswamy, 2004; Basmer et al., 2014; Redlich et al., 2014). User Innovation, an act in which users (individuals or firms) innovate for themselves to make products and services they want without manufacturer's assistance or interference (Gault, 2012; Baldwin et al., 2006; De Jong & Von Hippel, 2009a; 2009b). It is also simply defined as an innovation developed and benefited by the user to meet its needs (Gault & von Hippel, 2009). A typical example of what can be classified as user innovation is when a firm or a consumer develops a new product or modifies an existing product for its own use, either for

cost reduction purpose, or for operation optimization purposes (Kim & Hyunho, 2010; von Hippel, 2005; De Jong & von Hippel, 2009a). As indicated in this paragraph, there are two possibilities in which user innovation can occur. First, is the user firm, these are firms whether large or small medium enterprises (SMEs) with greater technological and financial capability, that engages in user innovation as defined above. While the second option is a consumer that engages in the act of user innovation.

Moreover, existing literatures also showed that users pioneer the innovation activities in a vast array of new product developments (NPD), process equipment, and services introduced into the market place (von Hippel, 1977, 1988, 2005; Flowers et al, 2010; Baldwin et al. 2006; Gault & von Hippel, 2009). Majority of the innovations in fields such as scientific instruments (tools used by scientists to collect and analyse data), extreme sport equipment, computerized library information system, chemical production processes, semiconductor processing, medical instruments, and oil refining field were first developed by user innovators (Franke & Shah, 2003; Morrison et al. 2000; Baldwin et al. 2006; Gault & von Hippel, 2009; Flowers et al, 2010; De Jong & Von Hippel, 2009a). From our review, we gathered that 99% of existing studies explored the significance of user innovation from the context of developed countries. Which means, little or nothing is known about the state of user innovation from the context of an emerging economy. In addition, Flowers et al (2010) indicated a high incidence of user innovation within the age range 15 – 34 in the United Kingdom (UK). Since most of the posited user innovator within this age range would probably be in the higher education level. Therefore, as a foundational study on the stance of user innovation in emerging economies, this study will attempt to explore the state of user innovation in Nigeria, with specific focus on the higher education students. As well as to verify whether the notion pertaining to user innovators in developed countries also hold in emerging economies.

This chapter is arranged as thus: the following section presents a background literature on the subject of user innovation, and how it relates to the Nigerian ecosystem. This will be followed by section 4.3 which present the net outcome of these research findings where the incidence of user innovators is mapped to their approach, activities, gender, and types of inventions developed. This is then followed by a detailed discussion of the research findings which is

presented in section 4.4. Lastly, this chapter ends with a conclusive remark which is presented in section 4.5.

4.2 Background Literature

The concept of User Innovation, like every other forms of innovation is a critical field that contributes to the opulence of individuals, firms, and economies alike. Background literatures indicated that a user innovator could be in the form of a firm or a consumer (von Hippel, 1977, 1988, 2005; Flowers et al, 2010; Baldwin et al. 2006; Gault & von Hippel, 2009; von Hippel & Jin, 2009; Gault, 2012). In addition, some distinctions between user innovators, user-centred innovation, and users as collaborators in innovation were further highlighted. From this distinction, a user innovator benefits from solving a problem, while in user-centred innovation, users are deemed as a source of information for innovation. Lastly, users are also a good source of products or processes improvement.

Moreover, in order for an innovation to be qualified as user innovation, Gault (2012) indicated from the OSLO Manual that there must be a visible connection between the product and the market, which symbolises the existence of a commercial activity for the user innovation expedition. This can be argued to be true, due to the usage of the term 'innovation' rather than invention. As some of the clear distinctions between invention and innovation is the ability of the invention to be commercialized (Dorf et al, 2011), and also the radical and incremental approach of the innovation. While an invention is simply the creation of a new product for the first time. Therefore, it is the connection to the market that qualifies the process improvement as an innovation and in this case a user innovation. In addition to the commercialization rate of user innovation, based on a survey conducted on the UK consumers, Flowers et al. (2010) discovered that 8% of the surveyed consumers created or modified one or more products, out of which 2% of their products have been commercialized.

According to this assertion several questions are brought to light. Some of which includes 'Does the product have any chance of being commercialized?', 'what is the effect of club membership on the user innovation abilities?', 'How much and how long did the SUIs spend on the innovation expedition?', 'How did they fund their innovation?', and 'Did they receive

any support from others and what kind of support did they receive?'. Moreover, another set of questions that relates to the commerciality of their innovation activities comes to mind. These are 'Can User innovators protect their inventions?', 'what is the success rate of the user innovation?', 'What is the adoption rate of these user innovations?', and 'what commercialization activities has occurred on these user innovation activities?'. However, previous studies revealed that most user innovators tend to share the knowledge of their products freely with other users (Kim & Hyunho 2010; Henkel & von Hippel, 2005; von Hippel 2005; Allen, 1983; Nuvolari, 2004; Franke and Shah, 2003; von Hippel and Finkelstein, 1979; Morrison et al., 2000; De Jong and von Hippel, 2009a; 2009b). In addition, with the advent of new licensing platform for open source technologies (such as Creative commons, General Public License (GPL), MIT License, etc.), user innovators can now share more, while also having some form of protections over their innovations. Being the first in-depth study to explore the rate of user innovation in a developing country. Factors listed in literatures will be explored from the context of Nigeria's higher education students. The succeeding section highlights the objectives and methodology used to conduct this research study.

4.3 Findings

This section first presents the prevalence rate of user innovation among the Nigerian higher education students. This study then reports upon the factors that encourage Nigerian higher education student engage in user innovation activities. Followed by a thorough presentation of the implication of gender on the user innovation activities among Nigerian higher education students. Lastly, the predominant types of product invention among the user innovators will also be presented.

4.3.1 Prevalence rate of User Innovation in Nigeria higher education

To uncover the prevalent rate of user innovation among the Nigerian higher education sector, the respondents were asked whether they have developed (new) or modified (existing) any invention/equipment/technology for your personal use or for the usage of others. With this question, this study aims to uncover the incidence rate of user innovation among the Nigerian higher education students. In addition, the respondents were further asked to provide

information about the total innovation expenditure spent during their user innovation process, as well as question to identify the implications of club membership or professional association on the user innovation activities among Nigerian higher education sectors. This will be presented in the following sections.

4.3.1.1 Incidence of User Innovation in Nigerian Higher Education

As can be seen from Table 4.1, this study discovered that there are 304 user innovators in the south west region of Nigeria. This will henceforth be referred to as 'Student User Innovator' (SUIs). Out of which 21% have developed new products, while the remaining 79% have modified existing products. In addition, from Table 4.2, this study discovered that majority (53%) of the SUIs created or modified their products within the last three years. Moreover, 29% of the SUIs worked on their product in the past 3 to 5 years, while 16% SUIs worked on their products in a period above 5 years ago.

Table 4-1: Incidence of User Innovators in Higher Education Students (n = 304)

	Percent
New Product	21.4
Modified Existing product	78.6
Total	100.0

Note. Data from Author's 2018 PhD survey.

Table 4-2: Period of Invention (n = 304)

	Percent
Between 1 and 3 years ago	52.6
3 to 5 years ago	28.9
Above 5 years ago	15.8
Total	97.4
Total	100.0

Note. Data from Author's 2018 PhD survey. Value was not determined for 25 cases.

From Table 4.3, it can be observed that a high incidence of NPDs and modified products occurred recently between 1 and 3 years ago, majority of which are modification projects. Moreover, 95.5% of the user innovation activities accomplished by the SUIs within the period of 3 to 5 years ago are modifications made on existing products. Furthermore, this study also discovered that 85% of the user innovation activities period above five years ago (i.e. 2013 downwards) were modifications done on existing products. In addition, by taking a percentage difference of the period of invention, it was discovered that the SUIs who innovated between 1 and 3 years ago created more NPDs, that is 29% more than the NPDs created between 3 to

5 years ago, and 18.5% more than the number of NPDs created in a period above 5 years ago. Lastly, Table 4.3 also revealed that with regards to the incidence of modifications with respect to the period of invention, the SUIs made more modifications within the period between 3 and 5 years ago than other periods observed during this study. This is 10% more than the modifications made in a period above 5 years, and 29% more than the numbers of modifications made recently.

Table 4-3: Bivariate Analysis of Incidence of SUIs and Period of Invention (n = 304)

		Period of Invention			
		Between 1 and 3 years ago	3 to 5 years ago	Above 5 years ago	Total
Developed or Modified	New Product	33.1	4.5	14.6	21.4
	Modified Existing product	66.9	95.5	85.4	78.6
	Total	100 (160)	100 (88)	100 (48)	100 (304)

Note. Data from Author's 2018 PhD survey.

4.3.1.2 User Innovation Expenditure in Nigerian Higher Institution

Table 4.4: Development duration of SUI's User Innovation (n = 304)

	Frequency	Percent	Cumulative Percent
1 Week	59	19.4	19.4
2 - 5 Weeks	142	46.7	66.1
6 - 10 Weeks	46	15.1	81.2
11 - 15 Weeks	13	4.3	85.5
>15	18	5.9	91.4
Work in Progress	1	.3	91.7
Total	279	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for 25 cases.

To analyze the total expenditure of the user innovation activities of the SUIs, this study explored the time and cost investment spent by the SUIs on their user innovation activities. According to Table 4.4 majority (47%) of the SUIs spent between 2 to 5 weeks working on their projects, while 19% spent at most 1 week working on their project, after which 15% of the SUIs indicated that they spent between 6 to 10 weeks on their user innovation. To understand how this duration affects the user innovation activities, a cross-tabulation of the incidence rate and the development duration was conducted, the result is presented in Table 4.5 below. From Table 4.5, it can be observed that majority of the user innovation works, which includes the summation of NPDs and modifications, were done within a period of 2 to 5 weeks. While the next was done within a week, which includes NPDs and modifications, followed by user innovation works done within the duration of 6 to 10 weeks. However, the percentage

difference analysis of this findings revealed that the modifications accomplished within 2 to 5 weeks by the SUIs is 6% higher than those accomplished within 1 week, it is also 12% higher by those accomplished within 6 to 10 weeks, and also 17% higher than those accomplished within 11 and 15 weeks.

Table 4.5: Bivariate Analysis of Incidence of SUIs and Development Duration (n = 304)

		Development Duration						
		1 Week	2 - 5 Weeks	6 - 10 Weeks	11 - 15 Weeks	>15	Work in Progress	Total
Developed or Modified	New Product	20.3	14.1	26.1	30.8	50.0	0	20.4
	Modified Existing product	79.7	85.9	73.9	69.2	50.0	100.0	79.6
Total		100 (59)	100 (142)	100 (46)	100 (13)	100 (18)	100 (1)	100 (279)

Note. Data from Author's 2018 PhD survey. Value was not determined for 25 cases.

With regards to the cost of innovation incurred by the SUIs with respect to their user innovation activities, 66% (200) of the SUIs reported the total amount spent on their user innovation expedition. This is tabulated in Table 4.6. According to the findings of this survey, it was discovered that the SUIs spent a minimum amount of ₦500 and a maximum of ₦500,000 on their user innovation. In addition, Table 4.6 indicates that majority (50%) of the SUIs spent an amount of ₦5000 or less on their user innovation cost, while according to the cross-tabulation of the incidence of the SUIs and development cost presented in Table 4.6, it was identified that a vast majority of this expenditure (92%) are spent on modifications of existing products. In addition, according to Table 4.6, it was also observed that an average amount of ₦29,395, as well as a total amount of ₦5,879,100 was spent by the SUIs on their user innovation expedition.

Table 4.6: Development Cost of SUI's User Innovation (n = 304)

Statistics	
Mean	29,395.5000
Median	5,250.0000
Mode	5,000.00
Std. Deviation	69,142.42187
Range	499,500.00
Sum	5,879,100.00

Cost of Development (Naira)	Frequency	Percent
<= 5,000	100	50.0
> 5,000 – 10,000	26	13.0
> 10,000 – 20,000	18	9.0
> 20,000 – 50,000	27	13.5
> 50,000 – 100,000	17	8.5
> 100,000 – 500,000	12	6.0
Total	200	100.0

Note. Data from Author's 2018 PhD survey. Value was not determined for 104 cases.

As can be observed from Table 4.7, 92% of the SUIs who spent ₦5,000 or less on their user innovation reported that it was spent on making modifications to existing products. The same goes for SUIs who spent between ₦5,000 and ₦10,000 on their user innovation. In addition, majority of the innovation expenditure which ranges from ₦10,000 and ₦20,000, as well as the innovation expenditure which ranges from ₦20,000 and ₦50,000 were also spent on making modifications to existing products. However, Table 4.7 revealed that as the innovation expenditure increases, the focus of the SUIs changes from modifications to the creation of NPDs. As can be seen from Table 4.7, 53% of the innovation expenditure which from ₦50,000 to ₦100,000, are spent on the creation of NPDs, while 50% of the cost of innovation above ₦100,000 was spent on NPDs and modifications projects respectively.

Table 4.7: Cross-tabulation of Incidence of SUIs and Development Cost (n = 304)

		Development Cost						
		<= 5,000	> 5,000 – 10,000	> 10,000 – 20,000	> 20,000 – 50,000	> 50,000 – 100,000	> 100,000 – 500,000	Total
Developed or Modified	New Product	8.0	7.7	11.1	18.5	52.9	50.0	16.0
	Modified Existing Product	92.0	92.3	88.9	81.5	47.1	50.0	84.0
Total		100 (100)	100 (26)	100 (18)	100 (27)	100 (17)	100 (12)	100 (200)

Note. Data from Author's 2018 PhD survey. Value was not determined for 104 cases.

Moreover, Table 4.8 indicates that majority (64%) of the user innovation done by the SUIs were self-funded, while the next high fund was a joint funding between the SUIs and other collaborators. Lastly, Table 4.8 also revealed the lack of interaction between other entities of the national innovation system (such as government, private businesses, and academic institutions), as all these entities only contributed sparingly to the user innovation activities engaged by the SUIs. Furthermore, to understand how the source of funds are distributed according to the user innovation expedition, the incidence rate of the SUIs was cross-tabulated with the sources of funds, which is presented in Table 4.9 below.

Table 4.8: Source of Funds (n = 304)

	Frequency	Percent
Self-funded	194	63.8
Jointly funded by collaborators	68	22.4
Funded by Academic Institution	11	3.6
Funded by private business organization	4	1.3

Funded by Government	3	1.0
Others	19	6.3
Total	299	98.4

Note. Data from Author's 2018 PhD survey. Value was not determined for five cases.

Table 4.9: Cross-tabulation of Incidence of SUIs and Sources of Funds (n = 304)

		Source of Funds						
		Self-funded	Jointly funded by collaborators	Funded by Academic Institution	Funded by private business organization	Funded by Government	Others	Total
Developed or Modified	New Product	24.2	7.4	54.5	50.0	33.3	10.5	21.1
	Modified Existing product	75.8	92.6	45.5	50.0	66.7	89.5	78.9
Total		100 (194)	100 (68)	100 (11)	100 (4)	100 (3)	100 (19)	100 (299)

Note. Data from Author's 2018 PhD survey. Value was not determined for five cases.

As can be seen in Table 4.9, majority of the user innovation cost spent by the SUIs was incurred on modifications made on existing products. This includes the self-funded user innovation, the jointly funded ones, the one funded by the government, and the ones funded through other means. However, Table 4.9 also revealed that 54.5% of the user innovation expenditure covered by academic institution were expended on the creation of NPDs. In addition, Table 4.9 also shows that equal amount of the funding received by the SUIs are spent both on creating NPDs and making modifications to existing products.

Lastly, a cross-tabulation of the source of funds and development cost was conducted, this is presented in table 4.10. From Table 4.10 it was discovered that majority (54%) of the self-funded project by the SUIs covers an innovation expenditure of ₦5000 or less. While majority of the projects jointly funded by the SUIs and other collaborators, as well as those funded with funds derived from other sources also costs an innovation expenditure of ₦5000 or less. In addition, Table 4.10 also identified that the SUIs were rarely funded by their academic institutions, private organizations, and by the government. However, 67% of the funding received from the academic institution ranges between ₦100,000 and ₦500,000. In addition, from Table 4.10 suggests a lack of technology learning by private firms, as well as insufficient support from the governmental structures, which could consequential to the academic institution's inability to adequately fund the SUI's user innovation projects. The implication of this finding on the national innovation system as well as on the technology adoption rate of firms will be discussed further in the discussion section.

Table 4.10: Cross-tabulation of Source of funds and Development Cost (n = 304)

		Source of Funds						
		Self-funded	Jointly funded by collaborators	Funded by Academic Institution	Funded by private business organization	Funded by Government	Others	Total
Development Cost	<= 5,000	53.6	43.4	33.3	50.0	50.0	50.0	50.0
	> 5,000 – 10,000	13.8	13.2	0	0	0	14.3	13.1
	> 10,000 – 20,000	11.4	3.8	0	0	50.0	7.1	9.1
	> 20,000 – 50,000	11.4	18.9	0	0	0	21.4	13.6
	> 50,000 – 100,000	6.5	13.2	0	50.0	0	7.1	8.6
	> 100,000 – 500,000	3.3	7.5	66.7	0	0	7.1	5.6
	Total	100 (123)	100 (53)	100 (3)	100 (2)	100 (2)	100 (14)	100 (198)

Note. Data from Author's 2018 PhD survey. Value was not determined for 106 cases.

4.3.1.3 Significance of Club Membership on User Innovation in Nigerian Higher Institution

Saint et al (2003) highlighted that the research output of Nigerian higher institutions is extremely low and insufficient to stimulate innovation-based productivity gains. Therefore, this study took this into consideration and attempts to uncover the contribution of other external small-scale initiatives, such as science or innovation clubs, as a means to stimulate innovation-based productivity gains among Nigerian higher institutions. The findings of this study is tabulated in Table 4.11 and briefly explored in this section.

Table 4.11: Incidence of Club members (n = 304)

	Frequency	Percent	Cumulative Percent
Yes	60	19.7	19.7
No	241	79.3	99.0
Total	301	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for three cases.

To understand the contribution of local science and innovation clubs as a means to encourage user innovation activities in Nigeria, Table 4.11 above shows that out of the SUIs, 79% do not belong to a local science or innovation club. Moreover, a cross-tabulation of the incidence rate of the SUIs and club members was conducted to understand the significance of science or innovation club membership on spurring user innovation activities in Nigeria. From Table 4.12 it was deduced that out of the NPDs developed by the SUIs, 23% were created by members of a science and innovation clubs, while 19% of the modifications made by these SUIs were done by members of a science clubs. Which in total sums to 20% of all NPDs and modifications made by the SUIs. Which shows that, despite the diminutive size, being a member of a science or innovation club could result in the creation of more NPDs than modification of products.

Hence, being a member of a science and innovation club encourages more user innovation activities among the Nigerian higher education students.

Table 4.12: Cross-tabulation of Incidence of SUIs and Club Member (n = 304)

		Developed or Modified		
		Developed New	Modified Existing product	Total
Club Member	Yes	23.4	19.0	20.0
	No	76.6	81.0	80.0
Total		100 (64)	100 (237)	100 (301)

Note. Data from Author's 2018 PhD survey. Value was not determined for three case.

Moreover, the SUIs were further quizzed to uncover other avenues from which they were supported during their user innovation expedition. These supports include financial assistance, workmanship, and components acquisition. Their responses are tabulated in Table 4.13. From Table 4.13, it can be observed that a great percentage (35%) of SUIs were supported by their friends, while the next significant of support (12%) received by the SUIs came from their affiliation to specific science or innovation clubs. Moreover, 11% indicated that they were supported by their families, while 7% indicated that they were supported by their course mates, and 6% indicated that they were supported by some external professional contacts. However, 27% indicated that they solely executed the user innovation expedition.

Table 4.13: Avenues of Support for SUIs (n = 304)

	Frequency	Percent
Yes, Club Members	37	12.2
Yes, Course mates	20	6.6
Yes, Family Members	32	10.5
Yes, External professional contact	18	5.9
Yes, Friends	106	34.9
No	82	27.0
Total	295	97.0

Note. Data from Author's 2018 PhD survey. Value was not determined for nine case.

4.3.2 Reasons why SUI innovate in Nigeria Higher Education system

Table 4.14: Reason for the invention (n = 304)

	Frequency	Percent
To suit my needs	165	54.3
To provide solution to a social issue	47	15.5
Project initiated as part of school project	46	15.1
I just love creating things	35	11.5
Project initiated by my Club or Association	3	1.0

Others		8	2.6
	Total	304	100.0

Note. Data from Author's 2018 PhD survey.

To ascertain the state of user innovation in Nigeria, the survey respondents were requested to indicate the reason why the product was created or modified. As depicted in Table 4.14, 54% of the respondents indicated that the product was created to meet their immediate needs, while 15.5% indicated that the products was created to solve a social issue. 15% indicated that the project was initiated as part of their school project, while 11.5% indicated that the reason for the creation or modification was due to their 'love for creating things'.

Table 4.15: Cross-tabulation of SUIs Incidence and Reasons (n = 304)

		Reason for the Invention						
		To suit my needs	To provide solution to a social issue	Project initiated as part of school project	I just love creating things	Project initiated by my Club or Association	Others	Total
Developed or Modified	New Product	7.3	44.7	30.4	37.1	0	62.5	21.4
	Modified Existing product	93.7	55.3	69.6	62.9	100.0	37.5	78.6
	Total	100 (165)	100 (47)	100 (46)	100 (35)	100 (3)	100 (8)	100 (304)

Note. Data from Author's 2018 PhD survey.

In addition, looking at the number of products created or modified according to the innovators' motivations, from Table 4.15 it can be observed that the highest incidence of the creation of NPDs done by the SUIs were done to provide solution to some other needs such as 'helping a friend', 'for business purpose' and so on. While the second highest prevalence rate of the reasons why the NPDs were created was to provide specific solutions to social issues, then followed by user innovation projects created due to the enjoyment or learning opportunities it brings to the SUIs, and followed by SUIs who created products as part of their school project. While only 7% of the SUIs indicated that the NPDs were created to meet their impending needs.

Moreover, with regards to the reason why the SUIs made modifications to existing products, Table 4.15 reveals that modifications of products occurred mostly to suit the innovator's unsatisfied needs, while almost 70% of the SUIs who modified products did so in order to complete their academic projects. Almost 63% of the SUIs modified the products due to the

sheer passion for product development. Lastly, 55% of the modifications made were done to provide solution to a social issue.

Table 4.16: Technology Sharing of SUIs (n = 304)

	Frequency	Percent	Cumulative Percent
Yes, With anyone for free	101	33.2	33.2
Yes, with selected individuals or firms	61	20.1	53.3
No	127	41.8	95.1
Total	289	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for 15 cases.

Table 4.17: Cross-tabulation of SUIs Incidence and Technology Sharing (n = 304)

		Developed or Modified		
		Developed New	Modified Existing product	Total
Technology Sharing	Yes, With anyone for free	43.1	32.9	35.0
	Yes, with selected individuals or firms	39.7	16.5	21.1
	No	17.2	50.6	43.9
Total		100 (58)	100 (231)	100 (289)

Note. Data from Author's 2018 PhD survey. Value was not determined for 15 cases.

Table 4.16 examines the SUIs willingness to share their works. The results indicate that about 53% SUIs are willing to share their works. Out of which, 33.2% are willing to engage in a peer to peer transfer with no monetary reward expected, while 20.1% indicated that they are willing to reveal their works to selected individual. Lastly, 41.8% are not interested in revealing their works. In addition, with regards to the incidence of user innovation and their willingness to share their product, Table 4.17 illustrates a large amount of SUIs (51%) who modified an existing product are unwilling to share their modification. While almost 33% of the SUIs who made modifications to a product are willing to share the modifications made with other users. However, with respect to the willingness of the SUIs to share their NPD, it was discovered that 43% of the SUIs are willing to share their invention, while almost 40% of the SUIs revealed that they are willing to share their invention with selected individuals or firms. Lastly, a minority of the SUIs are not willing to share their NPD.

4.3.3 Effect of Academic Level on User Innovation within Nigeria Higher Education Institutions

This sections aims to answer the third research question which is to uncover the role of the academic level on the user innovation activities among the surveyed SUIs. The table (4.18) below shows the distribution of the academic accomplishments of the surveyed SUIs.

Table 4.18: Academic Level of SUIs (n = 304)

	Frequency	Percent
100LEVEL	62	20.3
200LEVEL	63	20.7
300LEVEL	54	17.8
400LEVEL	25	8.2
500LEVEL	20	6.6
Master's Degree	1	0.3
HND1	25	8.2
HND2	10	3.3
ND1	2	0.7
ND2	18	5.9
TECH2	8	2.7
YEAR2	7	2.3
YEAR3	2	0.7
Total	297	100.0

Note. Data from Author's 2018 PhD survey. Value was not determined for 7 cases.

As depicted in Table 4.18 above, of the 304 SUIs identified, 74% of the SUIs are University students, 18% are in the Polytechnic, while 3% respectively are students of the College of Education and Technical college respectively. In addition, it is worth highlighting the grouping system used by the higher education systems in Nigeria. Universities group their students using 100 level to represent new students, and respectively. However, depending on the field of studies the final year student at a Nigerian university could be 400 level or in the case of Engineering and the Medical field of study the final year students could be in 500 level. Polytechnics are divided into two different stages. 1, Ordinary National Diploma (OND or ND), and 2, Higher national Diploma (HND). With these two stages comprising of two different levels (for example, OND 1 and OND 2 to represent the beginning levels at the Polytechnics). In addition, the technical colleges are grouped using TECH1 to represent the new intakes. Lastly, the Colleges of Education groups their students using YEAR1 to represent their new intakes.

From Table 4.18 above, it can be observed that information was collected from respondents in all academic levels in the University, and Polytechnic. While only one level of study was represented by Technical College, and only two levels of education were represented by the College of Education. In furtherance, to answer the research question on the impact of the academic accomplishment of the SUIs to their user innovation activities, a cross-tabulation analysis of the academic level and the type of user innovation will be conducted.

Table 4.19: Cross-tabulation of Academic Level and Incidence Rate of SUIs (n = 304)

	Incidence of SUIs		
	Developed (New)	Modified (Existing product)	Total
100LEVEL	4	58	62
200LEVEL	10	53	63
300LEVEL	9	45	54
400LEVEL	7	18	25
500LEVEL	8	12	20
Master's Degree	0	1	1
HND1	8	17	25
HND2	3	7	10
ND1	0	2	2
ND2	7	11	18
TECH2	3	5	8
YEAR2	4	3	7
YEAR3	0	2	2
Total	63	234	297

Note. Data from Author's 2018 PhD survey. Value was not determined for 7 cases.

To fully understand the impact of the academic level to the incidence rate of the SUIs as presented in the cross-tabulation analysis depicted in Table 4.19 above, a percentage difference analysis will be conducted between the different academic levels. These analyses will be presented in the subsections below.

4.3.3.1 Impact of Academic level on the User Innovation Activities of University SUIs

Table 4.20: Percentage Difference Analysis of University Level and Incidence Rate of SUIs (n = 304)

	Incidence of SUIs		
	Developed (New)	Modified (Existing product)	Total

Academic Level	100LEVEL	11	31	28
	200LEVEL	26	29	28
	300LEVEL	24	24	24
	400LEVEL	18	10	11
	500LEVEL	21	6	9
	Total	100 (38)	100 (186)	100 (224)

Note. Data from Author's 2018 PhD survey.

As depicted in Table 4.20 above, two different findings can be observed. As one would presume that students in the lower level of education should not be more innovative than the senior SUIs. In the first discovery of this analysis with respect to the creation of new products, drawing a conclusion on the significance of the academic level of the SUIs resulted in an inconclusive finding. In that, the increase in academic level did show a sign of a partial effect on the ability of the SUIs to engage in user innovation activities. However, there is no linear growth trend in the findings. As the highest incidence of NPD was evident among the 200 level SUIs, which is followed by a regressing value by the 300 level SUIs. In addition, with respect to the impact of the academic level to the abilities of SUIs to make modifications to existing products, this analysis affirms that lower level SUIs tend to make more modifications than the senior students. The reason behind this disparity between these findings will be explained in section 4.4.3. The next subsection will conduct the same percentage analysis to identify the effect of the academic level on the innovativeness of the SUIs in the Polytechnic system.

4.3.3.2 Impact of Academic Level on the User Innovation Activities of Polytechnic SUIs

Table 4.21: Percentage Difference Analysis of Polytechnic Level and Incidence Rate of SUIs (n = 304)

		Incidence of SUIs		
		Developed (New)	Modified (Existing product)	Total
Academic Level	ND1	0	5	4
	ND2	39	20	33
	HND1	44	31	45
	HND2	17	13	18
	Total	100 (18)	100 (37)	100 (55)

Note. Data from Author's 2018 PhD survey.

Contrary to the findings identified from the analysis of the University students in the previous subsection, Table 4.21 indicates a skewed growth pattern in the relationship between the effect of the academic level on the incidence of user innovation among the SUIs in Polytechnic system, this is evident both in the creation of NPDs and modifications to existing products. The reason for these skewed findings cannot be easily understood. So many factors beyond the focus of this studies could be responsible.

4.3.3.3 Impact of Academic Level on the User Innovation of Colleges of Education SUIs

Table 4.22: Percentage Difference Analysis of College of Education Level and Incidence Rate of SUIs (n = 304)

		Incidence of SUIs		
		Developed (New)	Modified (Existing product)	Total
Academic Level	YEAR2	100	60	78
	YEAR3	0	40	22
	Total	100 (4)	100 (5)	100 (9)

Note. Data from Author's 2018 PhD survey.

As can be seen from Table 4.22 above, in the College of Education system, the lower level SUIs, engage more in the creation of NPDs and modifications to existing products than the senior SUIs. The reason for this trend cannot be understood. As it is naturally expected that senior SUIs, due to their advanced academic skills, should be more involved in innovation activities than the lower level SUIs.

Lastly, there is insufficient data to elicit the impact of academic accomplishments to the user innovation abilities of the SUIs at the technical college. Therefore, a study focusing specifically on the impact of academic level on user innovation activities would be ideal in uncovering this information. The next section will explore the role of gender on the user innovation activities among the SUIs.

4.3.4 Role of Gender classification on User Innovation in Nigeria

Table 4.23: Gender Classification of SUIs (n = 304)

	Frequency	Percent
Male	238	78.3
Female	66	21.7

Total		100.0

Note. Data from Author's 2018 PhD survey.

Table 4.24: Cross-tabulation of SUIs Incidence and Gender Classification (n = 304)

		Gender		
		Male	Female	Total
Developed or Modified	New Product	22.7	16.7	21.4
	Modified Existing product	77.3	83.3	78.6
	Total	100 (238)	100 (66)	100 (304)

Note. Data from Author's 2018 PhD survey.

Table 4.23 depicts the role of gender on the SUI activities. From Table 4.23, it was discovered that in general, the user innovation activities among Nigerian higher education students is male dominant. As depicted in Table 4.18, 78% of the SUIs are Males, while the remaining 22% are females. Elaborating further, Table 4.24 illustrates that almost 23% of the Male SUIs developed NPD, while majority (77%) modified an existing product. In addition, 17% of the Female SUIs developed a new product, while 83% have modified existing products. Taking a percentage difference of the implications of gender on the user innovation activities among Nigerian higher education students, this study discovered that male SUIs are more focused on the creation of new products than female SUIs, while this study also discovered that with regards to modifying existing products, female SUIs are more dominant.

Table 4.25: Cross-tabulation of SUIs Gender classification with the reason for invention (n = 304)

		Reason for the Invention						
		To suit my needs	To provide solution to a social issue	Project initiated as part of school project	I just love creating things	Project initiated by my Club or Association	Others	Total
Gender	Male	71.5	87.2	80.4	94.3	66.7	87.5	78.3
	Female	28.5	12.8	19.6	5.7	33.3	12.5	21.7
	Total	100 (165)	100 (47)	100 (46)	100 (35)	100 (3)	100 (8)	100 (304)

Note. Data from Author's 2018 PhD survey.

In addition, further correlations were conducted to study whether gender plays any role on the reason for the NPD or product modification. From Table 4.25, it was observed that most males engaged in their user innovation activities due to their found love for creating things, which is then followed by 87.5% male SUIs who engage in user innovation for other reasons. While another 87% male SUIs indicated that their reason for engaging in user innovation is to solve a specific social issue. 80% of the male SUIs indicated that their user innovation activities

were done as part of their school project. Lastly, 71.5% of the male SUIs indicated that their user innovation activities were done to meet their specific needs.

Meanwhile, with respect to the effect of the female gender on the reason why the invention was created, Table 4.25 depicted that the major reason why the female SUIs engaged in user innovation was due to their being involved in a science club or association. In addition, 28.5% of the female SUIs also indicated that the other main reason for engaging in user innovation is to create or modify a product to suit their impending needs. While almost 20% also indicated that their user innovation activities were done as part of their school projects, while almost 13% indicated that they got involved in user innovation to solve a particular social issue.

4.3.5 Identify the types of products developed

Table 4.26: Types of Invention (n = 304)

	Frequency	Percent	Cumulative Percent
Agricultural/Mechanical Equipment	16	5.3	5.3
Electrical Equipment	50	16.4	21.7
Health/Medical Equipment	95	31.3	53.0
IT/Software Application	26	8.6	61.6
Education	10	3.3	64.6
Household Equipment	87	28.6	93.5
Others	6	2.0	95.5
Total	290	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for 14 cases.

Furthermore, from Table 4.26 it was discovered that majority (31%) of the product developed by the SUIs are health related products, followed by almost 29% household equipment. In addition, 16% of the products developed by the SUIs are Electrical products, while almost 9% are IT or software products, 5% are Agricultural and mechanical products, 3% are educational products, while the remaining 2% are other products which includes animations, website, architectural modelling tool, and food related product. Lastly, Table 4.27 depicts the relationship between the types of user innovation and the types of invention created by the SUIs. From Table 4.27, it can be observed that the major NPD developed are other products and electrical equipment. This is then followed by 26% health or medical equipment, and 19% agricultural or other mechanical products. While the highest product modified by the SUIs is household equipment (94%), which is almost 10% more than the modifications made on software related products, 13% more than the modifications made to agricultural products,

14% more than the modifications made to education products, 20% more than modification on 70 health/medical equipment, and 28% more than those made to the electrical equipment.

Table 4.27: Cross-tabulation of SUIs with Types of Invention (n = 304)

		Types of Invention							
		Agricultural/Mechanical Equipment	Electrical Equipment	Health/Medical Equipment	IT/Software Application	Education	Household Equipment	Others	Total
Developed or Modified	New Product	18.8	34.0	26.3	15.4	20.0	5.8	50.0	20.3
	Modified Existing product	81.2	66.0	73.7	84.6	80.0	94.2	50.0	79.7
Total		100 (16)	100 (50)	100 (95)	100 (26)	100 (10)	100 (87)	100 (6)	100 (290)

Note. Data from Author's 2018 PhD survey. Value was not determined for 14 cases.

Table 4.28: Cross-tabulation of gender with Types of Products (n = 304)

		Types of Invention							
		Agricultural/Mechanical Equipment	Electrical Equipment	Health/Medical Equipment	IT/Software Application	Education	Household Equipment	Others	Total
Gender	Male	81.3	90.0	87.4	65.4	30.0	70.1	100.0	79.0
	Female	18.7	10.0	12.6	34.6	70.0	29.9	0	21.0
Total		100 (16)	100 (50)	100 (95)	100 (26)	100 (10)	100 (87)	100 (6)	100 (290)

Note. Data from Author's 2018 PhD survey. Value was not determined for 14 cases.

Lastly, despite the male dominance, Table 4.28 reveal some vital information about the product focus of both genders. Looking at the kind of product focus of keen interest to the female SUIs, this study discovered that a high prevalent number of women focused on educational products, followed by IT/software products, then household products, then agricultural equipment, and then followed by health/medical products. Which to proves the findings of Mendonca et al. (2012), who discovered that the female user innovators in Portugal develop solutions related to children and education, software and health. However, detailed implications of all these findings will be presented in the following section.

In addition, with regards to the effect of gender on the type of invention of interest to the male SUIs, from Table 4.28 depicted that the SUIs are keenly interested in the electrical equipment, then followed by health or medical equipment, then agricultural or mechanical equipment, then household equipment, followed by IT or software related products, and lastly by education products. One remarkable findings of this study is that female SUIs are more focused on educational components than the male SUIs.

4.3.6 Commercialization of User Innovation

As indicated in section 1 and 1.8 above, innovations developed by users often find their route to the market, either through manufacturers that takes advantage of the willingness of users to freely share their product invention, or through users that after the innovation process decided to proceed into creating a user enterprise from their innovation efforts. Hence the reason it was called innovation in the first place. With regards to the commerciality of these innovations, this section explores the success rate and novelty of the user innovation expeditions by the SUIs. in addition, this section also presents two additional information. Firstly, about the protection mechanisms used (if any) by the SUIs to protect their innovations. Secondly, information about the willingness of the SUIs to share their invention with others.

4.3.6.1 Success Rate and Novelty of User Innovation

Table 4.29: Success rate of SUI's User Innovation (n = 304)

Success Rate			
	Frequency	Percent	Cumulative Percent
Complete success	111	36.5	36.5
Partial success	109	35.9	72.4
Unsuccessful	31	10.2	82.6
Yet to be tested with other users	44	14.5	97.1
Total	295	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for nine cases.

During the data gathering phase of this study, the SUIs were asked to provide information about the success rate and novelty of their invention, as well as whether they applied for IPR for their invention. From Table 4.29, it can be observed that with respect to the success rate of the SUIs user innovation, majority (72%) of the SUIs indicated that their innovation was either a complete success or was partially successful, while 15% of the SUIs were yet to test the invention to ascertain the successfulness. In addition, 10% of the SUIs indicated that their user innovation was unsuccessful. The possible reason behind this high success rate and the minimal unsuccessful rate will be elaborated and presented in the discussion section of this phase.

Table 4.30: Novelty of SUI's User Innovation (n = 304)

	Frequency	Percent	Cumulative Percent
To few people	217	71.4	71.4

To many people but not all	62	20.4	91.8
To everyone, It is totally novel	21	6.9	98.7
Total	300	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for four case.

Moreover, with regards to the novelty of the inventions. Table 4.30 indicated that 71% of the SUI's user innovation was only considered 'novel to few people', which correlates to the high incidence rate of modifications discovered in section 4.3.1 above. Moreover, 20% of the SUIs indicated that their work is 'novel to many people but not all', while 7% indicated that their user innovation was of a radical nature therefore totally new to everyone.

Table 4.31: Cross-tabulation of Incidence of SUIs and Novelty of Invention (n = 304)

		Novelty of Invention			
		To few people	To many people but not all	To everyone, It is totally novel	
Developed or Modified	New Product	16.6	30.7	42.9	21.3
	Modified Existing product	83.4	69.3	57.1	78.7
	Total	100 (217)	100 (62)	100 (21)	100 (300)

Note. Data from Author's 2018 PhD survey. Value was not determined for four case.

In addition, the findings of the novelty and the incidence rate of the user innovation were cross-tabulated, this was presented in Table 4.31 above. According to Table 4.31, it can be observed that 17% of the user innovations considered as 'novel to few people' are NPDs, while the remaining 83% were modifications made to existing products. Furthermore, 31% of the user innovation that were considered 'novel to many but not all' are NPDs, while the majority (69%) are modifications. Lastly, 43% of the totally new user innovation are NPDs, while the remaining 57% are modifications to existing products. Therefore, taking a percentage difference of this finding, it was discovered that the innovation considered to be totally new are 12% more than those considered to be new to many people but not all, and 26% more than innovation considered new to few people.

4.3.6.2 Intellectual Property Rights of User Innovation

Just like every other forms of innovation, user innovation outputs can also be protected by any protection mechanism the innovator finds relevant for their innovation. These protective mechanisms include: patents, Technical protection, Confidential agreement, trademark,

copyright, and trade secrecy. Therefore, this section explores the protection mechanisms used by the SUIs to protect their innovation. The findings are presented in Table 4.32.

Table 4.32: Intellectual Property Rights of SUI's User Innovation (n = 304)

	Frequency	Percent	Cumulative Percent
Yes, Patent	16	5.3	5.3
Yes, Technical Protection	13	4.3	9.6
Yes, Confidentiality Agreement	4	1.3	10.9
Yes, Trademark	4	1.3	12.2
Yes, Copyright	12	3.9	16.1
Yes, Secrecy	1	.3	16.4
No	241	79.3	95.7
Total	291	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for thirteen cases.

With regards to the intellectual property rights of the user innovation. Table 4.32 revealed that only 5% of the SUIs successfully applied for IPR for their project, and this was done at the local level in Nigeria. Moreover, 4% of the SUIs has successfully applied for a technical protection and copyright for their invention, while there is only 1% confidential agreement between the SUIs and some unknown parties. In addition, another 1% has successfully trademarked their innovation. However, majority of the SUIs (80%) did not file for an IPR. The reasons behind this could be due to their willingness to share which will be next explored, or it could also be due to the awareness of the SUIs about the intellectual property rights of the existing products modified, or the complexities of applying for IPR in Nigeria which includes costs. All these will be detailed in the discussion section of this study.

Moreover, to understand how these user innovation expeditions relates to the IPR attempts by the SUIs, a cross-tabulation of the incidence rate of the user innovation and IPR rate was conducted, followed by a cross-tabulation of the IPR rate with the novelty of the user innovation activities. These findings are presented in Tables 4.33 and 4.34 below. From Table 4.33 it can be observed that 44% of the patent filed for were for NPDs, while the remaining 56% are for modifications to existing models. 14% of the technical protection covers NPDs, while majority (75%) of the confidential agreement covers NPDs. In addition, it can be observed that 50% of the trademark and copyright filed for the user innovation are for the NPDs. While 67% of the NPDs are unprotected, as well as 87% of the modifications.

Table 4.33: Cross-tabulation of Incidence of SUIs and Intellectual Property Rights (n = 304)

	Intellectual Property Rights

		Yes, Patent	Yes, Technical Protection	Yes, Confidentiality Agreement	Yes, Trademark	Yes, Copyright	Yes, Secrecy	No	
Developed or Modified	New Product	43.8	15.4	75.0	50.0	50.0	0	17.0	21.0
	Modified Existing product	56.3	84.6	25.0	50.0	50.0	100.0	83.0	79.0
Total		100 (16)	100 (13)	100 (4)	100 (4)	100 (12)	100 (1)	100 (241)	100 (291)

Note. Data from Author's 2018 PhD survey. Value was not determined for 13 cases.

Table 4.34 depicts the relationship between the novelty of the invention and the protection mechanisms use by the SUIs. As can be seen in Table 4.34, with regards to the innovations considered to be new to few people, a high incidence of protection such as technical protection, copyright and secrecy were discovered to be more utilized by the SUIs. The only question is why do this SUIs choose to use these types of protection mechanisms for their innovation? Could it be due to the ease of using this protection mechanism or due to the type of innovation made by the SUIs? In addition, this study also identified a high incidence of protection such as patent, confidential agreement, and trademark was utilized by the SUIs whose user innovation were considered to be new to many but not all.

Lastly, Table 4.34 also revealed that the totally new user innovations used almost 7% patents, and 8% technical protection and copyright respectively to protect their invention. However, von Hippel (2005) suggested that most user innovations are freely shared by the innovators, the following section will attempt to uncover the openness of the SUIs to share their innovation freely, if not, the commercialization rate of their innovation will also be presented.

Table 4.34: Cross-tabulation of Intellectual Property Rights to Novelty of Invention (n = 304)

		Intellectual Property Rights							
		Yes, Patent	Yes, Technical Protection	Yes, Confidentiality Agreement	Yes, Trademark	Yes, Copyright	Yes, Secrecy	No	Total
Novelty of Invention	To few people	13.3	53.8	33.3	25.0	83.3	100.0	77.8	72.5
	To many people but not all	80.0	38.5	66.7	75.0	8.3	0	15.5	20.9
	To everyone, It is totally novel	6.7	7.7	0	0	8.3	0	6.7	6.6
Total		100 (15)	100 (13)	100 (3)	100 (4)	100 (12)	100 (1)	100 (239)	100 (287)

Note. Data from Author's 2018 PhD survey. Response was not determined for 17 cases.

4.3.6.3 Commercialization Rate of User Innovation

Table 4.35: Adoption rate of SUI's User Innovation (n = 304)

	Frequency	Percent	Cumulative Percent
Yes	107	35.2	35.2
No	178	58.6	93.8

Total	285	100.0	

Note. Data from Author's 2018 PhD survey. Response was not determined for 19 cases.

To understand the commercialization rate of the user innovation, this study first explored whether the innovations developed by the SUIs have been adopted. This was done by asking the SUIs to provide information about the adoption rate of their innovation. The response is presented in Table 4.35. From Table 4.35, it can be observed that majority (59%) of the user innovation has not been adopted by any firms. While 35% of the SUIs indicated that their user innovation has either been adopted by firms or other users. Moreover, to better understand the commercialization rate of these user innovation, this study also will attempt to assert the willingness of the SUIs to share their innovation. This is vital because according to von Hippel (2005) and De Jong & von Hippel (2009a), innovation shared by users enhances social welfare, and also results into information spillovers which are beneficial to manufacturers. This results are tabulated in Table 4.36.

Table 4.36: Technology Sharing rate of SUI's User Innovation (n = 304)

	Frequency	Percent	Cumulative Percent
Yes, in exchange for something of value	36	11.8	11.8
Yes, for a fee	85	28.0	39.8
No, I made it open on the online open source platform	17	5.6	45.4
No, but I plan to make it open on the online open source platform	65	21.4	66.8
No, I have no such Intention	18	5.9	72.7
Others	9	3.0	75.7
Total	230	100.0	

Note. Data from Author's 2018 PhD survey. Response was not determined for 74 case.

While with respect to the Technology sharing rate, according to Table 4.36, the highest incidence of the SUIs (28%) indicated that their innovative effort has been commercialized for a fee, while 12% of the user innovation was traded for something valuable to the SUIs. Which in total indicates that 40% of the user innovation by the SUIs have been commercialized, either for a fee or in exchange for another product. However, Table 4.36 also revealed that a total of 27% of SUIs have either revealed their invention or plan to freely reveal it on an open source platform. While 6% indicated that they had no plans of commercializing their innovation. The significance of this section will be detailed in the discussion section of this research study. The next section explores the limitations to the user innovation activities in Nigeria. This was done by asking the SUIs to list the major impediments to their innovation activities.

4.4 Discussion

This study's analysis presented in the preceding section has demonstrated that user innovation activities does exist among Nigerian higher education students. The findings of this study and its implications on future studies will be thoroughly discussed in this section. This discussion will be presented based on the research questions attempted by each segments.

4.4.1 Prevalence Rate of User Innovation in Nigeria Higher Education

First and foremost, this research study has uncovered that almost 10% of the Nigerian higher education students are user innovators. Hence aligning with the high incidence rate of user innovation within the age group 15 – 34 discovered by Flowers et al. (2010). From the findings presented in this chapter, it was discovered that a high incidence of SUIs are more interested in modifying existing products than creating a new product. Which also correlates to the findings by Flowers et al (2010), which discovered that the consumer user innovator in the UK are more focused on modifying existing products than creating a new product from the scratch. Moreover, majority of this user innovations were done recently, which could be due to the advancement in technological infrastructure in the country, or the increased level of technological exposure now available to Nigerian students. In addition, other reasons as envisioned in this study could also be the emergence and propagation of open- source technological approaches and initiatives.

In addition, since the opulence of any economy is partly dependent on the innovative activities within the borders of the country, and since some notable commercial products are as a result of innovation 'spillovers' from undeserved users who innovated to solve their immediate need. This study also discovered that majority of the user innovation expeditions of the SUIs were self-funded and mostly created within 6 weeks of project inception. One key finding from this is the determination of the SUIs in developing their project despite the insufficient support received from government, public institutions, and private institutions

Therefore, the significance of this finding is relevant in indicating applicable policies and corporate practices which could be invigorated and explored by policymakers and corporate

firms to achieve social ambience. As suggested by Saint et al (2003), for innovation to thrive and accomplish its benefits in an economy, there must be a public policy that shapes the innovative capacity by investing intensely in human capital development and creates incentives for innovation. This indicates that for user innovation to thrive in emerging economies, there must be adequate external support for the user innovators. As this is confirmed from the findings in Table 4.13 where a cumulative amount of 70% of the SUIs received some sorts of support from external sources. In addition, though the prevalence is not significant enough, the findings from this study shows traces that being a member of a science and innovation club could further encourage user innovation activities in emerging economies, as members of clubs were also identified to provide suitable support to the SUIs during their innovation process.

4.4.2 Reasons why SUI Innovate

As highlighted in existing studies on user innovation, user innovation occurs when the critical needs of lead users are unmet by the existing commercial products. Therefore, these lead users either modifies the existing product or creates a new one to meet his critical need (von Hippel, 1976; 1979; 1988; 2005; 2009; Raasch et al., 2008; Flowers et al., 2009; 2010; De Jong & von Hippel, 2009a; 2009b; Foxall, 1986; Rothwell, 1986; Lee, 1996; Füller et al., 2013; Morrison et al., 2000; Franke & Shah 2003; Franke & von Hippel 2003; Lüthje et al., 2005; Shah & Tripsas, 2016; Henkel & von Hippel, 2005). With regards to the reason why the SUIs ventured into user innovation, this study has revealed that most SUIs in Nigeria got involved in user innovation so as to provide solution to their unmet needs, as well as to provide solution to an identified social issue. Therefore, confirming the findings from existing studies that indicates that most users innovate in order to meet their immediate need (von Hippel, 2005; von Hippel & Jin, 2009; Flowers et al., 2010).

Moreover, from the findings presented in this chapter, it was discovered that a majority of the modifications done by these SUIs were done to meet their needs which the existing commercial products failed to meet. In addition, this study also identified a small incidence of SUIs who created new products to meet their critical needs. Despite the small incidence rate of SUIs interested in creating new products, this study also discovered that a majority of the

SUIs are also engaged in user innovation due to other reasons such as, 'to provide solutions to a social issue' and 'I just love creating things'. Hence aligning with the high incidence rate of user innovation within the age group 15 – 34 discovered by Flowers et al., (2010), as well as the statement cited by von Hippel (2009) which indicated that additional incentives such as the psychological value placed on the innovation process by the user, as well as the enjoyment derived from product development could encourage users to innovate. However, this study did not focus on the implication of agency costs on the user innovation abilities of Nigerian higher education students.

4.4.3 Effect of Academic Level on User Innovation within Nigeria Higher Education Institutions

With regards effect of the academic level on the user innovativeness of the surveyed SUIs, this study discovered an inconclusive result in the relationship between the academic level and the incidence of user innovation. Based on presumption, one would expect an outright level of innovativeness from the senior level SUIs on both types of user innovation (that is, creation of NPDs and modifications to existing products). However, the study uncovered some surprising results on all the higher education system.

Contrary to expectations, with regards to modifications made to products, a regressing growth trend was identified among the University SUIs and the SUIs in the Colleges of Education. This study uncovered that junior SUIs are more involved in modifications than the senior SUIs. While the study also identified that in the College of Education, junior SUIs are more user innovative than senior SUIs with the creation of NPDs. The reason for this surprising result could be partially traced to the intensity of the study schedule and workload the senior SUIs are expected to be engaged in order to finish their studies. To some extent one could assume that junior SUIs have more time to be engaged in innovative activities than the senior SUIs. However, this is yet to be empirically ascertained. In the absence of existing studies on the role of academic level on the innovativeness of students. One is left with little option than to recommend a further study focusing on exploring the full impact of academic levels on the innovativeness of the higher education students should be conducted. This will help to ascertain the cause of the inertia discovered in this study.

4.4.4 Role of Gender Classification on User Innovation

With regards to the incidence of SUIs by gender and its implications on the user innovation activities among the Nigerian higher education students, this study discovered that Male SUIs in Nigeria engage in user innovation about thrice as often as the female SUIs. This is an improvement over the findings by Flowers et al., (2010) which indicated that male user innovators tend to innovate twice as more as the females. In general, this is not a surprising discovery, as existing studies has often cited the inequality of the involvement of both genders in STE as a global issue (Aguele & Uhumuavbi, 2003; Aguele & Agwagah, 2007). Moreover, from a developing country's context, one would expect the potential contribution of women in Science, Technology, Engineering (STE) to likewise be undervalued, and underutilised due to cultural beliefs, societal norms, and religious influences.

In addition, this study also identified a unique role played by the gender distribution on the user innovation abilities of the SUIs. As discovered in this study, male SUIs are more focused on the creation of new products than female SUIs, while this study also discovered that female SUIs are more oriented towards making modifications to existing products than male SUIs. the exact reason behind this discovery is unknown, and baffling. However, this is worthy of been studied further in another research study. Moreover, this study also identified that most Male SUIs engage in user innovation due to the love or enjoyment they derive from project development, then followed by their keen interest in providing solution to some social issues, then due to their school projects, which is then followed by their keen interest to solve their needs. These findings uncovered that Male user innovators are less interested in meeting their needs but are mostly involved in user innovation due to their passion for creating things. Which is expected of a masculine demeanour.

In addition, with regards to the role played by feminism on the reason for user innovation, this study identified that most females in the Nigerian higher education system are involved in user innovation due to their involvement in a science or innovation club, which specifically supports the assertion made earlier in section 4.4.1 on the significance of club membership on promoting user innovation activities in emerging economies. This study also showed that

the secondary reason female SUIs are engaged in user innovation is so as to meet their needs. The significance of this discovery is because this is the first instance in the study of user innovation where the effect of gender was correlated to the reasons for innovation.

Evidently so, existing studies on the role of women in STE revealed that women are generally under-represented in almost all STE field (NACETEM, 2010b; Salami, 2007; FME, 2003; Saint et al., 2003). Therefore, in order to know the most innovative among both genders, attempts were made to conduct a comparative analysis between the enrolment level of both males and females into a tertiary institution in Nigeria, especially into the STE, and the incidence of user innovation based on gender discovered in this study. These attempts included a search for data on both male and female enrolment into the tertiary institutions from the UNESCO Institute of Statistics (UIS), World Bank's data, data from Nigeria's Federal Ministry of Education, as well as data from Nigeria's National Universities Commission (NUC). The gathered data were either too generic or a significant amount of the data are missing, which makes them impossible to extrapolate the needed. However, NACETEM (2010b) reported that despite a 77% increase in female enrolment into STE fields experienced in Nigeria in the past decade, males still take up 75% enrolment into STE both at the undergraduate and postgraduate level. Moreover, further analysis of gender distribution on enrolment into Sciences and Engineering according to their geopolitical zone in Nigeria unveils a remarkable finding. From this finding it was discovered that at least twice as many female students enrolled into Science courses in the South West region, from a period of 1995 to 2004. While in the remaining four geopolitical zones, the female enrolment covers one third of the total enrolment (NACETEM, 2010b).

In addition, with regards to the engineering field, it was discovered that female contributes between a third or a quarter of the total enrolment in all the geopolitical zones (NACETEM, 2010b). Several factors are liable for this vast differential experience, some of which include, social economic factors, family influence, traditional values, societal-perception, and religious stance among others (Salami, 2007; FME, 2003; Obasi, 1997; Anugwom, 2009). Therefore, this study posits the reason behind the dominance of male SUIs could be due to the influences of these issues, which directly links men to technical fields such as engineering, while women are stereotyped into feminine roles of housewives, nurses, teachers, secretaries, social workers

among others (Chovwen, 2003; NACETEM, 2010b; Salami, 2007; Obasi, 1997). However, this study actually found traces of this perception in the product focus of female SUIs, which is predominantly education, household and health/medical equipment. This will be further elaborated in the following section which discusses the types of products created by the SUIs.

4.4.5 Types of Products Developed by the SUIs

With regards to the types of product developed by the SUIs, this study identified health and medical related equipment to be the predominant type of innovation created by the SUIs. which is then followed by household equipment. However, further analysis revealed that the predominant type of new product created by the SUIs is electrical equipment followed by health or medical equipment. In addition, this study also revealed that household equipment is the predominant product modified by the SUIs, which is then followed IT or software products and agricultural or mechanical equipment.

Moreover, this study also revealed the impact of gender on the types of products developed by the SUIs. one remarkable finding is that female SUIs are more focused on educational technologies than the male SUIs. which affirms the findings by Mendonca et al. (2012), who discovered that the female user innovators in Portugal develop solutions related to children and education, software and health. The major reason behind this could be due to the female instinct to want teach or it could also be traced to the stereotypical role of societal norms and cultural beliefs identified in section 4.4.3 above. However, this remains to be proved. In addition, this study has identified that male SUIs focus more on the creation or modification of electrical equipment, followed by health or medical equipment, which is then followed by agricultural and other mechanical equipment.

4.4.6 Commercialization of User Innovation

This study found that majority of the user innovation activities of the SUIs are successful, but not totally novel. Speculations about the reason behind this high success rate cannot be stated. Moreover, majority of Nigerian higher institution students did not protect their innovation. Possible reason behind the lack of protection was cited as the complexities of

implementing protective mechanisms for their innovation. However, the highest form of protection used by the SUIs is patent application.

In addition, the findings of this study also indicates that majority of the SUIs are willing to do a peer to peer transference of knowledge without expecting a monetary reward, thus confirms the findings from previous studies (Benkler, 2006; Kim & Hyunho 2010; Henkel & von Hippel, 2005; von Hippel 2005; Allen, 1983; Nuvolari, 2004; Franke and Shah, 2003; von Hippel and Finkelstein, 1979; Morrison et al., 2000; De Jong and von Hippel, 2008, 2009a). Moreover, by free revealing their innovations, SUIs can achieve several benefits such as social return on investment, which could in turn increase the job prospects (Allen, 1983; Lerner & Tirole, 2002; de Jong & von Hippel, 2009). In addition, by free revealing their innovation, SUIs increases the impact of their innovation, increase access to valuable feedback to enhance their innovation efforts (De Jong & von Hippel, 2009a; Raymond, 1999; Harhoff et al., 2003). Moreover, the innovation spillovers created by the user innovation activities could be a significant source of more entrepreneurial activities in emerging economies, thereby enriching the livelihood of the citizens.

Lastly, with regards to the claim that 'in order to be termed as user innovation, the innovation must have a direct link to the market' (Gault 2012; OECD, 2005), this study found glimpses of the presence of this commercialization link between the consumer and the producer. This was evident in the adoption rate of the user innovations developed by the SUIs, as the findings revealed that one third of the innovations developed by Nigerian higher education students have been adopted by firms or by other users. However, the low adoption rate confirms the findings by De Jong et al (2015) which states that only a minority of the solution developed by users are adopted by others.

4.5 Conclusion

The empirical findings suggested in this phase has emphasized the potential significance accrued to user innovation, which would be advantageous to the growth and development of emerging economies considering the existent of issues such as insufficient R&D expenditure among others. These added advantages include: the provision of free access to innovative

ideas, which inadvertently could yield more NPDs, or customer-centric or user-friendly products with a shorter route to market, reduced R&D expenditure, and high profit margin for any organization or country. Therefore, it is believed that the empirical findings presented in this paper will be beneficial to both SMEs and big firms in emerging economies, by providing foundational structure to maximize the user innovation opportunities emanating from the tertiary institutions present within their borders, as well as to push more for stringent collaborative effort with higher education institutions within their locale.

5 Measuring User Innovation in Nigeria Small Medium Enterprises

Synopsis

Apart from many other benefits, SMEs has been identified to play a key role in promoting a sustainable economic growth, through the creation of jobs at relatively low capital cost, as a viable means in alleviating poverty, and as an adequate means for accelerating rapid industrialization growth. Due to the significant role played by SMEs in fortifying an economy as well as both their financial and technological capabilities, existing studies on user innovation gave more priority to exploring the user innovation activities of SME firms than individual users. To this effect, this chapter will present the results of the research survey conducted to uncover the prevalence of user innovation among Nigerian SMEs. Other issues such as the effect of firm's age and size on their user innovation activities will also be presented. Lastly, other factors such as the innovation expenditure of the SME firms and their intellectual property rate, and the technology transfer approach used will also be presented in this chapter. Lastly, this chapter ends with a case study review of two key examples of user innovations in Nigeria.

5.1 Introduction

In the light of the ongoing global focus on sustainable development especially in emerging economies, SMEs becomes a key determinant in promoting a sustainable economic growth. Some important findings have been discovered about SMEs and their innovative abilities. SMEs, according to Laursen & Salter (2004), Lee et al (2010) and Gunasakaran et al (2011), have been identified to possess enough potential for innovative capacity, even more, than larger firms in terms of radical innovation. Furthermore, Audretsch & Vivarelli (1996) and Wade (2014) indicated that SME firms tend to possess the ability to generate a higher productivity from their R&D expenditures than larger firms. However, other studies asserted that SMEs, especially those in emerging economies, are more focused on making incremental

modifications to existing products than seeking radical breakthrough innovations (Egbetokun et al., 2007; Abubakar et al., 2019; Rosenberg, 1992; Goedhuys & Sleuwaegen, 2010).

Other benefits accrued to the existence of SMEs in an economy include: creation of jobs at a relatively low capital cost (Akingunola, 2011; Okpara, 2009; Apulu & Ige, 2011; Apulu & Latham, 2010; Mutula & Brakel, 2006; Terungwa, 2012; Aremu & Adeyemi, 2011), an adequate avenue for poverty alleviation (Aremu & Adeyemi, 2011; Okpara, 2011; Aina, 2007; Etuk et al., 2014; Agwu, 2014), the ability to guarantee the reduction income disparities (Akinguola, 2011; Okpara, 2009; Agwu, 2014; Juliana, 2013), means for the acceleration of rapid industrialization (Harris & Gibson, 2006; Sauser, 2005; Eeden et al., 2004; Arinaitwe, 2006; Kiggundu, 2002; Yusuf & Schindehutte, 2000; Monk, 2000; Goedhuys & Sleuwaegen, 2000), the creation of semi-skilled and skilled workers for future industrial endeavours (Akingunola, 2011; Okpara, 2009;), adequate utilization of rural technology for the production of intermediate goods (Aina, 2007), SMEs also provide a bilateral connection between diverse sectors of many economies (SMEDAN, 2005). Lastly, SMEs offer an excellent avenue for the incubation of entrepreneurial and managerial talents (Okpara, 2009; Akingunola, 2011).

In addition, SMEs were also identified to possess a high advantage in accelerating innovation due to their specificity and flexibility (Lee et al., 2010; Gunasekaran et al., 2011). However, due to internal resource constraints, SMEs are identified to involve other firms in their innovation process, which enables them recognize the importance of both internally and externally sourced information acquired from collaboration with other elements of the innovation system (Lee et al., 2010; Acs, 2002; Abubakar et al., 2019; Edwards et al., 2005; Narula, 2004). Moreover, there are significant amount of literature that highlighted the economic importance of SMEs in its ability to strengthen an economy. SMEs have been identified to play a crucial role in community development. In the UK, SMEs are identified to account for 99% of business, 55% of non-governmental employment and 51% of turnover (SBS, 2001; Lee et al., 2010). Therefore, devising policy initiatives that encourages innovation in SMEs is significant for stimulating economic development at all levels, which includes local, regional, and even at the national levels (Jones and Tilley, 2003).

The term SMEs are defined along any of these three dimension: employment; capital investment; or annual turnover (Egbetokun et al. 2007; Atkins & Lowe, 1997; Bala-Subrahmanya, 2005; Gulani and Usman, 2012; Etuk et al., 2014; Osotimehin et al., 2012). Therefore, the definition of SMEs focused on in this study are firms with 250 employees or less. However, this study does not place any emphasis on the capital investment and the annual revenue generated by the SMEs. This chapter is segmented as follow: the following section looks at the state of SMEs in Nigeria, also detailing some challenges faced by these SMEs. This is followed by section 5.3 which presents the results of the survey conducted for this study (for more information about the research approach, see section 3.4 in chapter 3). This is then followed by section 5.4 which provides a detailed discussion on the implications of the research findings on the subject matter. Lastly, section 5.5 provides an example of a typical case of user innovation in Nigerian SME.

5.2 State of SMEs in Nigeria

According to the information derived from the database of the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN). This study discovered that as at 2016, a total of 3264 registered SMEs were in Nigeria. Of course, this value is expected to have doubled due to the gross contributions of innovation incubators in the Nigerian innovation ecosystem. According to existing studies, 10% of the total manufacturing output and 70% of the industrial employment in Nigeria are facilitated by the SME firms (Aina, 2007), Nigerian SMEs constitute 97% of the companies in Nigeria which employs an average of 50% of the working population in addition to the 50% contribution made to the country's industrial output (Anigbogu et al., 2014; Ihua, 2009; Apulu & Ige, 2011; Ojeka, 2011). Which signifies that they have a tremendous positive influence on the distribution of income at both functional and nominal levels (Rajesh et al., 2008; General Statistics Office, 2007; Uzor, 2004; Mba & Emeti, 2014; Anigbogu et al., 2014). In addition,

Despite the identified benefits of SMEs, Agwu (2011) and Anigbogu et al. (2014) indicated that the performance of the Nigerian SMEs in employment generation has been poor and unimpressive in recent years. Probably due to challenges such as: poor financing structure, inadequate social infrastructures, lack of managerial skills, poor accounting system, multiple

taxation, poor knowledge of technology use, strategic planning problems, poor record keeping, socio-cultural problems, lack of management skills, poor marketing strategy, corruption, location/economic Problems, and unstable policy environment. Moreover, according to the findings made by Apulu and Ige (2011), Radwan & Pellegrini (2010), and Mambula (2002) the critical challenges to the growth and sustainability of Nigerian SMEs are those based on poor infrastructure such as electricity, and good road network, as well as financial constraints.

Lastly, in terms of the innovativeness of the Nigerian SMEs, Egbetokun et al (2007) identified that Nigerian SMEs focus more on incremental product or process innovation than radical innovation. In addition, Lee et al (2010) also indicated that SMEs prefer to involve universities and research centres in their innovation process to other firms. The findings of this study will attempt to uncover whether this assertion also holds for the user firms among Nigerian SMEs. The following section provides a review of the state of user innovation among the SMEs in developed countries.

5.3 Propensity of User Innovation among SMEs in Developed Countries

With regards to the propensity of user innovation in developed countries, Gault & von Hippel (2009) identified in their study that user innovation is engaged by a significant fraction of firms in developed countries, out of which majority of their efforts are dedicated to the creation of new products and processes beneficial to their firm, while 35% of their efforts are focused on modifying existing products or processes. Moreover, previous studies conducted to quantify the rate of user innovation among Dutch SMEs discovered that, 22% of the Dutch SMEs are user innovators, where 18% focus on modifying existing products, services or processes, and 4% on the creation of new products, services, or processes (Flowers et al., 2009). From this study, it was also discovered that Dutch manufacturing sector has the highest incidence rate of user innovators, with 31% of their activities focused on modification while 11% is focused on the creation of new products or processes. While a study conducted by Schaan (2010) on the state of user innovation in Canada manufacturing firms indicated that 21% of the user innovation activities is focused on modifying existing products or processes, and 22% of the

user innovation activities of Canadian manufacturing SMEs are devoted to the development of new products and processes.

In addition, from the same study conducted on the state of user innovation in the UK, studies showed that 15% of the surveyed firms are user firms, where 10% of the user innovation activities was based on modifications and 9% of the user innovation activity in the UK is based on the creation of new products or processes (Flowers et al., 2009; 2010). Studies also showed that the variability of user innovation is dependent on the type of industry (Flowers et al., 2009), with Manufacturing, Architectural and Design firms, as well as Software and IT firms reporting the highest incidence rate of 25%, 23%, and 50% respectively. In addition, Flowers et al., (2009) also discovered that modification activity is very high among the user firms in the Software and IT industrial sector, this percentage stands at 41% out of all the user innovation activities.

Lastly, with regards to the incidence of user innovation in Korea, Kim & Kim (2010) identified a very low incidence rate of 3% of user innovation among the Korean manufacturing firms. The lower incidence rate was traced to the lower level of technological capability, low level of social trust, and inadequate relationship between the Korean buyer and supplier community.

Before now, there exist no empirical data about the state of user innovation in Nigeria, as well as in emerging economies. Drawing from the overall catalytic abilities of user innovation to encourage innovation growth, and the abilities of SMEs to contribute to the economic growth of a country. Therefore, this study purports that adding the study of user innovation to existing studies on the innovativeness or innovative efforts of emerging economies could engender a new perspective, especially with regards to the development of favourable policies that promotes innovation in emerging economies. This study will explore the prevalence of user innovation in Nigeria as well as other factor such as the variations of user innovation, innovation expenditure of the SMEs in Nigeria, and their willingness to share their innovation with other firms and many more. All these details will be presented in the following section.

5.4 Findings

This section begins by first reporting the age distribution of the respondents as well as the numbers of employees working in these facilities. Next followed by a preview of the state of innovation of the respondents, which also includes the effect of firm's age and size on their innovative abilities. This is then followed by the report on the prevalent rate and types of user innovation in Nigerian SMEs. The type of user innovation focused on is based on the user product innovation and user involvement (Flowers et al., 2009). This is then followed by a report of the effect of the firm age on user innovation, as well as the effects of the size of the firm on its user innovation activities. Followed by a report of the intellectual property applications accomplished by the user firms, the commercialization rate, and the novelty of their innovations. Lastly, a report of the source of information used by the user firms will also be presented.

Table 5.1 below depicts the age frequency of the respondents. From this table it can be seen that the average age of the respondents is 12 years. In addition, majority (55%) of the respondents are within the age range of 1 and 10, which has been identified as a critical stage for any new venture (Agwu & Emeti, 2014; Aremu & Adeyemi, 2011). The next highest age group is between 11 and 20 years which consist of 26% of the responses. Based on one of the objective of this phase, which is to uncover the effect of the firm's age on its user innovation activities, this age distribution will help in providing a significant response to this objective.

Table 5.1: Age of SMEs (n=249)

Statistics

Mean	12.52
Median	9.00
Mode	9
Std. Deviation	18.701
Variance	349.715
Range	258

	Frequency	Percent	Cumulative Percent
1 - 10	137	55.0	55.0
11 - 20	65	26.1	81.1
21 - 30	16	6.4	87.5
31 - 40	5	2.0	89.5
41 - 50	3	1.2	90.7
51 - 60	2	0.8	91.5
>60	1	0.4	91.9
Total	249	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for 20 cases.

With regards to the distribution of the number of employees, Table 5.2 below indicates that the average employee employed by all the respondents is 128. Moreover, a total of 31941 employees are working at the sampled SMEs. While majority (57%) of the SMEs employed between 1 and 10 employees, followed by 28% SMEs which employed between 11 and 49 employees. While 9% of the SMEs employed between 50 and 250 employees, and the remaining 6% SMEs employed above 250 employees in their firm.

Table 5.2: Firm size of SMEs

Statistics

Mean	128.28
Median	10.00
Mode	5
Std. Deviation	627.712
Variance	394022.008
Range	4999
Sum	31941

	Frequency	Percent	Cumulative Percent
1 - 10	143	57.2	57.2
11 - 49	69	28.0	85.2
50 - 250	23	9.2	94.4
> 250	14	5.62	100.0
Total	249	100.0	

Note. Data from Author's 2018 PhD survey.

5.4.1 General State of Innovation in SMEs

Before proceeding to the main objective of this study phase, the respondents were asked if they had created a new product (NPD) or new services (NSD), or modified an existing product or service in the last three years which spanned from 2015 to 2018. These findings will be cross-tabulated with the firm age and firm size, so as to uncover their effects on the innovative activities of the Nigerian SMEs. As can be seen from the Tables 5.3, 49% reported that they have created an NPD, while 37% reported the creation of NSD. In addition, with respect to the state of incremental innovation in the Nigerian SMEs, Table 5.3 reveals that Nigerian SMEs are more focused on the modification of existing product than existing services, which buttresses with their more focus on NPDs than NSDs. From Table 5.3, it can be seen that 30.5% of the responding SMEs have modified an existing product, while only 20% of the respondents indicated the modification of existing services.

From this finding it can be uncovered that Nigerian SMEs are more involved in the creation of NPDs and NSDs than modifying existing products or services. In addition, with respect to the focus of the Nigerian SMEs, it can also be observed that they are more oriented towards product creation and product modifications than service creation and modifications. However, it is worth noting that this finding does not represent the state of user innovation, this will be presented in the next section.

Table 5.3: Incidence of Radical and Incremental Innovation in Nigerian SMEs

Incidence of NPD			
	Frequency	Percent	Cumulative Percent
No	128	51.4	51.4
Yes	121	48.6	100.0
Total	249	100.0	
Incidence of NSD			
No	157	63.1	63.1
Yes	92	36.9	100.0
Total	249	100.0	
Incidence of Product Modifications			
No	173	69.5	69.5
Yes	76	30.5	100.0
Total	249	100.0	
Incidence of Service Modifications			
No	200	80.3	80.3
Yes	49	19.7	100.0
Total	249	100.0	

Note. Data from Author's 2018 PhD survey.

Moreover, Table 5.4 displays the frequency of products or services created or modified by the respondents. As can also be seen from Table 5.4, the survey also revealed that a total of 685 radical and incremental innovations has been implemented by these SMEs. While majority (28.5%) of the respondents indicated that they have either created or modified two products or services, followed by the 27% which have created or modified three products or services. Followed by 26% of the respondents who indicated that they have either created or modified only one product or service in the past three years. Which is then followed by 9% respondents that indicate that the creation or modification of at most 4 products or services. While the remaining respondents indicated that they have either created or modified products or services which ranges between 5 and 20. This finding is contrary to highlights from existing studies that revealed that due to internal resource constraints, SMEs are identified to involve other firms in their innovation process, which enables them recognize the importance of both internally and externally sourced information acquired from collaboration with other elements of the innovation system (Lee et al., 2010; Acs, 2002; Abubakar et al., 2019; Edwards

et al., 2005; Narula, 2004). In summary, Table 5.4 indicated that majority (90%) of the SMEs surveyed have created or modified between 1 and 4 products or services in the past three years.

Table 5.4: Number of NPDs, NSDs, and Modifications Made by Nigerian SMEs

Statistics

Mean	2.75
Median	2.00
Mode	2
Std. Dev	2.220
Variance	4.930
Range	20
Sum	685

	Frequency	Percent	Cumulative Percent
1	64	25.7	25.7
2	71	28.5	54.2
3	68	27.3	81.5
4	23	9.2	90.7
5	4	1.6	92.3
6	2	.8	93.1
7	2	.8	93.9
8	10	4.0	97.9
10	1	.4	98.3
12	1	.4	98.7
15	1	.4	99.1
20	1	.4	99.6
Total	249	100.0	

Note. Data from Author's 2018 PhD survey. Value was not determined for one case.

5.4.1.1 Effect of Firm_Age on the Innovative Activities of Nigerian SMEs

As can be seen in Tables 5.5, 5.6, 5.7, and 5.8, the survey reveals that the maturity (age) of the firm does not have any effect on its innovative activities. As majority of the SMEs with some innovation activities which includes both radical and incremental innovations, are within the critical age of 1 and 10 years old, followed by the age group 11 to 20 years. While the more matured SMEs reported some very minimal innovation activities. This in general negates the traditional beliefs which posits that based on knowledge and experience which could only be acquired by maturity, big firms are supposed to be more innovative that younger firms. However, this study identified that majority of the less innovative firms are firms that might have been founded merely after the independence of Nigeria. Therefore, posits that the lack of innovation could be due to the adverse effect of the lack of technological or economic experience in Nigeria in the early period of independence. The next section provides the overall effect of firm size in the innovative activities of the Nigerian SMEs.

Table 5.5: Bivariate Table Showing the Relationship Between Firm_Age and NPDs

		NPD		
		No	Yes	Total
	1 - 10	60.5	59.1	59.8
	11 - 20	27.7	29.1	28.4
	21 - 30	8.4	5.46	7.0
Firm_Age	31 - 40	1.7	2.70	2.2
	41 - 50	0.84	1.82	1.3
	51 - 60	0.84	0.91	0.9
	> 61	0	0.91	0.4
Total		100	100	100
		(119)	(110)	(229)

Note. Data from Author's 2018 PhD survey. Value was not determined for 20 cases.

Table 5.6: Bivariate Table Showing the Relationship Between Firm_Age and NSDs

		NSD		
		No	Yes	Total
	1 - 10	57.5	63.6	59.8
	11 - 20	29.1	27.3	28.4
	21 - 30	7.8	5.7	7.0
Firm_Age	31 - 40	2.8	1.13	2.2
	41 - 50	1.4	1.13	1.3
	51 - 60	0.7	1.13	0.9
	> 61	0.7	0	0.4
Total		100	100	100
		(141)	(88)	(229)

Note. Data from Author's 2018 PhD survey. Value was not determined for 20 cases.

Table 5.7: Bivariate Table Showing the Relationship Between Firm_Age and Modified Products

		Existing Product Modification		
		No	Yes	Total
	1 - 10	62.6	53.0	59.8
	11 - 20	25.8	34.9	28.4
	21 - 30	6.1	9.1	7.0
Firm_Age	31 - 40	1.84	3.0	2.2
	41 - 50	1.84	0	1.3
	51 - 60	1.23	0	0.9
	> 61	0.61	0	0.4
Total		100	100	100
		(163)	(66)	(229)

Note. Data from Author's 2018 PhD survey. Value was not determined for 20 cases.

Table 5.8: Bivariate Table Showing the Relationship Between Firm_Age and Modified Services

		Existing Service Modifications		
		No	Yes	Total
	1 - 10	58.0	67.5	59.8
	11 - 20	30.0	20.9	28.4
	21 - 30	7.0	7.0	7.0
Firm_Age	31 - 40	2.6	0	2.2
	41 - 50	2.1	2.3	1.3
	51 - 60	0.5	2.3	0.9
	> 61	0.5	0	0.4
Total		100	100	100
		(186)	(43)	(229)

Note. Data from Author's 2018 PhD survey. Value was not determined for 20 cases.

5.4.1.2 Effect of Firm_Size on the Innovative Activities of Nigerian SMEs

Just like the effect of Firm age reported in the preceding section, the same effect is recorded for the effect of the firm size on the innovative activities of the Nigerian SMEs. As can be seen in Tables 5.9, 5.10, 5.11, and 5.12, majority of the firms with higher NPDs, NSDs, and modification works are firms with 1 and 10 employees. Followed by SMEs with the firm size between 11 and 49. This finding is contrary to beliefs and findings in existing literatures which shows that due to their sheer strength in terms of human capitals, bigger firms should be more involved in innovative activities than smaller firms. However, the reason behind this trend in the Nigerian SMEs will be briefly discussed in the discussion section of this phase. The next section proceeds with the main objective of this study phase which is to uncover the prevalent rate and types of user innovation predominant in the surveyed SMEs. After which, the effect of both firm size and firm age will also be explored in the user innovative activities of the SMEs.

Table 5.9: Bivariate Table Showing the Relationship Between Firm_Size and NPDs

		NPD		
		No	Yes	Total
Firm_Size	1 - 10	59.4	55.4	57.4
	11 - 49	25.8	29.7	27.7
	50 - 250	10.2	8.3	9.3
	> 250	4.6	6.6	5.6
Total		100	100	100
		(128)	(121)	(249)

Note. Data from Author's 2018 PhD survey.

Table 5.10: Bivariate Table Showing the Relationship Between Firm_Size and NSDs

		NSD		
		No	Yes	Total
Firm_Size	1 - 10	53.5	64.1	57.4
	11 - 49	29.9	23.9	27.7
	50 - 250	10.2	7.6	9.3
	> 250	6.4	4.4	5.6
Total		100	100	100
		(157)	(92)	(249)

Note. Data from Author's 2018 PhD survey.

Table 5.11: Bivariate Table Showing the Relationship Between Firm_Size and Product Modifications

		Existing Product Modifications		
		No	Yes	Total
Firm_Size	1 - 10	59.5	52.6	57.4
	11 - 49	26.6	30.3	27.7
	50 - 250	8.7	10.5	9.3
	> 250	5.2	6.6	5.6
Total		100	100	100
		(173)	(76)	(249)

Note. Data from Author's 2018 PhD survey.

Table 5.12: Bivariate Table Showing the Relationship Between Firm_Size and Service Modifications

	Existing Service Modification		
	No	Yes	Total

	1 - 10	60.0	46.9	57.4
Firm_Size	11 - 49	25.0	38.8	27.7
	50 - 250	9.5	8.2	9.3
	> 250	5.5	6.1	5.6
Total		100 (200)	100 (49)	100 (249)

Note. Data from Author's 2018 PhD survey.

Lastly, since the major objective of this study is not to explore the state of innovation but the prevalence of user innovation. More information about the state of innovation in the Nigerian SMEs are tabulated in the tables presented in Appendix I, and will be presented in order studies that pertains to the specific study of innovation in Nigerian SMEs. The following section will proceed by exploring the prevalence of user innovation in Nigerian SMEs.

5.4.2 Prevalence and Types of User Innovation in Nigeria SME

In order to accomplish the first objective of this phase that is to identify the prevalence rate and types of user innovation among the Nigerian SMEs, the respondents, in addition to the initial questions asked in section 3.4.1 were further asked to indicate if they created or modified the product or services solely or in collaboration with other parties which includes customers, firms, or higher education institutions, or whether the product was created by an external party. This will be the basis with which we will attempt to extrapolate the prevalence of user innovation in the Nigerian SMEs. The result of this survey will be tabulated in Table 5.13 below and presented in the succeeding paragraph.

5.4.2.1 Prevalence of User Innovation in Nigerian SMEs

Table 5.13 depicts the incidence rate of the user firms in Nigeria SMEs. From Table 5.13, it can be observed that out of the 249 identified innovative SMEs, 83% are user firms, that is the summation of radical innovation activities accomplished solely by the SMEs, innovation activities accomplished by the SMEs in collaboration with customers (User Involver), innovation activities in collaboration with higher education institutions, innovation activities accomplished in collaboration with other firms, and incremental innovation accomplished by the modifications made by the SMEs on existing products and services.

Moreover, out of these user firms, 61% created the product themselves without the interference of any external parties. 10% indicated that they involve their customers during their innovation process. While 8% indicated that their user innovation activities were accomplished in collaboration with other enterprises which could also include competitors. In addition, 3% out of these user firms indicated that their user innovation was done as a result of modifications made on existing products or services. Lastly, 1% indicated that their user innovation was done in collaboration with higher education institution. The significance of these findings will be presented in details in the discussion section.

Table 5.13: Incidence Rate of User Innovation in Nigerian SME (n=249)

	Frequency	Percent	Cumulative percent
Your enterprise	151	60.6	60.6
Your enterprise with customers	26	10.4	71.0
Your enterprise with a higher education institution	3	1.2	72.2
Your enterprise with other enterprises	19	7.6	79.8
Your enterprise by modifying existing products/services	8	3.2	83.0
*External enterprises or institutions	42	16.9	100.0
Total	249	100.0	

Note. Data from Author's 2018 PhD survey.

Moreover, in order to focus solely on the objective of this phase, the data in the following sections will be presented using a bivariate analysis of the incidence of user innovation given in Table 5.13 with variables such as Firm_Size, Firm_Age, IPR_Rate, Commercialization rate, adoption rate, and so on. The following section presents information about the types of user innovation predominant among the Nigerian SMEs.

5.4.2.2 Types of User Innovation of Nigerian SMEs

Table 5.14: Bivariate Table Showing the Relationship Between Types of Innovation and Incidence of User Firm (n = 249)

	Incidence of User Innovation						
	Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
NPD	33.2	32.3	33.3	41.4	27.3	48.0	35.8
NSD	26.9	26.5	33.3	27.6	36.3	26.0	27,2
Product Modification	24.5	26.5	16.7	20.7	27.3	12.0	22.5
Service Modification	15.4	14.7	16.7	10.3	9.1	14.0	14.5

Total	100 (208)	100 (34)	100 (6)	100 (29)	100 (11)	100 (50)	100 (338)

Note. Data from Author's 2018 PhD survey.

As can be seen from Table 5.14, considering the radical user innovation activities of the firm solely, in collaboration with its customers, and the user innovation activities in collaboration with other firms, this study discovered that the user firms in Nigerian SMEs specialize more in the creation of NPDs than NSDs. However, with regards to the radical user innovation activities engaged in collaboration with higher education institutions, this study did not discover any difference between the NPD and NSD. In addition, this study also discovered that these SMEs focus more on the creation of both NPDs and NSDs than modifying existing products or services, which negates the findings from literatures that highlighted that SMEs in developed countries engages more on incremental user innovation activities than radical user innovation activities (Flowers et al., 2009; 2010). The possible reasons behind these findings will be elaborated upon at the discussion section of this study. The next section provides information about the effect of the firm age on the user innovation activities engaged by these SMEs.

5.4.3 Effect of Firm Age on the Incidence of User Innovation

Table 5.15: Bivariate Table Showing the Relationship Between Firm_Age and Incidence of User Firm (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Firm_Age	1 - 10	64.8	47.9	0	35.2	37.5	67.5	59.8
	11 - 20	23.8	34.9	100	47.1	50.0	25.0	28.4
	21 - 30	7.9	4.3	0	5.9	12.5	5.0	7.0
	31 - 40	1.4	4.3	0	5.9	0	2.5	2.2
	41 - 50	0.7	4.3	0	5.9	0	0	1.3
	51 - 60	0.7	4.3	0	0	0	0	0.9
	> 61	0.7	0	0	0	0	0	0.4
Total		100 (139)	100 (23)	100 (2)	100 (17)	100 (8)	100 (40)	100 (229)

Note. Data from Author's 2018 PhD survey. Value was not determined for 20 cases.

With regards to the effect of age on the SMEs ability to engage successfully in user innovation, Table 5.15 discovered that, within the age group between 1 and 10 years, 65% of the respondents who engage in user innovation independently, and 48% of the respondents who innovate in collaboration with their customers reported a high incidence of user innovation. In addition, within the age group of 11 and 20 years, Table 5.15 also revealed a high incidence rate of user innovation among SME firms who collaborate with higher education institutions,

SME firms who involve other firms which includes competitors in their user innovation activities, and also among SMEs firms who focus more on making modification to existing products and services.

In addition, taking a percentage difference of the effect of the Firm's age on their user innovation activities, it was observed that younger firms within the age of 1 and 10 years who independently engage in user innovation, are 17% more innovative than firms who involve their customers in the user innovation activities, 65% more user innovative than firms who collaborate with higher institution, 30% more user innovative than firms that engage other firms in their user innovation activities. Lastly, 27% more user innovative that firms who are only focused on modifying existing products and services. Moreover, with regards to the effect of the firm's age on their user innovation activities, from Table 5.15, it was also observed that firms within the age range of 11 and 20 years who collaborate with higher education institutions are 76% more innovative that firms within the same age group who engages with user innovation activities independently, 65% more than firms who innovate in collaboration with their customers, 53% more innovative than firms who collaborate with other firms including competitors during their innovation process, and lastly, 50% more innovative than firms who focus solely on modifying existing products or services. The reason behind these occurrences will be presented in the discussion section.

5.4.4 Effect of Firm Size on the Incidence of User Innovation

Table 5.16: Bivariate Table Showing the Relationship between Firm_Size and Incidence of NSDs of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Firm_Size	1 - 10	54.3	50.0	0	36.8	62.5	85.7	57.4
	11 - 49	29.8	30.8	33.3	52.6	12.5	9.5	27.7
	50 - 250	10.6	11.5	66.7	0	25.0	0	9.3
	> 250	5.3	7.7	0	10.6	0	4.8	5.6
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

With respect to the effect of the firm size on the user innovation abilities of the SMEs. Table 5.16 reveals that, the respondents whose firms employed between 1 and 10 employees,

independently work on their user innovation activities, or collaborate with their customers, or make modifications to existing products or services reported a higher incidence rate of user innovation activities than other big-sized firms. However, Table 5.16 also noticed the effect of the firm's size in the user innovation activities done in collaboration with other firms, as 53% of the respondents with a firm size from 11 and 49 indicated a high incidence of user innovation. As well as, some slight implications of the firm size (11 – 49) among firms who independently engage in their user innovation activities, SMEs who involve their customers, SMEs who collaborate with higher education institutions, and SMEs who specialize in modifying existing products or services. In addition, a major implication of the firm size between the range of 50 and 250 employees was reported by respondents who involve the higher education institution in their user innovation activities. The reason behind this occurrence will also be presented in the discussion section. The following section will present the findings based on the expenditure of the SMEs on their user innovation activities, as well as their ability to generate a revenue turnover from their innovation expenditure.

5.4.5 Innovation Expenditure and Turnover

In order to highlight the innovation expenditure of the surveyed SMEs, the respondents were asked to provide an estimate of the innovation expenditure which entails the total amount spent during the innovation process until the product or service was commercialized. These findings will be presented by reviewing the expenditure in terms of the time and financial investment during the user innovation activities. The following section will explore the total time invested by the SMEs on their user innovation activities.

5.4.5.1 Time Investment (Week)

With regards to the total time invested by the SMEs on their user innovation activities, Table 5.17 reveals that majority of the user innovation activities accomplished independently by the SMEs (35%) and those accomplished in collaboration with other firms (37%), was done between 1 and 10 weeks. While majority (50%) of the user innovation accomplished in collaboration with the customer was done within a period of 11 and 20 weeks. In addition, 67% of the user innovation accomplished in collaboration with higher education institution

was accomplished within the period 60 weeks and above. Lastly, Table 5.17 also reveals that 25% of the SMEs invested a time between 1 to 10 weeks, 11 to 20 weeks, 21 to 30 weeks, and a period of 60 weeks and above to modify products or services. For the information about the overall time invested on the general innovation activity please consult Appendix I.

Table 5.17: Bivariate Table Showing the Relationship Between Time Investment and Incidence of User Innovation

		Incidence of User Innovation						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Time Investment	1 – 10	35.1	15.4	33.3	36.8	25.0	54.8	36.1
	11 - 20	21.9	50.0	0	26.4	25.0	23.8	25.3
	21 - 30	15.2	11.6	0	10.5	25.0	9.5	13.7
	31 - 40	2.6	3.8	0	0	0	0	2.0
	41 - 50	2.0	0	0	0	0	0	1.2
	51 - 60	2.0	0	0	10.5	0	0	2.0
	> 60	21.2	19.2	66.7	15.8	25.0	11.9	19.7
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

5.4.5.2 Financial Investment (Naira)

With respect to the financial investment of the SMEs on their user innovation activities, Table 5.18 reveals that majority (31.5%) of the SMEs that were independently engaged in their user innovation activities, 42% of the SMEs that involved their customers in their user innovation activities, as well as 32% of the SMEs that involves other firms including their direct competitors in their user innovation activities invested an amount above 10,000,000 Naira on their user innovation activities. While Table 5.18 also reveals that majority (67%) of the SMEs who collaborate with higher education institutions during their user innovation activities invested an amount within the range of 500,000 and 1,000,000 Naira on their user innovation activities. Lastly, with respect to the amount spent on the modification works done on existing products, Table 5.18 reveals that most innovating SMEs (37.5%) spent an amount within the range of 100,000 and 200,000 Naira on their user innovation activities.

Table 5.18: Bivariate Table Showing the Relationship Between Innovation Expenditure and Incidence of User Innovation

	Incidence of User Innovation						
	Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total

Innovation Expenditure	1000 - 50000	3.9	3.8	0	5.3	12.5	19.0	6.8
	50001 - 100000	9.8	11.6	0	10.5	12.5	21.5	12.0
	100001 - 200000	7.8	19.2	0	0	37.5	9.5	9.6
	200001 - 500000	11.2	11.6	0	15.8	12.5	19.0	12.9
	500001 - 1000000	15.5	3.8	66.7	26.3	12.5	11.9	14.5
	1000001 - 10000000	20.3	7.7	0	10.5	0	2.4	14.5
	> 10000000	31.5	42.3	33.3	31.6	12.5	16.7	29.7
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

5.4.5.3 Revenue Turnover

To uncover the benefits of the innovation expenditure invested by the user firms, the respondents were asked to indicate whether they have generated a revenue turnover from their user innovation activities, the initial findings are presented in Table 5.19. As can be seen in Table 5.19, 81% of the respondents reported that their firms have generated a reasonable revenue from their innovation expenditure. However, the value of the revenue and how it relates to the user innovation activities is presented in Tables 5.20 and 5.21 below.

Table 5.19: Revenue Turnover from Innovation

		Frequency	Percent	Cumulative Percent
Valid	No	46	18.5	18.5
	Yes	202	81.1	99.6
	Total	249	100.0	

Note: Data from Author's 2018 PhD survey. Data cannot be determined for one case

Table 5.20 represents the amount and percentage of revenue generated from the radical user innovation. As can be seen in Table 5.20, majority of the SMEs reported that they have generated an amount between 200,000 and 500,000 Naira from their user innovation activities. This in specifics relates to 42% of the user firms who independently engaged in user innovation activities, 35% of user firms who involve their customers in their user innovation activities, 100% of the user firms who collaborate with higher education institutions, and lastly, 37% of the user firms who collaborate with other firms including competitors. However, with respect to the modifications made on existing products, Table 5.20 indicates that 37.5% of the SMEs have generated revenues between 1,000,000 and 10,000,000 Naira from their user innovation exploits.

Table 5.20: Bivariate Table Showing the Relationship Between Revenue for Radical UI and Incidence of User Innovation

	Incidence of User Innovation

		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Revenue Turnover for Radical User Innovation	1000 - 50000	11.9	23.1	0	10.5	25.0	16.7	14.1
	50001 - 100000	10.7	11.6	0	15.8	12.5	23.8	13.3
	100001 - 200000	5.3	3.8	0	5.3	0	0	4.0
	200001 - 500000	42.4	34.6	100.0	36.8	12.5	35.7	39.7
	500001 - 1000000	3.9	0	0	0	0	0	2.4
	1000000 - 10000000	15.9	23.1	0	15.8	37.5	14.3	16.9
	> 10000000	9.9	3.8	0	15.8	12.5	9.5	9.6
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

In addition, with respect to the generation of revenue from the innovation expenditures invested in the incremental user innovation activities, Table 5.21 reveals that 31% of the user firms who innovate independently, and all the user firms who collaborate with higher education institutions have generated an amount between 200,000 and 500,000 Naira from their user innovation expenditure. In addition, 23% of the user firms who involved customers in their user innovation activities have generated an amount between 1,000 and 50,000 as well as 200,000 and 500,000 from their user innovation expenditures. Lastly, 37% of the user firms who collaborated with other firms during the modification work, and 50% of the user firms who modified existing products have generated an amount above 10,000,000 Naira from the amount invested in their user innovation. The overall significance of this on the user innovativeness of the SMEs will be further elaborated in the discussion section.

Table 5.21: Bivariate Table Showing the Relationship Between Revenue for Incremental UI and Incidence of User Innovation

		Incidence of User Innovation						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Revenue Turnover for Incremental User Innovation	1000 - 50000	10.7	23.1	0	15.8	37.5	16.7	14.1
	50001 - 100000	3.3	7.7	0	0	0	0	2.8
	100001 - 200000	9.9	11.5	0	10.5	12.5	26.2	12.8
	200001 - 500000	31.1	23.1	100.0	31.6	0	28.5	29.7
	500001 - 1000000	2.6	0	0	0	0	0	1.6
	1000000 - 10000000	17.2	15.4	0	5.3	0	14.3	14.9
	> 10000000	25.2	19.2	0	36.8	50.0	14.3	24.1
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

The following section will present information about the novelty rate, IPR rate and the technology sharing strategy which focuses on the willingness of the user firms to freely share their innovations with others which includes customers and even competitors.

5.4.6 IPR Rate and Technology Sharing of User Innovation in Nigerian SMEs

Just as highlighted in the introductory section of this study, User innovations are the major source of most commercialized products which consists of medical fields, mechanical fields, sports equipment, household accessories, and other office accessories. Which also means that activities of user innovations can be legally protected to ensure that the user firms can reap a dividend of their innovation expenditure. However, has indicated from literatures (von Hippel, 2005; 2009; Flowers et al. 2009; 2010; De Jong & von Hippel, 2009b) majority of the user innovators opts to share their innovations with others rather than taking the route of commercialization. This section will attempt to uncover information which helps to highlight the IPR rate, novelty of the innovations, and the willingness of the user firms to share their innovation freely with others.

The respondents were asked to provide answers whether they have successfully applied for any form of protection for their innovation. The results are presented in Table 5.22. As can be seen in Table 5.22, all the SMEs have not successfully applied for protection for their innovation. This could be due to some of the financial, legal, and other complexities identified with protecting innovation, or it could also be due to the sheer interest of the user innovators to engage in social welfare by freely revealing their innovations with other users which could also include their competitors. However, this will be further explored in the succeeding paragraphs in this section.

5.4.6.1 IPR Rate

Table 5.22: Overall IPR rate of the SMEs

	Percent	
	Yes	No
Local Patent	14.5	85.5
International Patent	8.0	92.0
Industrial Design	16.9	83.1
Trademark Registration	25.7	74.3
Claim Copyright	14.9	85.1
Grant License	14.9	85.1
Trade secret	22.5	77.5

Note. Data from Author's 2018 PhD survey.

With regards to the significance of this IPR rate on the incidence of user innovation, Table 5.23 reveals that with regards to the user innovation activities accomplished independently by the user firms, the highest rate (23%) of protection acquired is in trademark, which is a distinctive sign used to identify products or services belonging to different firms (Cetindamar et al., 2016). This is followed by 20% respondents who have successfully utilized trade secret which is a non-public information about the technological commercialization and production processes of a firm (Cetindamar et al., 2016). This is then followed by 17% of the respondents indicating the acquisition of an industrial design rights which protects the appearance, shapes, and design of an industrial object. While 12% of the respondents indicated that they have acquired local patent, copyrights, and other licenses for their user innovation. Lastly, while 6% of the respondents indicated the acquisition of an international patent.

In addition, with regards to the protection of the user innovation activities done by user firms who involved their customers in their user innovation processes. As can be seen from Table 5.23, just like in the case of the protective mechanisms utilized by the user firm who independently executed their user innovation activities, the highest form of protection accomplished by user firms that involved their customers in their user innovation activities is trademark which has a percentage of 17%. While 15% indicated the acquisition of copyrights, licenses, and trade secrets. Lastly, 13% of the respondents indicated the acquisition of local and international patents, and industrial design rights for their user innovation activities.

Table 5.23: Bivariate Table Showing the Relationship Between IPR Rate and Incidence of NSDs of User Innovation (n = 249)

		Incidence of User Firm						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
IPR Rate	Local Patent	12.1	12.8	16.67	14.3	0	0	12.3
	International Patent	6.0	12.8	0	7.1	0	0	6.8
	Industrial Design	14.6	12.8	16.67	17.9	0	0	14.4
	Trademark	23.0	16.9	16.67	21.4	40.0	0	21.9
	Copyright	12.1	14.9	16.67	14.3	0	0	12.7
	Grant License	12.1	14.9	16.67	10.7	20.0	0	12.7
	Trade Secret	20.1	14.9	16.67	14.3	40.0	100.0	19.2
	Total	100 (199)	100 (47)	100 (12)	100 (28)	100 (5)	100 (1)	100 (292)

Note. Data from Author's 2018 PhD survey. Information cannot be identified for two cases

Moreover, with regards to the predominant forms of protection used in the user innovation activities that involves collaboration with higher educational institutions, 17% of the respondents reported the acquisition of protection in the form of local and international patent, industrial design rights, trademarks, copyrights, licenses, and the utilization of trade secrets. While in the form of protection used in protecting the innovation activities that involves collaboration with other firms, 21% have successfully acquired a trademark protection, while 18% have acquired for industrial designs. In addition, 14% indicated the acquisition of local patents, copyrights, and trade secrets. Lastly, 7% have successfully protected their user innovation through international patent structure.

Finally, Table 5.23 also reveals a surprising information which pertains to the protection of the modifications to existing products or services. From Table 5.23, it can be observed that 40% of the modifications jobs done by the SMEs were protected through trademark and trade secrets, while 20% was protected using other licensing structures. The detailed significance of this findings will be detailed in the discussion section. The following section will now present information about the technology sharing avenues used by the user innovating SMEs.

5.4.6.2 Technology Sharing

As indicated by von Hippel (1975) most user innovators always choose to share their innovations rather than commercialize it themselves, which is beneficial to the product manufacturer. Therefore, in order to uncover the state of technology sharing among the Nigerian SMEs, the respondents were asked to provide information about their willingness to share their innovation which includes their competitors, and the extent of information they are willing to disclose. Table 5.24 reveals the overall response of the respondents.

Table 5.24: Overall Willingness of SMEs to share their innovation or Modification (n = 249)

	Definitely not	Probably not	Neutral	Probably yes	Definitely yes
To other parties including competitors	54	33	30	73	59
Design only	53	30	38	71	57
Also willing to help interested users adopt it	36	25	42	85	61
Freely reveal innovation	123	29	42	30	25

Note. Data from Author's 2018 PhD survey.

As can be seen in Table 5.24, with regards to the sharing of their innovations with other firms which includes competitors, sharing only their design, as well as helping the interested users adopt their innovation, it can be observed that a high majority of the respondents are willing to share their innovations with regards to these factors. However, with regards to their innovation being freely revealed, Table 5.24 reveals that a high majority of the SMEs are not willing to fully disclose their innovation. Later on, this will be correlated with their ability or expectations for a compensation. In addition, Table 5.25 presents the willingness of the identified user firms to share their innovation to other firms which could also include their competitors.

As revealed in Table 5.25, with regards to the innovation independently executed by the user firms, it can be determined that a cumulative value of 42% of the user firms are not willing to share their innovations with other firms, while 46% are willing to share their innovations. In addition, with regards to the innovation created in conjunction with customers, a cumulative percentage of 54% are willing to share their innovation. While with regards to the innovations created in collaboration with higher education institutions and with other enterprise, it was observed that 67% and 58% respectively are willing to share their innovation with other firms. Which indicates that most of the user firms are willing to share their innovation. However, with regards to modifications to existing products and services, Table 5.25 further reveals that the user firms are neither willing nor unwilling to share their innovation.

Table 5.25: Bivariate Table Showing the Relationship between SME's Sharing with other firms and the Incidence of User Innovation

		Incidence of User Firm						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
To other parties including competitors	Definitely not	29.1	11.6	33.3	5.2	25.0	7.2	21.6
	Probably not	12.6	15.3	0	15.8	25.0	11.9	13.3
	Neutral	12.6	19.2	0	21.1	0	4.7	12.1
	Probably yes	24.5	46.2	66.7	42.1	25.0	28.6	29.3
	Definitely yes	21.2	7.7	0	15.8	25.0	47.6	23.7
	Total	100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

With regards to the willingness of user firm to share their design with others, Table 5.26 once again reveals that most of the user firms are willing to share the design of their innovation.

This includes innovations created independently by the user firms, innovations created in collaboration with customers, innovations created in collaboration with higher education institutions, and innovation created in collaboration with other firms. However, with regards to the sharing of modifications to existing products and services, Table 5.26 reveals that majority of the user firms are not willing to share the designs made from their modifications.

Table 5.26: Bivariate Table Showing the Relationship between SME's Sharing Design and the Incidence of User Innovation

		Incidence of User Firm						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Design only	Definitely not	26.5	11.5	33.3	10.5	25.0	11.9	21.3
	Probably not	10.6	11.5	0	31.6	25.0	7.1	12.1
	Neutral	17.2	15.4	0	10.5	12.5	11.9	15.3
	Probably yes	23.8	53.9	66.7	31.6	0	31.0	28.5
	Definitely yes	21.9	7.7	0	15.8	37.5	38.1	22.9
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

In addition, as can be seen from in Table 5.27, majority of the respondents reported their willingness to assist interested parties adopt their innovation. This is reflective among the user firms who independently accomplished their innovation, user firms who involved their customers in their innovation processes, user firms that collaborated with other enterprises, as well as user firms who only made modifications to existing products or services. However, with regards to the user firms who involve higher education institutions in their user innovation activities, it was discovered that they are neither willing nor unwilling to assist interested users in the adoption of their innovation.

Table 5.27: Bivariate Table Showing the Relationship between SME's Willing to Help Users and the Incidence of User Innovation

		Incidence of User Firm						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Willing to help interested Users adopt it	Definitely not	20.5	3.9	0	0	12.5	7.1	14.5
	Probably not	11.3	7.7	33.3	15.8	0	4.8	10.0
	Neutral	18.5	7.7	33.3	36.8	12.5	7.1	16.9
	Probably yes	30.5	61.5	0	21.1	25.0	40.5	34.1
	Definitely yes	19.2	19.2	33.3	26.3	50.0	40.5	24.5
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

Lastly, with regards to the willingness of the SMEs to freely reveal their innovation, although Table 5.24 has already indicated that most SMEs are unwilling to freely share their innovation. However, taking a close-up look Table 5.28 reveals that in all the area of focus, the user firms are not willing to share their innovation freely with other firms or users. This includes, majority (69%) of the user firms who independently conducted their user innovation activities, 58% of the SMEs who involved their customer in their innovation processes, 33% of the SMEs that innovate in collaboration with higher education institutions, 37% of the SMEs who collaborate with other enterprises, and SMEs that made modifications to existing products or services. However, a higher percentage (67%) of the respondents chose to maintain a neutral stance with regards to their willingness to freely reveal their innovation, as well as a percentage of 37% were also reported by SMEs who involve other enterprises in their user innovation activities. The significance of this findings will be elaborated further in the discussion section.

Table 5.28: Bivariate Table Showing the Relationship between SME's Freely Sharing Innovation and the Incidence of User Innovation

		Incidence of User Firm						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Freely reveal Innovation	Definitely not	58.3	42.3	33.3	21.1	25.0	40.5	49.4
	Probably not	10.6	15.4	0	15.8	37.5	7.1	11.6
	Neutral	13.3	11.5	66.7	36.8	25.0	19.1	16.9
	Probably yes	9.9	23.1	0	21.1	0	11.9	12.1
	Definitely yes	7.9	7.7	0	5.3	12.5	21.4	10.0
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

In addition to the information revealed above with regards to the willingness of the SMEs to freely share their innovation, the respondents were further asked to provide information whether they received any compensation from manufacturers or other users for sharing their innovation, the result of this findings are presented in Table 5.29. As can be seen from Table 5.29, majority (38.5%) of the respondents did not receive any compensation for sharing, while 25% indicated that they received a royalty fee for sharing their innovation. In addition, 18% reported that they are expecting a compensation, while 10% reported that their innovation was traded in exchange for another product or service, and 1% indicated the reception of a discount or subsidy for sharing their innovation. However, though very minute, 8% of the

respondents indicated that they freely revealed their innovation, hence no compensation was needed. The importance or effect of this findings will also be elaborated further in the discussion section.

5.29: Compensation from Technology Sharing

	Frequency	Percent
No compensation has been received, but compensation is expected	21	17.9
We willingly revealed/transferred the innovation for free	9	7.7
We received a royalty	29	24.7
We received discounts or subsidies on other products/services	1	0.9
Innovation was exchanged for other products/services	12	10.3
No compensation	45	38.5
Total	117	100.0

Note. Data from Author's 2018 PhD survey. Value was not determined for 132 cases.

5.4.6.3 Novelty Rate of Innovation

Despite the lack of novelty, most users find incremental user innovation very beneficial (Stock et al., 2015). Therefore, this study will also attempt to explore the novelty rate of the user innovation done by the identified user firms. In order to assert the novelty of their innovation, the respondents were requested to provide information on their perception on the novelty of their product or services, and as can be seen in. Table 5.30 reveals that, 44% of the user innovation done independently by the user firms, 54% of the user innovation done in collaboration with customers, 67% of the user innovation done in collaboration with higher education institutions, 63% of the user innovation done in collaboration with other firms as well as the modification made on existing products and services were considered novel by the user firms.

Table 5.30: Bivariate Table Showing the Relationship between Adoption Rate of User Innovation and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	Total
Adoption of Innovation	No	55.6	46.2	33.3	36.8	50.0	57.1	53.0
	Yes	44.4	53.8	66.7	63.2	50.0	42.9	47.0

Total	100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

5.4.6.4 Sources of Innovative Information

SMEs have been identified to effectively use external resources better than big-sized firms (Lu & Beamish, 2001; Lee et al., 2010). Therefore, this study will also attempt to uncover whether these findings also holds in SMEs in Nigeria. In order to account for this, the respondents were asked to provide information about their source of information. The sources focused on are: internal source, suppliers, customers, consultants or private R&D institutions, higher education institutions, Government or public research institutions, Conferences or exhibitions, Scientific journals, and professional associations. The findings with respect to the overall SMEs can be found in Appendix I. However, with regards to the focus of the study, this result in relation to the user innovation activities of the SMEs will be presented in the tables below.

Table 5.31: Bivariate Table Showing the Relationship between Internal Source of Information and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Internal Sources	High	62.9	30.8	66.7	52.6	37.5	78.6	60.6
	Medium	26.5	38.5	33.3	15.8	50.0	16.7	26.1
	Low	6.0	23.1	0	21.1	0	4.8	8.4
	Not used	4.6	7.7	0	10.5	12.5	0	4.8
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

As can be seen from Table 5.31, respondents that created their user innovation independently, SMEs that collaborated with higher education institution, and SMEs that involve other firms in their innovation activities indicated that they use internally sourced information during their innovation process. While SMEs that involves their client in their innovation process, as well as SMEs that modified existing products or services indicated that they moderately utilize internally sourced information during their innovation process.

Table 5.32: Bivariate Table Showing the Relationship between Supplier Source of Information and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Suppliers	High	25.8	26.9	33.3	31.6	25.0	9.5	23.7
	Medium	24.5	34.6	66.7	21.1	37.5	14.3	24.5
	Low	19.2	11.5	0	15.8	25.0	9.5	16.5
	Not used	30.5	26.9	0	31.6	12.5	66.7	35.3
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

In addition, Table 5.32 also reveals that only in rare occasion does the user firms in Nigeria utilize the suppliers of raw materials or equipment as their source of information. As the highest response (32%) from the respondents was observed among SMEs that collaborate with other firms. However, the same number of respondents (32%) also indicated the lack of usage of suppliers as their means of information. Moreover, the respondents indicated the moderate usage of suppliers as their source of information, majority of which is evident in SMEs that innovate in collaboration with their customers, SMEs that collaborate with higher education institutions, and SMEs that modifies existing products or services to meet their needs.

Table 5.33: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Customers	High	11.9	7.7	33.3	15.8	25.0	2.4	10.8
	Medium	13.9	26.9	33.3	31.6	0	11.9	16.1
	Low	20.5	26.9	0	26.3	37.5	7.2	49
	Not used	53.6	38.5	33.3	26.3	37.5	78.6	19.7
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

With respect to the utilization of customers as a source of information, Table 5.33 reported that a high proportion of the SMEs in Nigeria rarely or do not use this source of information. Especially with the SMEs who innovate independently, it was discovered that 54% of these SMEs do not use information derived from their customers. In addition, with regards to firms who collaborate with customers, it was also discovered that 38.5% of these firms do not utilize their customers as sources of information. Which is rather surprising because the whole

essence of collaboration revolves around the effective distribution of information between the SMEs and customers.

Moreover, Tables 5.34, 5.35, and 5.36 reveals that most user firms in Nigeria utilize external sources of information emanating from consultants, commercial laboratories, or private R&D institutions, as well as higher education institutions, and government as the major sources of innovation. further analysis reveals that only 8% of the SMEs has actually been supported by the government, while only 2% of these SMEs have also been supported by the higher education institution they claim to use as their source of information.

Table 5.34: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Consultants	High	40.4	50.0	33.3	26.3	37.5	59.5	40.2
	Medium	21.2	15.4	66.7	42.1	25.0	11.9	21.3
	Low	16.6	11.5	0	5.3	0	16.7	14.5
	Not used	21.9	23.1	0	26.3	37.5	11.9	20.9
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

Table 5.35: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
University	High	43.1	30.8	33.3	36.8	12.5	54.8	42.2
	Medium	31.1	30.8	66.7	52.6	75.0	28.6	34.1
	Low	17.2	30.8	0	5.3	0	14.3	16.5
	Not used	8.6	7.6	0	5.3	12.5	2.4	7,2
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

Table 5.36: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Government	High	52.3	57,7	66.7	47.4	50.0	78.6	57.0
	Medium	26.5	15.4	0	31.6	37.5	21.4	24.9
	Low	15.2	15.4	33.3	10.5	12.5	0	12.5

	Not used	6.0	11.5	0	10.5	0	0	5.6
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

Lastly, as revealed in Tables 5. 37, 5.38, and 5.39, all the respondents indicated that they either rarely or do not utilize external sources of information such as conferences, trade fairs, exhibitions, scientific journals and trade technical publications, as well as professional and industrial associations as their source of information. The implications of these findings will be presented in the following discussion section.

Table 5.37: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Conferences	High	12.6	7.7	33.3	15.8	12.5	7.1	11.7
	Medium	15.8	19.2	33.3	21.1	0	7.1	14.8
	Low	16.6	15.4	33.3	21.1	37.5	7.1	16.1
	Not used	55.0	57.7	0	42.1	50.0	78.6	57.4
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

Table 5.38: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with its customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Scientific journals	High	12.6	7.7	33.3	10.5	25.0	4.8	11.2
	Medium	15.9	15.4	0	21.1	12.5	7.1	14.5
	Low	5.3	15.4	0	10.5	0	2.4	6.0
	Not used	66.2	61.5	66.7	57.9	62.5	85.7	68.3
Total		100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

Table 5.39: Bivariate Table Showing the Relationship between Internal Sources and the Incidence of User Innovation (n = 249)

		Incidence of User Innovation						
		Your enterprise	Your enterprise with customers	Your enterprise with a higher education institution	Your enterprise with other enterprises	Your enterprise by modifying existing products/services	External enterprises or institutions	
Professional and Industry associations	High	11.9	7.7	66.7	5.3	12.5	2.4	10.0
	Medium	14.6	19.2	0	26.3	12.5	7.1	14.5
	Low	10.6	7.7	0	10.5	0	4.8	8.8
	Not used	62.9	65.4	33.3	57.9	75.0	85.7	66.7

Total	100 (151)	100 (26)	100 (3)	100 (19)	100 (8)	100 (42)	100 (249)

Note. Data from Author's 2018 PhD survey.

5.5 Discussion

This phase explores the overall state of user innovation in the Nigerian SME firms, covering areas such as the prevalence rate of user innovation, types of user innovation activities engaged by these SMEs, the implications of the firm age and the size of the firm on the user innovation abilities of the SMEs. In addition, the total expenditure invested by the SMEs on their innovation activities and the generation of revenue was also considered during this phase. In addition, since user innovators are not restricted from protecting their innovations, this study also explores the protection measures utilized by the SMEs, by reviewing areas such as their IPR rates, the technology sharing measures employed whether they are willing to freely reveal their innovation with others. Lastly, this study also indicated from previous studies that due to resource-constraints, SMEs utilize external sources of information more effectively than big-sized firms. Therefore, this study also provided information about the sources of information used by the identified user firms.

5.5.1 Prevalence Rate of User Innovation in Nigerian SME Firms

In our sample of 365 manufacturing and service SMEs firms, spread across the south west geo-political zones in Nigeria. It was discovered that there are 249 innovative SME firms, out of these, 83% were identified as user firms, that is firms who develop or modify products, services or process technologies to serve their urgent in-house needs, thereby improving the efficiency of their production system which could inadvertently result in favourable financial output (De Jong & von Hippel, 2009b; Flowers et al., 2009; 2010; Lee, 1996). Compared to previous studies conducted in developed countries, the incidence of user firms in Nigeria is significantly lower than those reported in previous studies. The causal factors behind this differences are purported to be partly due to those highlighted in section 3.4.1, as well as the complexities in accessing the Nigerian SME firm's population due to infrastructural problems which includes inadequate information about the location of the SMEs, as well as a small

population base of SMEs. Despite this limitation, this study has established the presence of user innovators in the Nigerian SME firms.

In addition, this current study identified that 61% of the identified user firms in the Nigerian SMEs firms function independently without the interference or support of any other firm. Which is contrary to the findings highlighted in existing studies that states that due to internal resource constraints, SMEs are identified to involve other firms in their innovation process, which enables them recognize the importance of both internally and externally sourced information acquired from collaboration with other elements of the innovation system (Lee et al., 2010; Acs, 2002; Abubakar et al., 2019; Edwards et al., 2005; Narula, 2004). As was described in the literature review, Flowers et al. (2009) highlighted one of the types of user innovation as user involver. This study also found that 10% of these user firms are user involver, that is user firms that involve their customers during their user innovation process. While the remaining user firms has successfully collaborated with institutions such as higher education institutions, and other enterprises which includes competitors in their user innovation process. To some extent these findings shows the existence of some interactions between the SMEs and other elements in the Nigerian national innovation system.

5.5.2 Types of User Innovation in Nigerian SME Firms

One remarkable findings made by this study relates to the predominant types of user innovation focused on by these firms. This study discovered that the Nigerian SME firms are more oriented towards the novel development of products and services. Moreover, a small incidence rate of modifications of existing products and services in the Nigerian SME firms was also identified. This discovery is contrary to the findings made by existing studies by Flowers et al., (2009; 2010), Egbetokun et al., (2007), Abubakar et al., (2019), Rosenberg, (1992), and Goedhuys & Sleuwaegen, (2010), which indicated that user firms engage more in product modifications than the development of new products or services. The likely reason behind the intense focus of the SME firms on the creation of new products and services rather than modification could be due to the poor state infrastructural development in Nigeria, which could affect the productivity or capability of the SMEs. In addition, another reason for the predominance of new product and service development over modifications could due to the

objective of SMEs in emerging economies which is to generate profits, lower its development cost, and maintain a good competitive advantage in their niche market. Other envisaged reason could be due to the 'stickiness' of the innovation – that is the incremental nature of the innovation expenditure been transferred (von Hippel, 1994; Bogers et al., 2010). However, this last assertion is a theory that remains to be tested in the Nigerian SMEs.

In addition, this study discovered a finding similar to that of Gault & von Hippel (2009), which identified that majority of the efforts of user firms are dedicated to the creation of new products and processes beneficial to their firm. This was affirmed to hold also among the user firms in Nigerian SMEs, since the survey revealed that Nigerian SMEs generates 19% more product creation than modifications to existing product, and 17% more service creation than modifications to existing services. Drawing from the intense focus of the identified user firms to create new products and services than modifying existing products and services, this could be the reason why Nigerian user firms chose not to freely reveal their innovations by opting for some form of compensation for their innovation efforts. Hence the reason why user innovators in developed countries always opted to reveal their innovation freely. However, an area that merits further investigation is the nature of improvements effected on existing products or services.

5.5.3 Effect of Firm Age on the Incidence of User Innovation

With regards to the effect of age on the SMEs ability to engage successfully in user innovation, this study discovered two contradicting information. Firstly, this study discovered that the age of the firm does not have a significant effect on the user innovation activities engaged by younger SME firms (within the age of 1 and 10 years) who engaged independently on their user innovation activities, and the user innovation activities executed in collaboration with their customers. Which corroborates with the discoveries made by previous studies which stipulates that younger firms experience more productive growth than matured firms (Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992).

Secondly, this study has also discovered the effect of the firm's age on its user innovation output with regards to the age group between 11 and 20 years old SME firms. Therefore, the age of the firm does have an effect on the user innovation activities, both radical and

incremental, done in collaboration with the higher education institution, user innovation activities done in collaboration with other enterprises which includes competitors, as well as modifications done on existing products or services. Which aligns with the findings made by previous studies that discovered that matured firms have more learning effects which allow them to build on existing routines and capabilities hence innovate more effectively (Coad et al., 2016; Van Praag & Versloot, 2007). However, with regards to other older SME firms above the age of 20, this study discovered a static growth trend, which was envisioned as a result of inertia stipulated in literatures (Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992).

5.5.4 Effect of Firm Size on the Incidence of User Innovation

This study has identified that an average of 128 employees, and a total number of 31941 are employed by the surveyed SMEs in Nigeria. With regards to the effect of the firm size on their user innovation activities, this study has discovered a variety of implications based on how the SME firms engaged on their user innovation activities. Firstly, this study uncovers a high incidence rate of user innovation among small-sized SMEs, especially among firms that conducted their user innovation activities independently, firms that collaborate with their customers, and firms that engages more on making modifications on existing products or services. Therefore, the firm size is identified to have an effect on small-sized SMEs in Nigeria.

Secondly, a medium-sized firm was highlighted to have a workforce below 250 employees. In this discussion, this will be separated into firms with 11 to 49 employees and firms with 50 and 250 employees. With regards to the first group, this study noticed some implications of the firm size on the user innovation activities of medium-sized SME firms. The biggest implication was identified among SMEs that engages in user innovation activities in collaboration with other firms. While other SMEs who conduct their user innovation activities independently, firms that collaborate with their customers, firms that collaborate with higher education institutions, and firms that engages more on making modifications on existing products or services.

Moreover, with regards to the second group of the medium-sized, this study discovered a major implication of firm size among SMEs that collaborate with higher education institutions

during their user innovation activities. The reason behind this high incidence rate could be purported to the level of graduate workforce employed within this establishments, which this study assumes to be the linkage between these firms and the higher education institutions. Moreover, as will be seen later in 6.5.3 of this thesis, the amount of graduate workforce in a firm was identified to have an effect on their innovation output.

Lastly, with regards to big-sized firms (with employees greater than 250), this study did not identify any effect of their size on their user innovation activities. Therefore, this study has discovered that small-sized SMEs who work independently, or collaborate with their customers, or make modifications to existing products or services are more user innovative than medium-sized SMEs who uses the same innovation approach. However, this study also discovered that medium-sized firms who innovate in collaboration with other firms, or in collaboration with higher education institutions are more user innovative than small-sized firms and big-sized firms in Nigeria. In summary, the findings of this phase does not overly support or contradict the findings by Flowers et al. (2009), (2010), and De Jong & Flowers (2018) which indicates that larger firms are more active user innovators than smaller firms.

5.5.5 User Innovation Expenditure and Revenue

As is popularly known that no innovation activity would be possible without sufficient innovation expenditure. This section will discuss the implications of the innovation expenditure of the identified user firms on their user innovation expenditure. In addition, this discussion will also present the results of the implications of the revenue generated on promoting more user innovation activities among Nigerian SME firms. From the survey presented in the results section, the average cost expenditure spent by the Nigerian SME firms on their user innovation activities during the past three years was ₦42,223,187, which equates to amount equivalent to €102,940. This is more than the average user innovation expenditure disclosed by previous studies in developed countries (Morrison et al., 2000; Flowers et al., 2010; Stock et al., 2015). However, lower than the average cost of innovation incurred by Dutch user firms (De Jong & von Hippel, 2009a). In addition, the survey reported a wide range of innovation expenditures by the Nigerian SMEs, with some SME firms indicating an expenditure that is as little as ₦3000 and the biggest expenditure being an amount of 2.5

trillion Naira. Which indicates that Nigerian SME spends more on their user innovation activities than those in the developed countries.

In addition, this study identified that majority of the SME firms spent below ₦200,000 Naira on their user modification projects, which correlates to the findings made by Morrison et al. (2000), that the innovation cost on user modification projects is low.

With regards to the time expenditure, compared to previous studies. This survey indicated that Nigerian SMEs also spent more time on their user innovation projects than disclosed in developed countries (Flowers et al., 2010; Morrison et al., 2000) the lowest time per week spent by the SME during their user innovation project was 1 week, while the most spent is 810 weeks. This could be evidence of the effect of the infrastructural insufficiencies existing in Nigeria. Considering the huge innovation expenditure made by the Nigerian SMEs which includes time, money and human capital investment, and the insufficient R&D expenditure purported in emerging economies, this finding shows to what extent SMEs contributes to the economic growth of a country especially in emerging economies.

In addition, as indicated in the result section, this study found that majority of the user firms have generated a revenue turnover from their innovation expenditure. This study also established that an average of ₦51,416,467 (equivalent to €125,376) has been generated by the user firms in Nigeria. While an average of ₦48,463,434 (€118,176) has been generated by the Nigerian user firms from the modifications made on commercial products or services. This is the first instance in the study of user innovation that the ability of the user firms to generate revenue from their user innovation activities will ever be disclosed. Moreover, with regards to the revenues generated from both the incremental and radical user innovation, this study discovered that a high number of the Nigerian SME firms generated a revenue between ₦200,000 and ₦500,000.

5.5.6 Technology Sharing and Protection of User Innovation

Though most studies on the subject of user innovation has indicated that user innovators mostly reveals their innovation freely than commercialize it (Shah & Tripsas, 2016; von Hippel,

1975; 1988; 2005; 2009; Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b; Henkel & von Hippel, 2004; Fisher, 2009). However, some user innovators after identifying the possibilities of drawing profits from their innovation expeditions choose to become a user entrepreneur (Shah & Tripsas, 2016), or apply for suitable protection for their innovation (Harhoff et al., 2003), or selling their innovation to producers through licensing or other means (Foxall & Tiernez, 1984; Lee, 1996). As identified in section 1.8, there are several reasons why user innovators either opt to protect their innovations or freely share it with other user which could also include their direct competitors. In this section, the implication of the protection rate and the openness of the user firms will be discussed.

With regards to the willingness of the identified user firms to reveal the innovation freely, this study has identified that most SMEs in Nigeria are not willing to freely share their innovation without a form of compensation or trade for their information. Which contradicts the findings from previous studies (von Hippel, 1975; 1988; 2005; 2009; Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b). However, this finding confirms the findings by De Jong et al. (2015) that states that minority of user-developed solutions are revealed. It also confirms the commercial benefits of user innovation identified by Bogers et al. (2010). This study has identified that most user firms in Nigeria engage in user innovation activities in order to generate some benefits which includes financial benefits, subsidies or discounts, exchange for another product or service, and royalty. This confirms the user's high benefit expectations which Luthje & Herstatt (2004) and De Jong & von Hippel (2009a) indicated encourages user innovator to maintain the monopoly over their innovation. In addition, the findings also correlate with the SMEs ability to generate a revenue turnover from their user innovation activities discussed in the preceding section.

Lastly, with regards to the incidence of protection and the methods utilized by the user firms in Nigeria to protect their user innovation. This study has identified that the incidence rate of technological protection by the user firms in Nigeria is very low, as a high majority who indicated their unwillingness to freely share their innovation, indicated that they did not protect their innovation. Which is consequential to Nigeria's static state indicated in the recent world intellectual property indicator. Despite their unwillingness to freely share their innovation, the weak protection rate indicates the possibility of information spillover from the

user firms to the local manufacturers (Flowers et al., 2010; De Jong & von Hippel, 2009a; Chesborough, 2006; Benkler, 2006; Morrison et al., 2000; von Hippel & Finkelstein, 1979). Moreover, the potential reason behind this weak protection rate could be due to the complexities of protecting innovation such as cost and infringement litigation (Dorf et al., 2011; Fisher, 2009; Liebeskind, 1996; Haefliger et al., 2010; Harhoff et al., 2003; Luthje et al., 2002; Benkler, 2002; Huizingh, 2011). Which to some extent could be beneficial to the user innovator as highlighted by Shah & Tripsas (2016), a weak protection regime could encourage the user firm to self-commercialize its product or service invention.

Moreover, this study has also discovered that SMEs in Nigeria mostly protect their user innovation through trademark and also by using trade secrets. Which is purported to be due to the nature of the innovation and the simplicity of using such protection method in Nigeria. In addition, some of the SMEs also utilize other protection methods which includes both local and international patent schemes, industrial design, copyright, and other licensing structures. To better indicated the state of user innovation among the Nigerian SME firms, the following section presents a typical example of User Innovation in Nigeria. With this example, a state of user innovation and their creation will be better depicted.

Another factor that could explain the lack of protection identified despite their unwillingness to share their innovation, is the novelty rate of their innovation. This study identified that majority of the user innovation expedition done independently by the SMEs are not totally new, while majority of those from other user firms are considered new by the user firms. The implication of this as imagined could have an effect on their willingness to freely share their innovation, as most collaborated with other elements in order to accomplish their user innovation activities. Which means the other party's objective for collaborating must also be considered before any decision with regards to the transfer strategy of the innovation can be reached.

Lastly, with respect to the source of information, this study identified a mixture of results worth elaborating on. To a large extent, this study discovered that Nigerian SME firms effectively utilize external sources of information which includes information from suppliers, customers, consultants, governments, and tertiary institutions as stipulated by Lee et al.

(2010). In addition, this study also identified that these SMEs, inasmuch as they have access to wealth of external information, also prefer to utilize internal information more than external information. Which also confirmed a statement by Lee et al. (2010). Though the study has identified that Nigerian SMEs use information derived from university, however, another important discovery made by this study indicate that, Nigerian SMEs do not use external information derived from conferences, scientific publications, and also from professional associations effectively. This discovery slightly affirms a statement by Rothwell & Dodgson, (1991) which states that SMEs lack the experience to establish appropriate connection with external sources of scientific expertise, as this study has indicated that the SMEs do not effectively utilize information sources that proceeds from scientific publication and conferences. However, a possible reason behind this contradicting discovery could be due to the quality of conferences and scientific publications conducted by Nigerian higher education institutions or also the level of exposure used in disseminating information about their conferences, which is likely not to reach the related industry. The following section provides a case study review a typical user innovator in Nigeria, detailing the nature of innovation, and the technology diffusion approach used by the user innovator.

5.6 User Innovation in Nigeria: A Case Study of Awojobi Clinic Eruwa (A.C.E)

It is no secret that Nigeria despite its abundant wealth of resources both human and minerals is heavily plagued with lots of solvable yet prevalent issues. One of which is the issue of incongruent healthcare system. This particular problem is very predominant in urban Nigeria, how much more the medical negligence experienced in the rural part of the country. To this end, Dr Awojobi recognizing the failures of the Nigerian government in providing adequate healthcare for her citizens, identified a niche and conceived an idea to solve the unsolvable by initiating Awojobi Clinic Eruwa (ACE) with the motto 'Private hospital in public service'. This in particular is the most suitable example of the state of user innovation in Nigeria. The objectives of this initiative and the appropriate medical inventions created will be adequately detailed in this section.

5.6.1 History and Objectives

Before proceeding further, it is vital to shed more light on the history of ACE. ACE was founded by Dr Oluyombo Awojobi and his wife Dr Atinuke Awojobi in October 27, 1986. The sole imperative of ACE was providing quality, adequate, affordable, and non-prejudgemental healthcare services in rural parts of Nigeria. The healthcare focus of ACE includes providing both surgical services and end stage pathology to members of the community. ACE, despite the lack of sophistication of a modern hospital, is not devoid of remarkable life-saving solutions. The hospital has catered for up to 250,000 patients since inception at the 52-bed frugally operated clinic.

The major approach employed was to use and promote methods synonymous to open source appropriate technology approaches in accomplishing the objectives hence providing suitable and quality healthcare service to the populace in the rural-settings of Nigeria. According to one of his philosophies 'there is no need to spend 100 Naira for what one can get for 10 Naira' which is synonymous to 'there is no need to send $10 for what can be gotten for $1'. Through his unique ability to function not just as a qualified medical surgeon and practitioner, but also as a welder, architect, electrician, bricklayer, engineer, carpenter, and many more, Dr Awojobi was able to fabricate 80 – 90% of the equipment and social amenities needed for the sustainability of his medical practice within the clinic's premises or in the local community. Hence massively reducing both the operating costs of the clinic and service fee for the patients. Other innovative approach used to accomplish the set objectives of ACE is: to run as a cooperative, where charges were levied based on the financial capabilities of the patients. Therefore, becoming an epitome of selflessness in the Nigerian and global medical field, and thus referred to as 'the caring physician of the world' by the World Medical Association in 2005.

5.6.2 Technological Inventions and Methodologies

Laden with incoherent infrastructural challenges such as deficient electricity supply, Dr. Awojobi in conjunction with his son resourcefully designed and developed a low-cost and replicable power inverter to capture the rare and occasional bursts of power supply from the public provider as well as from the power generator. This was fabricated from car batteries and are used to power the hospital during power outages. Moreover, because most of his

inventions were purposely created to bypass reliance on electricity, the hospital does not depend on the unpredictable power supply or incur more cost in running the hospital. In addition, in response to the issue of lack of running water, two projects were initiated at ACE: The first is a series of water catchment drains to harvest rainwater from the roofs of the hospital, which were directed into a large round tank. Next, was the initiation of a dam fashioned by hand that is almost 200 metres long to provide a more formidable approach to harness excess rainwater during the rainy season which spans for six months annually.

In addition, Dr Awojobi also frugally utilized maize cobs which had no significant purpose and thus disposed from neighbouring farmlands as heating source for boiling water for sterilizing their equipment and other general use. The operating table and surgery equipment used in the clinic were also fabricated locally using 90% wood and 10% metal which is lowered and raised by car hydraulic car jack (See Figure 6.9). This table eventually costs less than 10% the cost of the foreign brand, despite still having the basic tilts required by any experienced surgeons. While also fabricating tricycles and bicycles as the village and hospital ambulance and also for other internal logistic purposes. Other frugal equipment fabricated includes:

a) His iconic and frugal Heath Robinson Autoclaves and Water Distiller: This was fabricated in 1985 from domestic cooking gas cylinders and powered by maize (See Figure 5.1). This invention won him an award in 1992.

b) Maize cob furnace to generate heat for the water distillery and sterilization purposes (see Figure 5.2).

c) Intravenous fluid production: this is fabricated daily within the hospital facility for as low as 5 cents, where a normal saline costs an equivalent of 60 cents in the open market (See Figure 5.3).

d) Washing machines; this was fabricated using local iron materials sourced from the community (See Figure 5.4).

e) Wheel chairs and Hospital beds: these are fabricated from iron materials and other materials readily available in the rural community (See Figures 5.5 and 5.6)

f) Energy efficient surgical lamps: This is fabricated using energy saving bulbs shielded by a household aluminium bowl (See Figure 5.7).

g) Energy efficient lamps: This was fabricated with series of light emitting diodes (LED) bulbs in place of the normal energy consuming 100W bulbs (See Figure 5.8).

h) The pedal suction pump: this is fabricated from a plumbing pipe, a piece of leather and a reversed bicycle valve.

i) The Haematocrit centrifuge: this was fabricated from the rear wheel of a bicycle (See fig 5.10). This equipment revolves at 5400 rpm, thereby creating a force 3000 times the force of gravity, which is suitable enough to compact the red blood cells in a blood five minutes so as to determine the percentage of blood.

j) Frugal operating Table (See Figure 5.9)

k) Biogas from poultry droppings and cow dung: The objective of this invention is to solve the issue of fuel scarcity through bio-technology.

l) Interlocking cement blocks and variations of concrete mixers

m) Epidural needle and intraosseous access

n) Atraumatic suture using fishing line and hypodermic needle

o) Inflated inner tube in the prevention of pressure ulcer

p) Portable concrete mixer that revolves 360 degrees like the swivel chair.

q) Pre-timed fish meal dispenser that enables a farmer feed his fish remotely.

r) Intravenous bottle top cover with plastic sheet and rubber

s) Serial alarm clock for midwives and nurses in rural medical practice

Apart from the radical innovations listed above, Dr Awojobi when faced with a shortage of plasticine used to seal tubes for containing blood, incrementally innovated a frugal version by using candle wax instead. In addition, it is worth highlighting here that all the inventions created by Dr Awojobi were freely diffused with any interested persons which includes other surgeons. In addition, in order to effectively diffuse and support other rural surgeons, Dr Awojobi with the support of two other surgeon friends launched the Association of Rural Surgical Practitioners of Nigeria (ARSPON), which pooled together and supported all other like-minded surgeons with the interest of the Nigerian populace at heart.

5.6.3 Challenges

Despite his sacrificial efforts, from the findings of this research, it was uncovered that Dr. Oluyombo faced lots of challenges with regards to the governmental policies and from within the medical community pertaining to suitability and certification of his inventions which he uses to provide one of the if not the most affordable healthcare service across the length and breadth of Nigeria. This limitation confirms some of the limitations to user innovation identified in by existing research (von Hippel & Jin, 2008; von Hippel, 2005; Henkel & von Hippel, 2005; Strandburg, 2008; Gangopadhyay & Mondal, 2012; Brüggemann et al., 2016; Fan et al., 2013; Chesbrough, 2003; Baldwin & von Hippel, 2011).

In addition, ACE faced financial challenges despite devising some frugal innovative ways to curb this challenge. This in particular was the case of what was supposed to be Nigeria's first cancer hospital which was embarked upon by ACE and could have been extremely beneficial to the rural community and Nigeria as a whole.

However, this research study also discovered that the casualty rate of the surgical operations was incomparable to the ones done in a well-equipped medical facility in Nigeria. Which is a testament of the impeccability of the quality approach used by the user innovator in the person of Dr Awojobi. In addition, by directly benefiting from the use of the equipment contrary to the opportunities of making more income from the sales of the equipment, Dr Awojobi stands as the most iconic user innovator in Nigeria. Who engaged both radical and the incremental form of innovation to meet his unsatisfied needs which presents itself in the form of low quality and unaffordable healthcare service in rural Nigeria.

Figure 5-1: Autoclave and equipment Sterilizer. Source: Author

Figure 5.2: Furnace for Autoclave. Source: Author

Figure 5.3: Intravenous Fluid Produced at ACE. Source: Author

Figure 5.4: Frugal Washing Machine. Source: Author

Figure 5.5: Frugal Wheelchair. Source: Author

Figure 5.6: Frugal Hospital Bed. Source: Author

Figure 5.7: Frugal Surgical Lamp. Source: Author

Figure 5.8: Low cost LED Lamp. Source: Author

Figure 5.9: Surgical Table 1. Source: Author

Figure 5.10: Bicycle Fabricated Centrifuge. Source: Author

The first case study presented in this section represents a case of freely diffused user innovation. This next case study reviewed in the following section will present a case of user innovation from the perspective of a commercialized user innovation attempt that combines both manufacturer involvement and user entrepreneurship.

5.7 User Innovation in Nigeria: A Case of Emergency Autotransfusion Set (EAT-SET)

EAT SET is a low-cost and appropriate technology system used to recover blood from internal bleeding. This low-cost autotransfusion system, developed by Dr. Oviemo Ovadje in 1989, provides an economical solution to problems that arises from the inaccessibility of emergency transfusion service in emerging economies (WIPO, 2000; 2003; 2010). The major application

of this life-saving equipment is to salvage blood from patients suffering from internal haemorrhage, such as road traffic accident victims, and ruptured ectopic pregnancy. It also prevents the transmission of blood infections by reusing the patients' blood (WIPO, 2000; 2003; 2010). Other benefits of EAT-SET are that it is compact and does not requires electricity (WIPO, 2003).

Just like every other user innovator, Dr Oviedo while undergoing a specialist training in Nigeria observed that one of the causes of the high mortality and morbidity rate during pregnancy in emerging economies is due to internal bleeding which arises from ruptured ectopic pregnancy. Therefore, he embarked on the quest to find an affordable solution this medical challenge. During the innovation process, Dr Oviedo was supported by the Nigerian government by providing suitable research facilities. However, the initial funds incurred during this innovation process was from a personal investment from the user innovator. While United Nations Development Program (UNDP) also provided necessary financial resources for the development and testing of the innovation (WIPO, 2010).

As can be seen in Figure 5.11, EAT-SET consist of a transparent rigid capsule, incorporating a V – shaped micro – filter with other components, which are arranged in a way that allows its adaptability as a manual source of low vacuum. With the EAT-SET device, the salvaged blood can be safely reinfused within 24 hours after haemorrhage (WIPO, 2010).

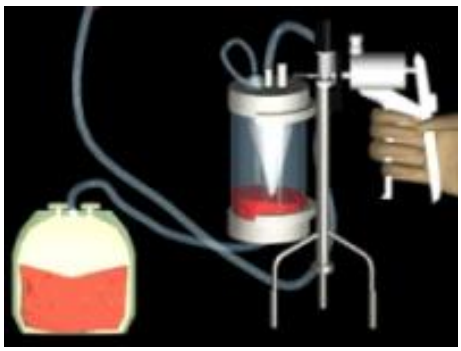

Fig 5.11: EAT-SET Device. Source: WIPO, 2010

5.6.1. Commercialization and Protection

To solidify the statements about the protection of user innovation, it was discovered that the EAT-SET has been patented by the African Intellectual Property Organization (OAPI) and also acquired trademark protections from nine African countries (WIPO, 2010). With regards to the commercialization, from this review, it was discovered that the device was jointly commercialized by the company setup by the inventor (EAT-SET Industries) and a manufacturer in India. Which depicts the possibilities of user entrepreneurship of user innovations (Shah & Tripsas, 2016).

5.8 Conclusion

If emerging economies are to accomplish economic growth, several factors need to be addressed. One of which includes increasing the R&D investment by government, as well as fostering a synergy between the elements of the national innovation system. However, since innovation has been identified as a critical driving force in achieving economic growth, and user innovation as the origin of most product sold on the commercial market. Therefore, the contribution of the lead user in the innovation process can no longer be overlooked in the emerging economies context. In addition, SME firms has long been identified as the major source of employment and income in any economy. This research study has attempted to bridge the gap in the quantification of the prevalence rate of user innovation among SMEs in emerging economies, and revealed so many ground-breaking discoveries.

First and foremost, this study phase discovered that 8% of the Nigerian SME firms are engaged in some forms of user innovation activities. These user firms are mostly focused on the development of new products or services than modifications of existing products or services to meet their needs. In addition to this, this study also found that the user firms in Nigeria are more oriented towards product innovations than service innovations. In addition, according to the case study reviews presented in this chapter, this study was able to confirm the claim by von Hippel (2001) that user innovation creates low-cost and socially optimal products that meets not just the needs of the user innovator, but also meets the needs of other users.

Moreover, other factors that could affect the prevalence of user innovation such as the age, size and financial capabilities of the user firms in the Nigerian was also explored, and

discovered that depending on how the user firm engaged in their innovation expedition, both their age and size could have an effect on their user innovation activities. In a nutshell, it is obvious that user innovation is significant to the Nigerian economy. Without doubt, considering the highlighted advantages of SMEs in an economy, one can easily assume that if the user innovation activities among the SME firms in developing can only be supported, then more income and employment will be generated. Therefore, it is important for better means to support this form of innovation should be provided both by the governmental structures and big companies.

6 Measuring the contributions of Private Innovation Incubators in Nigeria

Synopsis

Chapters 4 and 5 identified the prevalence rate of user innovation from the individual level and the firm level. However, considering the effect of infrastructural deficiencies was identified to negatively affect the propagation of user innovation activities in Nigeria and in the context of an emerging economy. Therefore, this chapter will explore the contributions of the innovation incubators to the Nigerian innovation ecosystem, as well as their contributions to the user innovation activities in Nigeria.

An innovation Incubator, private or public, are interfacial firms which aids the successful transition of technologies from research facilities to the commercial sector. Therefore, having a significant effect on the macro and micro level. This inductive study investigates 14 private innovation incubators in Nigeria and adopts a design, focused on exploring the impact of these private innovation incubators on the overall Nigerian innovation ecosystem. Moreover, this study was conducted using a qualitative research methodology, through personal visitation and telephone interview of respondents. The study reveals some evidences that, in terms of innovation input, process, and output private innovation incubators in Nigeria with the firm age below 5 years are more innovative than older incubators. In addition, it was also discovered that the firm size and the number of graduates have an effect on the ability of private innovation incubators to generate funds through self-funding. However, this study did not identify any significant effect of firm size and the number of graduates on the innovation process and output.

6.1 Introduction

Accumulation of literature has linked the role innovation plays in any organization or society to competitive advantages (Schumpeter 1934; Wang & Ahmed 2004; Davila et al., 2012; Rejeb et al., 2008; Tang & Yeo, 2003), driver of job creation, productivity, technological progress and social change (Elahi et al., 2014; OECD, 2010a), suitable solution to climate change, advances

sustainable development, promotion of social cohesion (Gault 2018), and the creation of values for customers and citizens through process or product innovation. However, to harness innovative efforts, several mechanisms have been developed which includes innovation incubation. The incubation concept highlights the importance of a mediating organization to serve as a linkage between technology, capital and know-how. This mediating organization, otherwise known as incubators, speed up technology exploitation rate by leveraging entrepreneurial talents, and accelerating the development process of new businesses (Grandi & Grimaldi, 2004). Grandi & Grimaldi (2004), mapped out four different types of incubators. These are: (1) corporate private incubators (CPIs); (2) independent private incubators (IPIs); (3) business innovation centres (BICs); and (4) university business incubators (UBIs).

The CPIs and IPIs are profit-oriented institutions, which in this study is grouped as private incubators (PIs). The major difference between the CPIs and IPIs are: CPIs are incubators set up and funded by large companies, while IPIs are incubators set up and funded by individuals or groups of individuals to support entrepreneurs and new businesses during the crucial early stages of their ventures (Grandi & Grimaldi, 2004). Compared to the public-sector incubators, which henceforth will be referred to as government-funded incubators (GFIs), Grandi & Grimaldi (2004) highlighted that, PIs provide more direct access to capital; creates more intangible and high value services to tenant firms; as well as provide better day-to-day operational support and access to advanced sources of technological and management expertise. Existing literature on the significance of the innovation incubators on Nigeria's innovation ecosystem majorly focused on the contributions of GFIs. Therefore, this research paper will contribute to the body of knowledge by exploring the contributions of PIs on Nigeria's Innovation ecosystem. Thus, the aim of this study is to establish the state of the art of innovation measurement and capture the state of the practice of innovation measurement in the PIs in Nigeria. As indicated in chapter 3, the objectives of this phase are:

1. To investigate the contribution of the PIs to Nigeria's innovation ecosystem
2. To study the effect of the firm size on their innovative activities
3. To study the effect of graduate employees on their innovative activities
4. To uncover the effect of the firm's age on their innovative activities
5. To examine the factors affecting PIs, as an industrial policy in Nigeria.

6. Lastly, to explore the numbers of user innovators supported by the PIs

The remainder of this phase is divided into six sections. The following section provides a review of the literature, by showcasing the importance, conceptual definition of innovation incubators, and the historical perspective of PIs. Section 6.3 showcases the different metrics used for innovation, the evolution of innovation metrics, and the significance of performing a measurement of innovation. Section 6.4 presents the findings and outcomes of the research. Section 6.5 provides detailed discussions on the results of the survey. Lastly, section 6.6 concludes with a summary of the study with some recommendations for future research on the subject matter.

6.2 Literature review of Innovation Incubator

Innovation Incubator has been a global phenomenon purported to stimulate new product development, business creation, as well as to increase the survival rate and growth of new ventures and economy (Robinson, 2010; Ratinho & Henriques, 2010; Bruneel, et al., 2012; Mathernova & Bail, 2010; Kuratko & LaFollette, 1987; Colombo & Delmastro, 2002; Adelowo et al., 2012; Adegbite, 2001; Soetanto & Jack, 2016; Isabelle, 2013; Peters et al., 2004). Mathernova & Le Bail (2010) defined innovation incubator as 'a business development centre for entrepreneurs and small medium enterprises (SMEs) that intend to develop innovative ideas'. In particular, it facilitates regional progress by establishing localized mechanisms that enable shared resources and knowledge development (Oh et al., 2016; Diez-vial & Montoro-Sanchez, 2017). In summary, much of the ground-breaking innovations enjoyed today are mostly due to the contribution of innovation incubators (Lalkaka, 2002b; Cooper, 1985). This is accomplished by providing ranges of support to new businesses and entrepreneurs, this includes: (1) access to networks, (2) monitoring, (3) knowledge development and dissemination, (4) finance and administrative mobilization, and (5) creation of exposure, (6) enterprise counselling and training (McAdam & McAdam, 2008; Samaeemofrad & Van den Herik, 2018; Grimaldi & Grandi, 2005; Adegbite, 2001; Baraldi & Havenvid, 2016; Bergek & Norrman, 2008; Mian, 1996; Bøllingtoft, 2012).

Apart from the contribution of innovation incubator to catalyze a country's technological and socio-economic growth, innovation incubators also have the ability to augment the development of indigenous technologies thereby promoting grassroots-innovation. Innovation incubators are interfacial firms, private or public, that aids the successful transition of technologies from research facilities, individual or small firms, to the commercial sector (Oyewole, 2010; Fisher, 1998). They are service providers that help new businesses maximize and achieve their objectives, by doubling as a facilitator of interactions and collaboration between innovators and investors.

6.2.1 Historical Perspective of Incubator in Nigeria

In emerging economies, such as Nigeria, innovation incubators were identified as a means to tackle socio-economic development challenges, due to its ability to generate strategies to create technology-based businesses, generate local and export income, and leverage broader economic activities (Bobou & Okrigwe, 2012). The history of incubators in Nigeria dated back to the pre-independence era in 1958, the first been a GFI launched at the Yaba district area of Lagos state (Adegbite, 2001), to promote indigenous entrepreneurship by providing tenant firms free access to the facilities to use for a period of three to five years. In addition, the first Technology based incubator (TBIs), nurturing technology intensive enterprises and knowledge-based organizations (Adelowo et al., 2012), was claimed to be established in 1993 (Adelowo et al., 2012; Adegbite, 2001; Bobou &Okrigwe, 2011). However, as at 2009, the total number of government-funded incubators (GFIs) stood at 25. With a total tenancy rate of 146 entrepreneurs (Adelowo et al., 2012). Moreover, with regards to the weaknesses and threats of the incubators, Adegbite, (2001), discovered that the same impediments confronted by older GFIs also plagued the TBIs in existence as at 2001. Some of which includes:

1. Insufficient funds and support by the government.
2. Reluctance of tenant firms to move out at the expiration of their tenancy period
3. Inability to generate sufficient funds from operational activities, which encourages dependence on government.

Based on these limitations, Adegbite (2001), concluded that the GFIs failed to achieve their primary objective of producing a constant flow of successful enterprises. In addition, in terms of impact and growth, the productivity of the GFIs are still not convincing (Akhuemonkhan et al., 2014; Adelowo et al., 2012). Comparing these literatures to the data collected, we discovered that as at 2018 the profound limitation experienced by most PIs, which includes CPIs and IPIs, still revolves around the lack of funds and support from the government. However, with regards to the reluctance of the tenant firms to vacate their premises, we discovered that most PIs also function as a co-working space, which means the tenant firms only utilize their facilities on a 'Pay per use' services.

Moreover, the services provided by these PIs include: coaching and consultation services; technology incubation and acceleration programs; training and entrepreneurship workshops; co-working spaces with uninterrupted access to Internet and Electricity which is highly needed in the quest for technological development, as well as serving as an interface between inventors and investors. Detailed information about this will be provided in the results section. To solidify the importance of this research study, section 6.3, through literature review uncovers the various metrics of innovation.

6.3 Metrics of Innovation

As a matter of course, innovation, being at the heart of a knowledge-based economy change (OECD 1997b), could be well argued to be the most frequent word used at both the macro-level and micro-level. However, due to its dynamic nature, the measurement of innovation remains a very challenging task on all levels due to the different approaches used to quantify the innovativeness of an organization and country. Moreover, Edison et al. (2013), linked the difficulties with measuring innovation to the variances in its definition, which some argued to be just radical while others believe it comprises both radical and incremental innovation. Concerning the measurements, the most used metric according to existing literature is the traditional configurational metrics which focuses on input, process, output approaches (Davila et al., 2012; Andrew et al., 2007; Manoochehri, 2010; Adams et al., 2006). As indicated by Shapiro, (2006), no single measure can cover all the aspects constituting innovation. Therefore, the ideal measures of innovation utilized will be a derivative of the perspective of

innovation by an organization (Edison et al., 2013; Jensen &Webster, 2009; Davila et al., 2012). Through literature review, a search of existing literature was conducted to extrapolate the different metrics used to measure innovations, and the level at which these metrics were employed. These findings are tabulated in Table 6.1:

Table 6-1: Metrics of Innovation and Focus

Innovation Metric	Macro-level	Micro-level	References
Research and Development (R&D) Expenditure (Business expenditure on R&D (BERD), Gross expenditure on R&D (GERD))	X	X	Born & Guo, 2016; Smith, 2005; Kleinknecht et al., 2002; OECD, 1997b; Coombs et al., 1996
Patent Application	X	X	Kleinknecht et al., 2002; Janger et al., 2017; Acs & Audretsch, 1989; Coombs et al., 1996; Elahi et al., 2014;
Total Innovation Expenditures	X	X	Kleinknecht et al., 2002;
Knowledge Economic Index (KEI)	X		Born & Guo, 2016; Radwan & Pellegrino, 2010; Janger et al., 2017
Knowledge management (Idea generation, absorptive capacity, knowledge repository, information flow)		X	Adams et al., 2006; Murovec & Prodan, 2009; Lund Vinding, 2006; Cohen & Levinthan, 2000
Bibliometric data or Specific Databases	X	X	Smith, 2005; Kleinknecht et al., 2002;
Technometric indicators (i.e. technical performance of products)		X	Smith, 2005; Saviotti, 1996; Wilhelm 2003
Synthetic indicators (Scorecard)	X	X	Davila et al., 2012; Smith, 2005; Cornelius et al., 2003; Janger et al., 2017; Zizlavsky, 2014;
Innovation Dashboard		X	Manoochehri, 2010
Sales of Imitative or Innovative products		X	Kleinknecht et al., 2002
Innovation Survey	X	X	OECD, 1997a; Archibugi & Pianta, 1996; Arundel & Garffels, 1997; Arundel et al., 1998; Sirilli & Evangelista, 1998; Hipp & Grupp, 2005; Inzelt, 2003; Wilhelm, 2003; Smith, 2005;
Non-R&D expenditure (New products or Services Development, patents and licenses acquisition, design, trial production and tooling-up, training of personnel, market research, investment in new production capacity, Rapid response to competitive demands, Number of Start-ups)	X	X	Brouwer & Kleinknecht, 1997; Evangelista & Sirilli, 1995; OECD 1997a; Smith, 2005; Kleinknecht et al., 2002; Archibugi & Pianta, 1996; Powell & Grodel, 2005;

Source: Compiled by Author

In addition to the different innovation metrics listed in Table 6.1, Milsberg & Vonortas, (2004) in their paper categorized the emergence of technological innovation measurements into four generations, which are Input indicators, Output indicators, Innovation indicators, and Process indicators. These evolutionary indications provide a new perspective on the growth pattern of the innovation metrics. Which are presented in Table 6.2.

Table 6-2: Evolution of Innovation Metrics by Generation

1st Generation Input Indicators (1950s – 60s)	2nd Generation Output Indicators (1970s – 80s)	3rd Generation Innovation Indicators (1990s)	4th Generation Process Indicators (2000s + emerging focus)
• R&D expenditures • Science and Technology (STE) Personnel • Capital • Technological Intensity	• Patents • Publications • Products • Quality Change	• Innovation surveys • Indexing • Benchmarking innovation capacity	• Knowledge • Intangibles • Networks • Demands • Clusters • Management techniques • Risk/Return • System Dynamics

Source: Table 1 in Milsberg & Vonortas, 2004

From Table 6.2, according to Milsberg & Vonortas, (2004) the evolution of innovation measurement occurred between 1950 and 1960, through the input indicators which includes research and development (R&D) expenditures, STE personnel and expenditures, Technical Intensity, and capital investments. This was later succeeded by the output era from the 1970s – 80s. Majority of earlier approaches to measure innovation totally omitted the innovation processes due to the perceived difficulties in quantifying non-R&D expenditures (Brouwer & Kleinknecht, 1997).

According to Table 6.2, the best metrics used to quantify innovation in the 4th generation should delineate more from knowledge and the intangible aspects of innovation. From review of existing literature, we discovered that factors in the 4th generation also incorporate those listed in the preceding generations. For example, Stones et al. (2008) indicated that inputs to innovation can exist in the form of tangible and intangible forms. The tangible forms are the physical embodiment of innovation and are cost incurred, while the intangible inputs are patents, databases, and other intellectual assets (Stones et al., 2008; OECD, 2010b). The only significant difference between the 4th generation from the preceding generations is the inclusion of the transformative innovation process of input to outputs. This in particular, corroborates the drawbacks of R&D listed by Coombs et al. (1998). To get a better understanding of how these metrics relate to the evolution highlighted by Milsberg & Vonortas (2004), we have cross-tabulated a table mapping specific metrics to their generation era.

Table 6-3: Metrics of Innovation Vs Evolution Period

Innovation Metric	Evolution period
R&D Expenditure	1st Generation
Patent Application	2nd Generation
Total Innovation Expenditure	1st Generation
Knowledge Economic Index	4th Generation

Knowledge Management	4th Generation
Bibliometric Data	2nd Generation
Technometric Indicators	1st Generation
Synthetic Indicators	3rd Generation
Innovation Dashboard	3rd Generation
Sale of Imitative or Innovative Products	2nd Generation
Innovation Surveys	3rd Generation
Non-R&D Expenditures	4th Generation

Source: Compiled by Author

Moreover, in this review, we discovered that R&D and patent data are by far the most used indicator of innovation (Adams et al., 2006; Milsberg & Vonortas, 2004). R&D in particular, comprises both the production of new knowledge and new practical applications of knowledge which covers basic research, applied research, and experimental research (Smith 2005). However, despite its gross utilization, R&D data indicators were highlighted to be constrained as an adequate indicator by the fact that it only measure input (Kleinknecht et al., 2002; Smith 2005; Acs et al., 2002), it does not show the efficiency of the transformation process of inputs into outputs, the economic significance of the innovative products (Coombs et al., 1996; OECD, 2010b). In addition, Coombs (1996) also highlighted the drawback of using patents as indicating inventiveness rather than innovativeness which entails the commercialization process of the invention.

Moreover, despite the drawbacks of R&D indicators, it is still the most used on the micro-level. Lastly, in order to properly measure innovation, the measurement of non-R&D metrics should also be included in the innovation metrics approach. The succeeding section details the research findings from this study.

6.4 Results

Figure 6.1 illustrates the focus of the surveyed PIs. From this survey, it was discovered that 20% of the PIs focus on 'Technology incubation and technology development'. This in particular, resonates the findings from prior research, which highlights that, despite the possibilities of incubators to serve variety of firms, they are often oriented towards technology-based firms (Peters et al., 2004; Smilor, 1987). In addition, 15% of the respondents indicated that they focus on providing 'affordable working space' and 'Training and Mentorship' services respectively. While 12% indicated they also focus on 'Business acceleration and support; 10% indicated 'Job placement and entrepreneurship' and

'Community Development'; 8% also focus on 'Youth empowerment'; while 5% indicated that they also focus on providing 'Access to technologies' and 'Capital investment'.

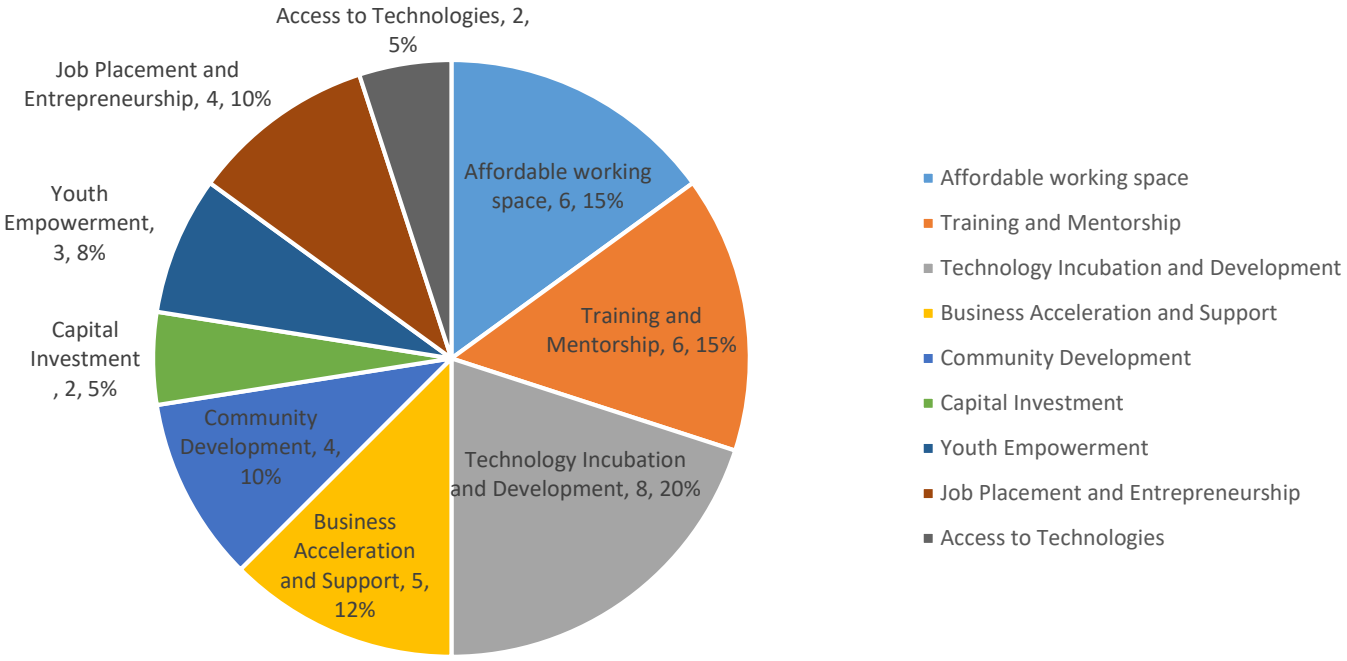

Figure 6-1: Organizational Focus of PIs (n = 14). Source: PhD Survey from Author

Table 6-4: List of factors for PIs

Respondent	Firm_Age	Firm_Size	Grad_Emp	Fin_Source	Num_Start-up	Num_Prod	Revenue	Innovation Strategy	IPR	Community Project	Collaboration with other firm
Respondent 1	6	22	15	1	10	1	1	1	2	2	2
Respondent 2	2	30	8	1, 2	4	4	1	1	2	1	2
Respondent 3	2	6	6	1	4	6	1	1	2	1	2
Respondent 4	10	3	3	4	20	2	2	2	1	1	2
Respondent 5	2	3	3	2	40	18	2	1	2	2	2
Respondent 6	4	40	35	1, 2, 4	50	0	2	2	2	1	2
Respondent 7	4	40	30	1, 3	4	0	1	1	2	1	2
Respondent 8	7	12	8	1, 2	10	2	1	1	2	1	1
Respondent 9	2	11	11	1	2	8	1	2	2	1	1
Respondent 10	1	1	1	2	0	0	2	1	2	1	2
Respondent 11	4	12	12	1, 2, 4	15	15	1	1	2	1	2
Respondent 12	1	10	10	1	25	10	1	1	1	1	2
Respondent 13	3	21	18	1, 2	47	2	1	2	2	1	2
Respondent 14	1	40	30	1, 2	7	12	1	1	2	1	2
Total	49	251	190		238	80					
Mean	3.50	17.93	13.57		17.00	5.71					
Std Dev	2.62	14.38	10.90		17.13	5.98					
Min	1.00	1.00	1.00		.00	.00					
Max	10.00	40.00	35.00		50.00	18.00					

Source: PhD Survey from Author

*Financial source: 1 = 'Self-funded', 2 = 'Private organization', 3 = 'Workshop fee', 4 = 'Government'

*Revenue, Innovation strategy, Community project, and Collaboration: 1 = 'Yes', 2 = 'No'

In this study, to avoid any confusion, the variable 'Firm_Age' is used as an indicator to represent the age of the surveyed PIs, the 'Firm_Size' indicate the total numbers of employees working in the PIs, Grad_Emp indicate the number of graduate employees working in the PIs, Fin_Source to represent how they generate the financial resources, 'Num_Start-up' to represent the Num_Start-ups founded or supported with the help of these PIs, 'Num_Prod' to represent the number of products developed by or with the support of the PIs, and lastly, 'Revenue' to represent their revenue turnover.

6.4.1 Firm Age on the PIs Innovativeness

As can be seen in Table 6.4, the average age of the samples is 3.5 years. From this, it can be observed that 50% of the respondents have been in existence for 2 years or less, while 21% have been in existence for 4 years. From this depiction, it was observed that 79% of the samples are within the age range of 1 to 4 years, which was identified as the critical period for the existence of new start-ups (Peters et al., 2004; Muhos et al., 2017; Saarela et al., 2016).

To uncover how the PIs are funded, we asked the respondents how they solicit their financial resources, which also covers other costs such as the acquisition of materials resources, rent, and other operational costs incurred by the organizations. This result is also presented in Table 6.4. From this analysis, it was observed that majority 46% of the respondent are self-funded, either through personal investments by the founders, provision of co-working spaces, and also by offering consultancy and services to external organizations. In addition, 81% of these PIs that are self-funded are young and still within the critical phase of survival.

Moreover, this study also observed that 33% of the respondent are either partly or fully funded by private organizations which also includes grants received from foreign organizations and embassies. In addition, looking at the effect of age on the ability of the PIs to generate income, it was uncovered that 87% of these PIs are firms with the Firm_Age <5. Meanwhile, 14% of the respondents also indicated that they are funded by the government. To uncover the type of government supporting these organizations, the respondents were asked to elaborate and we discovered that one was fully funded by the Federal government, and the others were partly funded by the state government. It is also worth noting that majority of these PIs supported by the government are young firms. Lastly, the remaining PI is funded by collecting workshop fee and is also a young firm within the critical age

range of 5 years. Therefore, the effect of the age of the firm, size of the firm, and the numbers of graduates on the financial resources will be elaborated in the discussion section.

Furthermore, Table 6.4 unveils that 71% of the respondents have generated a revenue turnover, while the remaining 29% are yet to generate any revenue turnover. In this study, it was assumed that the factor behind the lack of revenue for the remaining organizations without a revenue turnover could be based on the focus and policy of the source of their financial resources. Further analysis indicates that 50% of these organizations without revenue were funded by private organizations, while the remaining were funded by the federal and state government respectively. This discovery could indicate that their objective is based on empowering the social structure rather than generating revenues.

6.4.2 Firm Size on their Innovativeness

In the Nigerian context, a small business is considered to have between 10 and 50 employees, a medium sized business is considered to have between 50 and 300 employees, while big-sized firm is considered to have from 300 employees above (Ramachandran, 2002; Egbetokun et al., 2009; Oyefuga et al., 2008). In addition, existing studies conducted to uncover the effect of Firm_Size on the innovative activities of an organization focused on big sized-firms with more than 250 employees. However, drawing a comparative conclusion of our findings from existing studies could lead to inconsistencies. Therefore, to create a path for future research, this study deemed it worthy to establish the effect of Firm_Size on the innovative activities of surveyed PIs. Therefore, based on the data collected during this phase, the Firm_Size are grouped and analysed as firms with <=10 and >10 employees.

From Table 6.4, it can be observed that an average of 18 employees are employed by the PIs, while the lowest number of employee working in the PIs is 1, and the highest number of employee working at the surveyed PIs is 40. Which is aggregated to a total Firm_Size of 251. Based on the method used to group the Firm_size, it was discovered that 64% of the PIs has a workforce above 10 employees. Majority of which indicated that they have 40 employees working in their facility. While the remaining 36% have a workforce of 10 employees and below. However, existing research identified that the size of a firm does have an effect on the firm's innovative output (Coad et al., 2016; Van

Praag & Versloot, 2007; Hansen, 1992). It is worth noting that the innovative output considered in this study only covers the number of products, number of start-ups, and revenue generated. In addition to the effect of the firm size on the innovative, this study will also present the effect of Firm_Size on both the innovative input and process of the PIs.

One significant observation of the effect of Firm_Size can be observed on the source of finance. The findings of this study identified that all the PIs with a workforce above 10 are mostly self-funded. Which could be indicative of their effectiveness in utilizing consultancy and outsourcing services provided to external organizations. In addition, this study also discovered that 89% of the PIs with a workforce above 10 employees have generated a revenue turnover from their innovation activities. Which is also assumed to be due to the services provided to external organizations. These analyses and their implication on the innovative activities of the PIs will be elaborated further in the discussion section of this study. The next section provides the result of the effect of the numbers of graduates employed within these PIs on their innovative

6.4.3 Graduate Employee on the Innovativeness of the PIs

Due to both their academic and technology exposure, graduate employees are depicted to be more innovative, effective and efficient in a firm than non-graduate employees (Lundvall, 2008; Schultz, 1975; Nelson & Phelps, 2003). This section will present the results of the effect of the number of graduate workforce employed by the PIs on their innovative activities. In addition, it is worth highlighting that the graduate workforce covered in this study only includes employees with a minimum of a degree or higher national diploma (HND) certificate. Therefore, this survey did not consider other employees with an ordinary national diploma certificate and high school certificates. From this survey, it was discovered that an average of 14 graduate employees is employed by the surveyed PIs, with a value aggregating 190 graduates.

Moreover, this study identified that 76% of the total Firm_Size of the PIs are graduate employees holding either a bachelor's degree or HND certificate. With regards to the implication of this findings on their source of finance, this study uncovered that majority of the PIs whose workforce is constituted of 67% and above graduate employees generate incomes through self-funding. As indicated in previous section, the self-funding represented in this study involves the firm's ability to raise funds either through the personal investment of the founder, or through the provision of co-

working spaces, and also by offering consultancy and workforce outsourcing services to external organizations. However, out of these factors listed, the only way the significance of Grad_Emp can be explained still lies in the PIs' ability to provide workforce outsourcing services to other organizations.

Lastly, with regards to the effect of Grad_Emp on the revenue turnover, this study identified that 71% of the PIs constituted of 67% and above graduate employees have generated some revenues from the innovation activities of their firm. However, the implications of this findings will be adequately elaborated in the discussion section. Having provided the findings with regards to the effect of the Firm_Age, Firm_Size, and Grad_Emp on the innovative activities of the PIs, the next section will provide the analysis of the observed contributions of the PIs to Nigeria's innovation ecosystem.

6.4.4 Results of the Contribution of Private Innovation Incubators

In order to highlight the contributions of the PIs in the Nigerian innovation ecosystem, factors such as the number of products, numbers of start-ups, and their community-orientation will be utilized. As can be seen in Table 6.4, the Num_Start-ups amount to 238. Furthermore, 57% of the respondents with a minimum value of 10 start-ups have collectively supported 217 start-ups. Moreover, the average age of these respondents are 4.6. Which indicates that in order to support a significant number of start-ups the PI must be existing for 4 years and above. However, drawing a conclusion on the correlation of Num_Start-up to Num_Prod is inconclusive, due to the occurrences of some PIs with a high number of start-ups yet with few product developments. In addition, this study also discovered that some PIs with few number of start-ups yielded higher number of products. The reason for this disparity is unclear, and will be recommended for future studies.

In addition, we also discovered that all these start-up companies are focused on technology development, majority (68%) of which are focused on software development, while 32% are focused on the development of hardware technologies. In terms of the equipment, it is worth mentioning that out of these respondents, only 2 have technologies (such as, 3D printers, milling machine etc.) needed for rapid prototyping.

Table 6.4 also indicates that a total of 80 products have been developed with the assistance of the sampled organization. We also discovered that 50% of PIs supporting 4 or more products accumulates 91% out of the 80 products recorded.

6.4.4.1 Innovation Strategy

To understand more about the state of the PIs and their contributions, the respondents were further asked a closed ended question based on the nominal variables (Yes, No). These questions were framed on intellectual property rights (IPR), innovation strategy, collaboration with other firms, and the conduction of community-oriented projects. The outcome of the survey is also illustrated in Table 6.4. Also, it was discovered that majority (86%) of the sampled organizations and their start-up companies have not filed for any IPR either on the local or international level. However, 14% of the respondents indicated that they have filed for a total of 4 IPR protection at the local level.

Moreover, with regards to the significance of the innovation strategy, this study observed that 71% of the respondents have an innovation strategy used to accomplish the objectives of their organization, while 29% do not have any innovation strategies. However, 58% of the respondents with an innovation strategy also indicated a revenue turnover, while 14% do not have an innovation strategy and still recorded a turnover, another 14% have an innovation strategy but with no revenue turnover, while the last 14% does not have an innovation strategy and recorded no turnover. It is worth highlighting that the 2 respondents with an innovation strategy and no revenue turnover are those that are solely funded by a private organization and also partially affiliated to the state government, while one of the respondents without an innovation strategy and revenue turnover was solely funded by the federal government. Drawing from the high percentage of the respondents with an innovation strategy and also a revenue turnover, in as much as there is spatial scientific data to guarantee the correlation between an innovation strategy and the generation of revenue, from our survey, there is evidence that in order to generate a revenue turnover, the organization must have a well-developed innovation strategy (Teece, 2010; Dorf et al., 2011). In the discussion section, we will give an in-depth explanation of the reason behind the patterns recorded during this survey.

6.4.4.2 Community orientation

In addition, we also discovered that majority of the PIs (85%) have more than one community-oriented project, which corroborates the findings by Adelowo et al. (2012), that the broader objectives of PIs is to address local and regional economic development by promoting innovation in the traditional sectors.

Lastly, what has been indicated from previous research, shows that collaboration with other firms could enhance the firm's innovative process and output as well as its sustainability (Ahuja, 2000; Nieto & Santamaria, 2007; 2010; Rosenfeld, 1996; Ritter & Gemünden, 2004). In respect to this, the sampled PIs were asked whether they have collaborated with other firms in the past, and from this, we discovered that majority of the PIs have not collaborated with any other PIs. This in particular, is not shocking considering that most PIs are profit-oriented. Therefore, a sizable amount of competition is expected among them. An in-depth discussion of these results will be presented in the following section.

6.5 Discussion

In this discussion, we will be exploring the effects of the firm's age, firm's size, and the number of graduate employees on the innovation input (financial resources), innovation process (innovation strategy, and collaboration with other firms), and innovation output (numbers of products, start-up, and IPR). As well as the significant contribution of the PIs considering these factors will also be highlighted.

6.5.1 Firm Age on PIs Innovativeness

As pointed out by existing literatures, the age of a firm has diverse effect on its innovative input and output (Coad et al., 2016; Van Praag & Versloot, 2007; Cefis & Marsili, 2006; Geroski, 1995; Sutton, 1997; Caves, 1998). With regards to the effect of Firm_Age on the Fin_Source, from the findings of this study it was discovered that PIs with Firm_Age <5 generate more funds through self-funding and support from governmental agencies and/or private organizations than others. We posit the reason for this trend could be the inertia effect on older PIs (Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992). However, due to the uneven numbers of responses from the older and younger PIs, making an assertion on the effect of Firm_Age on the ability to generate funds will yield an inconsistency.

Moreover, with regards to the effect of Firm_Age on the innovation process which in this study covers the Innovation strategy and collaboration with other firms. Firstly, with regards to the innovation strategy, we discovered that 8 out of the 10 PIs with an innovation strategy are younger PIs with Firm_Age <5. Many factors could be responsible for this, one of which is the inertia effect experienced by older firms, or could be the inadequacies of older firms to generate sizable financial resources needed to advance their firms. However, we did not denote any effect of Firm_Age on the PI's ability or willingness to collaborate with other firms. The reason for this could be based on the business model employed by each PI which sees other PIs as direct competitors rather than collaborators.

Due to their experience, matured firms are expected to have more learning effects which allow them to build on existing routines and capabilities hence innovate more effectively (Coad et al., 2016; Van Praag & Versloot, 2007). Moreover, other research studies also uncovered that younger firms tend to experience more productive growth which later converges and reduces with time as a result of inertia (Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992). From this study, we discovered that the maturity of the firm does not have any significant effect on the PI's abilities to generate significant Num_Prod and Num_Start-up. As can be seen in Table 6.4, the PIs within the critical age of 1 and 4 has supported more start-ups (143) and also produced more products (61) than the matured PIs. Which to some extent attests to the trueness of the latter assumption, though there is a minute evidence of the effect of inertia on older PIs, but due to the paucity of the test samples we believe there is a need for an in-depth study of the effect of inertia on the older PIs still needs to be explored.

Out of the four types of innovation, product, process, market, and organization, (Edison et al., 2013; Jensen & Webster, 2009) the major type of innovation supported by PIs is predominantly product innovation. Which includes the production of agricultural software, financial software, educational software etc. However, we did not cover whether these innovations were radical or incremental. Lastly, we discovered that Firm_Age has no effect on the numbers of IPR filed by the PIs. The reason behind this could be due to inadequate knowledge about the local intellectual property office in Nigeria, or due to insufficient financial capability to file for IPR since the surveyed PIs are mostly self-funded.

6.5.2 Effect of Firm Size on PIs Innovativeness

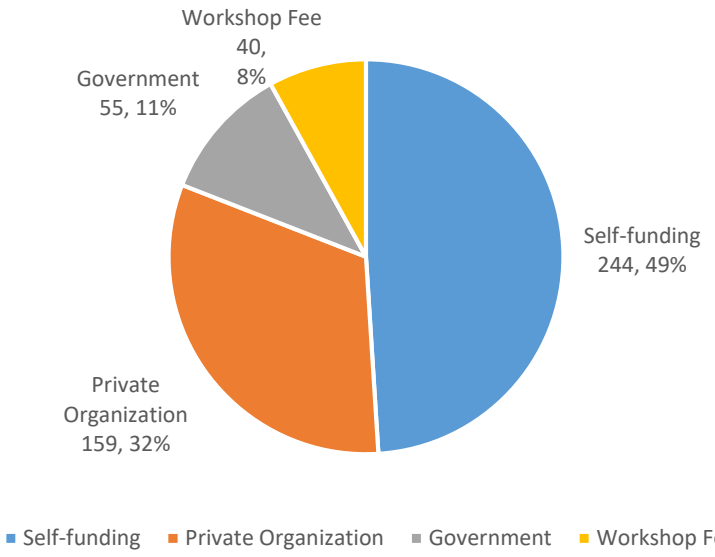

Figure 6-2: Association of Firm_Size on the Financial Resources. Source: PhD Survey of Author

With regards to the effect of the firm size on financial resources, according to Figure 6.2, it was discovered that the 49% of the PIs generate income through self-funding, and these PIs employed a total of 244 employees which ranges from 6 to 40 employees. This is followed PIs funded by private organizations, which employed a total of 159 employees. From the analysis, the effect of the Firm_Size on the financial cannot be vividly ascertained. However, this analysis does support one claim, and that is, Firm_Size has an effect on the PI's ability to generate financial resources through self-funding. As indicated in the result section above, most of these firms subcontract trained consultants to other organizations. However, apart from the evidence of Firm_Size in the self-funding, it is quite difficult to ascertain the correlation of the Firm_Size on the PIs ability to generate financial resources using other methods such as private organizations, governments, and workshop fee.

As indicated by Kamasak (2015), technological capabilities and innovation strategy generate more innovation output. Therefore, by reviewing the effect of Firm_Size on the innovation strategy, we discovered that 7 out of the 10 PIs with an innovation strategy are Firm_Size with >10 employees. Which shows that Firm_Size does have an effect on its innovative process, probably due to their wider knowledge base and human capital skills (Rogers, 2004). Moreover, there exist no relationship between the Firm_Size and the collaborative abilities of the PIs with other PIs or firms.

Due to the phenomenon of economies of scale, the size of a firm is expected to be crucial to its success (Olawale et al., 2017; Babalola, 2013), it was also described as the quantity and array of production (Shaheen & Malik, 2012). With regards to the effect of the Firm_Size on the innovation output, there are mixed findings from existing studies. Some studies concluded that small-sized firms have more innovative outputs (Rothwell, 1978; Globerman, 1975; Rothwell & Zegveld, 1982), while some concluded that big-sized firms tend to be more innovative (Armour & Teece, 1980; Moch & Morse, 1977; Kimberly & Evanisko 1981). With regards to the effect of Firm_Size on the Num_Prod, the survey presented an inconclusive evidence. From the study we discovered that smaller PIs developed 45% of the products while big PIs developed 55% of the products. Which is really inconsistent to draw a conclusion on the effect of Firm_Size on the Num_Prod. A possible reason behind this inconclusive notion could be based on the Innovation Efficiency highlighted by Ettlie & Rubenstein, (1987). However, we discovered that Firm_Size with >10 employees have more Num_Start-up (149) than Firm_Size <=10 (89). This indicates an inexistent relationship between the Num_Start-up and Num_Prod. Lastly, from the analysis we also conclude that the Firm_Size has no effect on the IPR filed for by the PIs. This could be equally based on the factors highlighted above for the effect of Firm_Age on IPR.

6.5.3 Effect of Graduate Employee on PIs Innovativeness

Moreover, with regards to the effect of the numbers of graduates employed by the PIs on their financial resources, this study discovered that the Grad_Emp has the same effect as the Firm_Size on the financial resources. Significantly, its effect on the PI's ability to generate funds through self-funding was evident based on our findings, that a total of 186 graduates work at the PIs who generated their major income from self-funding. However, just like the effect of the Firm_Size, we cannot vividly extrapolate the effect of the graduate on the PI's ability to generate funds through other means such as, private organization, and government.

Lastly, with regards to the effect of Grad_Emp on innovation strategy, we could not directly identify any relationship between them. However, since the majority of the PIs with graduate employees have an innovation strategy, we purport the existence of a partial relationship between Grad_Emp and Innovation strategy. Moreover, with regards to the effect of Grad_Emp on the collaborative efforts of the PIs, we could not identify any direct relationship probably due to the existence of competition between the PIs.

From the study, the initial effect of Grad_Emp on the innovation output seems inconspicuous. However, relating Grad_Emp to Fin_Source, we discovered that Grad_Emp does have an effect on Num_Prod. We noted that this relationship is relatively dependent on the source of finance, as PIs with larger Fin_Source had higher Num_Prod and higher Num_Start-up irrespective of the size of the graduates employed. In addition, a total of 118 Grad_Emp work for PIs that are either supported or directly funded by governmental agencies or private sectors. Which indicates the need for a stable financial source in order for the numbers of graduates employed to be maximized. Moreover, there exists no relationship between Grad_Emp and IPR.

6.5.4 Contribution of Private Innovation Incubators in Nigeria Innovation Ecosystem

The overall contributions of the PIs in Nigeria, as can be seen from other succeeding sections revolves around the provision of adequate employment opportunities in the Nigerian labour market, as well as the provision of support services to start-up companies, which includes services such as provision of production space, administrative support, and access to equipment needed to aid the development of their products (Oyewole, 2010; Schillings, 2010). These services were identified by (Peters et al., 2004; Knaup, 2005) as important to assist new firms get beyond the critical phase of development.

Further analysis as depicted in Figure 6.4, also confirms the assertions made here. As depicted in Figure 6.3, the PIs contribute to Nigeria's innovation ecosystem by providing prototyping and access to capital investment opportunities for new start-ups, job placement and creation for fresh and unemployed graduates, training and empowerment opportunities to community members, and they have also provided business support and development opportunities to new start-ups. Moreover, this study assumed that the omission of these services are some of the reasons behind every failed new business venture, especially at the critical incubation stage, within the age of 1 and 5 (Peters et al., 2004; Muhos et al., 2017; Saarela et al., 2016). Hence the reason why younger PIs tend to be more innovative in terms of the number of products developed and the number of start-ups founded than the older PIs.

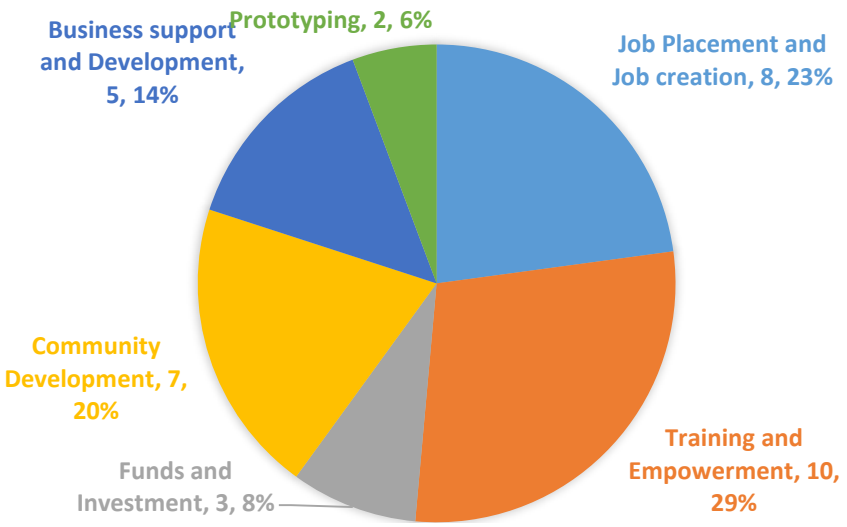

Figure 6-3: Contributions to Innovation. Source: PhD Survey by Author

6.5.5 User Innovation Supported by the Private Incubator

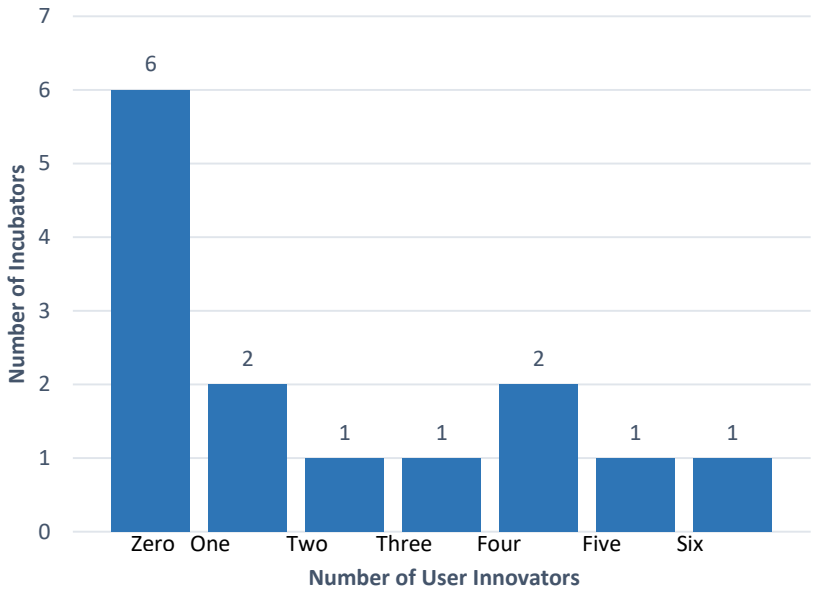

Figure 6-4: Numbers of User Innovators Supported by the PIs (n = 14). Source: PhD Survey by Author

During the interview process conducted with the private innovation incubators in Nigeria, the PIs were asked about their knowledge of user innovation, and whether any of their supported members can be classified as a user innovator. If yes, they were asked to quantify the numbers of their members that could be classified as user innovators. From this, this study gathered that 57% of the members of the PIs could be classified as user innovators. With regards to the numbers of user innovators supported by the PIs, it was also discovered that a total of 37 user innovators have been supported the PIs. As illustrated in Figure 6.4, it was discovered that the numbers of these user innovators ranges between 1 and 10. Further investigation indicated that most of these user

innovators are focused on software development, and have shared their innovation with other software developers online.

In addition, it is worth iterating that the user innovators supported by the PIs are individual users. However, this finding indicates the significant contribution of innovation incubators as a practicable toolkit to encourage the propagation of user innovation in emerging economies.

6.6 Conclusion and Recommendation

The objective of this study is to explore the contributions of private innovation incubators to Nigeria's innovation output. By studying the effect of their age, their size, and the numbers of graduate employees on their innovative capabilities. Being a ground-breaking and fact-finding study, the study was conducted by means of a qualitative research approach, through in-depth interview process. This presents us with the opportunity to gather adequate information to ascertain the objective of this research, and also to provide foundational information for future research.

Out of many things, this study reveals some evidences that, in terms of innovation input, process, and output PIs in Nigeria with Firm_Age <5 are more innovative than older PIs. Based on all the factors explored, we found younger PIs edge the older firms. The reason for this trend is concluded to be as a result of the inertia, which confirms existing findings on the effect of inertia on old firms (Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992). In addition, with regards to the source of finance, we discovered that Firm_Size has an effect on the PIs ability to generate funds through self-funding. Also, in order to generate funds through self-funding, the PIs should employ a significant number of graduates. Since most PIs outsource workers to other organization as a means to generate funds. Therefore, the size of the firm and the number of graduates employed by this firms is a significant determinant of their ability to generate funds as well as achieve revenue turnover. In addition, probably due to intellectual exposure and wider knowledge base (Rogers, 2004), this study discovered that the size of the firms and the number of graduates employed by the firms has an effect on the innovation process, as most PIs with Firm_Size >10 have an innovation strategy.

Moreover, this study revealed a mixed result on the effect of firm size and the number of graduates on the innovation output. As indicated in section 6.5, an inconclusive remark was noted, as there is no vivid difference between the numbers of products produced by the smaller PIs compared to those of the big PIs. However, the study also noted a positive effect of the firm size and the number of graduates on the number of start-up rolled out by these PIs. A particular mystery is the reason behind the lack of correlation between the number of start-up and the number of products, we believe this would be vital for future studies.

In addition, since incubation model has been identified as the vital way through which innovation incubators provide adequate support to start-ups to aid their value creation activities (Pauwels et al., 2016; Isabelle, 2013), we hereby recommend further studies to investigate the incubation models employed by the PIs, and their effect on their ability to generate an innovation output; Also due to the discovery of inertia on PIs with Firm_Age >5, we recommend further study on the effect of inertia on innovation incubators and firms. In particular, this study helps to encourage further research studies into the contribution of innovation incubators, and other grassroots innovation activities to the country's overall innovation input, process, and output.

In conclusion, with respect to the overall impact of the privately owned innovation incubators on the Nigerian innovation ecosystem, we discovered that these incubators, despite little, does contributes to Nigeria's innovation space. However, if adequately supported by government parastatal and other private organizations, PIs could help create adequate strategies to harness the untapped knowledge and capabilities in the Nigerian Innovation space, thereby creating a more knowledge-based economy on which a national economy has been depicted to thrive.

This phase provides more suitable background to the state of innovation in Nigeria, thereby providing adequate information on how to focus on the main objectives of this study which is to quantify as well as manage the rate of user innovation in Nigeria.

7 Managing User Innovation

Synopsis

Chapter one of this thesis outlined that the innovative expeditions engaged by users with a unique need is a key driver of both the product and process innovation system. While chapters four and five identified the incidence of user innovation among the Nigerian higher education students and the SME firms in Nigeria. Therefore, if user innovation is as important to the social system and the manufacturing companies as indicated in this study as well as in existing studies, then there must be means by which it can be adequately promoted and managed. This chapter makes suggestions on how user innovation can be managed, especially from the context of an emerging economies. Specifically, it is argued that digital fabrication workshops are an effective approach through which user innovation can be managed in a developing country like Nigeria. This suggestion is informed not only by the empirical results in the preceding chapters but also by a literature review on how user innovation has been managed in developed countries. Variations of the digital fabrication workshops and its state as applied to Nigeria are presented in this chapter. Moreover, a case study of GreenLab Micro-factory will be given, an initiative implemented to manage the user innovation activities in Nigeria will be outlined, detailing the approaches used, challenges faced during the implementation of the initiatives. Lastly, the implication of this concept in relation to the research objective will also be presented.

7.1 Introduction

The advent of user innovation has generated a paradigm shift from what was traditionally believed to be the source of innovation to the critical contributions of lead users in the innovation process. In addition, Douthwaite et al (2001) indicated that potential innovative technologies often fail due to the omission of user innovation during the adoption phase of the technology deployment. User innovation, according to studies, has been identified as a key contributor to an improved social welfare (Svensson & Hartmann, 2018; Flowers et al., 2010; von Hippel, 2009; Morrison et al., 2000; Henkel & von Hippel, 2005; von Hippel & Katz, 2002). This statement coupled with the benefits of user innovation highlighted in the introduction of this thesis, only points to one fact, and it is that the dynamics of user innovation should be adequately managed in order to effectively yield significant results. After having identified the existence of user innovators both at the at the firm

and consumer in Nigeria, and also considering some envisioned impediments to user innovation activities in emerging economies. It is worthwhile to indicate how user innovators in Nigeria and other emerging economies can be encouraged. Which brings the following questions to mind: firstly, are there suitable means by which user innovation can be managed? Secondly, what methods are presently being used to manage user innovations? Therefore, this chapter will provide information on how user innovation could be managed.

This chapter begins by providing a brief introduction detailing the objectives of the chapter (section 7.1). which encompasses the defence of the argument why user innovation should be managed, methods to managed user innovation activities in emerging economies are also presented in this section. Followed by a detailed analysis of the user innovation toolkits suggested in this chapter will then be presented (Section 7.2). This is then followed by a quick exploration of the state of digital fabrication workshops in Nigeria (Section 7.3). Then a case study of how this study attempted to manage the user innovation activities in Nigeria will be presented in section 7.4. The benefits of the user innovation management technique used in this study will be reviewed in section 7.5. Lastly, a conclusive remark about this study will be presented in section 7.6.

7.1.1 Why should User innovation be managed?

To solidify the significance of this chapter, this section will briefly review the reasons why user innovations should be managed. There are several reasons why this study proposed the management of user innovation. This study stipulates that the potential returns from a well-managed user innovation activity will exceed the innovation expenditure either monetary or in terms of social welfare. Other reasons why user innovation should be managed are presented in the bullets below. These reasons are given from both the firm's and users' perspective:

1. User innovation provides access to sticky information which is a rich source of innovation information for manufacturers (von Hippel, 1994; 2001; 2009; Henkel & von Hippel, 2005; von Hippel & Katz, 2002).
2. Managing user innovation harnesses the free technology development capabilities of users, thereby providing means to achieve cheaper, faster and better product development (von Hippel, 2001; 2009; Urban & von Hippel, 1988; Herstatt & von Hippel, 1992; Franke & von Hippel, 2003).

3. From firm's perspective, managing user innovation aids the development of quality products that meets or exceeds customers' expectations (Flowers et al., 2010; Weber, 2004; Harhoff et al., 2003; Raymond, 1999; Schillings, 2010; De Jong & von Hippel, 2009a; Chesborough, 2006; Benkler, 2006; Fuller et al., 2013)
4. From the users' perspectives, managing user innovation will enable the innovations reach more users (Flowers et al., 2010; Weber, 2004; Harhoff et al., 2003; Raymond, 2001; Schillings, 2010; De Jong & von Hippel, 2009a; Chesborough, 2006; Fuller et al., 2013)
5. Managing user innovation will create a network embeddedness between local user innovators. As well as connect local user innovators to foreign user innovators. Hence to a rich pool of information and capabilities.
6. Lastly, from both firm and users' perspectives, managing user innovation will further enhance the value creation approach (Humphrey et al., 2014).

Egbetokun & Olamade (2009) pointed out that the way innovations are managed and the available supporting structure are of significant importance to the level of innovation. Therefore, the following section looks at how user innovation can be managed.

7.1.2 How can user innovation be managed?

There are several other ways through which user innovations can be managed. Some of which include:

1. Introduction and implementation of policies and regulations that supports user innovation (von Hippel & Paradiso, 2008; von Hippel & Jin, 2008; von Hippel, 2005)
2. the availability of innovation subsidies, linkages with knowledge centres, firm-level investments in research and development (R&D) and the firm's internal processes of capability building are other identified ways to successfully manage innovation (Egbetokun & Olamade, 2009).
3. Another suggested approach by which user innovation can be effectively managed is through the deployment of what was termed 'user innovation toolkits' (Von Hippel & Katz, 2002; von Hippel, 2001; Franke & Piller 2004).

Furthermore, these user innovation toolkits were identified as a means by which firms can maximize their innovative activities by transferring or involving their users in the innovation process. The user innovation toolkits permit lead users to design new products through trial-and-error experimentation, deliver constant and instant feedback to manufacturers on the viability of their project design. According to von Hippel (2001) and Humphrey et al (2014), user innovation toolkits grant companies unlimited access to user-centric information regarding their needs, and also provides the customers with the opportunity to articulate their expectations to the significance of having an innovation toolkit for identified lead-users. This study will investigate the user innovation toolkit as the premise from where user innovation can be adequately managed.

Humphrey et al (2014) further highlighted that user innovation toolkits encourage mass customization by combining the advantages of product efficiency similar to those accomplished by mass production to that of product customization in order to suit individual user's needs. User toolkits, according to von Hippel (2001), must meet the following five requirements:

1. Provide appropriate solution space - User toolkits must offer appropriate solution space where users can experiment and develop solutions that meet their needs.
2. Enable learning by doing through trial-by-error - The user innovation toolkits must provide users with the results of their design decisions as well as provide feedback with regards to some design errors.
3. User friendly – The user innovation toolkits must be relatively easy to use for the intended users thereby encouraging their widespread use.
4. Library of common components – The user innovation toolkits must offer intended users a library of common base components to increase their utilization rate.
5. Easy transference into production – The outputs generated from using the toolkits must be translatable into an easy set of instructions for manufacturing purpose.

Drawing from these requirements and the explanation of the user innovation toolkits provided above, this study hereby proposes digital fabrication workshops such as Makerspaces, FabLab (which stands for fabrication laboratories) and Hackerspaces as a user innovation toolkit. Hence as a suitable means to manage user innovation. A detailed case of this concept will be described in the following section below.

7.2 Digital Fabrication as a User Innovation Toolkit

According to Hinsch et al (2014), workshops play a key role in the transference of technologies and new techniques, because they enable potential users to test the new acquired technique or technology in a secure environment with the possibilities of being assisted by the developer of the technique. This particular approach was called '*triability*' by Rogers (2010) which has been identified to have a positive influence on the adoption rate of the innovation. Digital Fabrication Workshops (DFW) enable people to design, develop and distribute their own products outside of conventional mass production channels. Examples of these DFWs include initiatives such as FabLabs (Fabrication Laboratories) and Makerspaces. FabLabs and makerspaces are open workshops where new product development practices such as open design, open innovation, distributed production and open source interacts with new materials and energy-intensive production approaches. They are open communities dedicated to tinkering, innovating, socializing, peer-to-peer learning and empowerment.

In addition, these workshops are equipped with digital fabrication or desktop additive and subtractive manufacturing equipment such as 3D printers, laser cutters, CNC (computer numeric control) milling machines, electronic stations for prototyping circuit boards, vinyl cutters, and sewing machines. with the use digital fabrication technologies, users are grafted into a 'Super user' position which enables them to function as manufacturers of small scale product at a relative low cost (Rayna et al., 2015; Weller et al., 2015; Bradonjic et al., 2018). According to Svensson & Hartmann (2018), digital fabrication workshops increase technological literacy, support technical training, encourage innovation, and enable rapid prototyping, which are aspects suitable to enabling optimum social welfare provided by user innovation activities.

Several discoveries with regards to the significance of managing user innovation through digital fabrication workshops were highlighted by recent research studies. Svensson & Hartmann (2018) indicated that without the involvement of users in makerspaces, valuable user innovation activities are prematurely terminated before reaching the prototype phase. They also indicated that almost all the innovative outputs developed from makerspaces are user innovation, with a potential returns ten times more than the required cost of innovation. In addition to this, Halbinger (2018) also discovered that the innovation (53%) and diffusion rates (18%) at any digital fabrication facilities are substantially higher than the national innovation surveys of independent individuals who innovate

at their own discretion. They further argued that makerspaces can be a substantial means to augment user innovation and the diffusion of innovation by users. Specifically, Morel & Le Roux (2016) and Katterfeldt (2014) also argues that FabLabs acts as places that catalyses and disseminates the Do-It-Yourself culture, and thus promote the user innovation culture in an environment.

Therefore, since digital fabrication workshops has been highlighted in this section as a viable means to manage user innovation, this study will proceed to study the state of digital fabrication in Nigeria, as well as the possible limitation to their propagation.

7.2.1 Types and Objectives of DFW

According to Table 7.1, there are no defining differences between some of the DFWs, as majority are understood to be community-orientated and egalitarian workshops where grassroots innovations are spurred by providing open or affordable access to fabrication tools. Generally, they are indifferentiable as most Makerspace, hackerspace, and FabLab are at times used synonymously. However, there are slight differences between all of these DFWs, some of which are obvious in their names and some which involves their objectives, technologies, and technical abilities. These differences will be highlighted in subsection 7.2.2 below.

Table 7.1: Types and objectives of DFWs

Type of DFI	Objectives									
	Grassroots Innovation	Education	Community empowerment	Job Creation	Prototyping	Solving local problems	Instructional Classes and events	Access to high end professional equipment	Technology or appliances repair	Global frequency
FabLab	X	X	X	X	X	X	X			+/- 2000
Makerspace	X	X	X	X	X	X	X			+/- 1400
Hackerspace	X	X	X	X	X	X				2322
Techshops					X		X	X		14
Repair cafes						X			X	1800

Source: Compiled by Author

7.2.2 Differences between the DFWs

Hackerspace: as the name implies hackerspace is defined as “concrete community-orientated facilities where individuals, engaged in a hacker ethic, meet on a regular basis to embark on meaningful and creative projects” (Kostakis et al, 2015). They were initially solely orientated

towards computing and digital technologies, but now are incorporated with digital fabrication tools (Morel & Le Roux, 2016; Cavalcanti, 2013).

Makerspace: Just like the hackerspace, Makerspace are physical locations where people mostly regarded as "makers" or technology handymen share their skills and knowledge collectively. The difference between Makerspace and other DFIs according to Morel & Le Roux (2016) is the term "makers" used to identify the members of the Makerspace community.

Techshops: are for-profit spaces. Techshops are private entities that provides public access to a variety of high-end manufacturing tools in exchange for a membership fee (Morel & Le Roux, 2016; Cavalcanti, 2013). The major difference between the Techshops and other initiatives is that Techshops are strictly membership-based which incurs a membership fee, and unlike some FabLabs, Makerspace, and hackerspace that uses open source equipment, Techshops are bolstered with professional equipment and software with cost possibly amounting to $1 million. Unfortunately, Techshops filed for bankruptcy in 2018 and no longer operational.

FabLabs: An abbreviation of fabrication laboratory, is a community-oriented workshop consisting of high tech tools and cutting edge machinery. One of the major difference between FabLab and other DFWs as identified by van Holm (2014) is that FabLabs are highly education concentrated than other DFWs. Also from previous research studies (Osunyomi *et al,* 2016), it was discovered that some FabLabs are also membership-based, but majority provide either an open access, or partial access to the digital fabrication tools. According to (Morel & Le Roux, 2016) another key factor that differentiates FabLabs from other DFIs is the existence of a principle published by MIT called the Fab Charter that all FabLabs are expected to adhere to.

Repair cafes: Unlike other types, Repair Cafes cannot be wholly identified as a DFW, as its major focus is to bring people together to repair general household appliances, toys equipment, etc. Hence the tools required in a repair café could range from simple screw drivers, soldering iron, hammer and other manual tools, most of which are also available in the earlier mentioned digital fabrication workshops, and not necessarily digital fabrication tools. However, due to its involvement in promoting a sustainable community we therefore include it as a low-cost digital fabrication initiative in this article. This is further supported by the statement made by Bosqué (2013) which states that

"*FabLabs are more about the people than the machines*". It is a centre where community and innovative development evolves.

Despite their slight individualities, these initiatives share a homogenous objective. Which is to bring people together, to provide access to manufacturing equipment, and create a collaborative workforce between the members. In the succeeding section, the outlook of the present state of digital fabrication in Nigeria will be presented.

7.3 State of Digital Fabrication in Nigeria

The growth rate of digital fabrication in Nigeria is somewhat appalling. According to information available online about the distribution of makerspaces and hackerspaces. As of March 2019, It was discovered that there is no registered makerspace and hackerspace on their online directory. Of course, this results could be false considering the limitations with technology infrastructure in Nigeria. However, with regards to the state of FabLab in Nigeria, this study discovered from the FabLab directory that there are 4 registered FabLabs in Nigeria out of over 2000 labs mushroomed globally.

In addition, there is another community-oriented DFW launched by General Electric (GE) in the Lagos metropolis called Lagos Garage. This initiative operates as a standalone workshop funded and coordinated by GE. Therefore, does not identify itself with any of the other global DFWs. During a personal visit to Lagos Garage, it was observed that this workshop is probably the most equipped DFW in the whole Nigeria. Granting restricted access to high-tech and sophisticated digital fabrication equipment (such as 3D printers, laser cutter, and milling machine) to selected members who have gone through their incubation program. From the visit, it was also uncovered that the main objective is to promote a sustainable entrepreneurial and innovative culture in Nigeria by providing access to a dedicated team of technology experts to assist the members during their prototyping phase, strategy, and business development process.

Despite the highlighted importance of DFWs in promoting a sustainable innovation culture, this study identified that the propagation rate of these initiatives in Nigeria is low. The ratio of DFW to member is postulated to be an alarming ratio of 1: 10,000. This signifies that huge amounts of socially valuable innovations are being lost regularly in Nigeria, while the ones that eventually gets

developed by the user innovators are posited to be under developed (Svensson & Hartmann, 2018). In addition, during the survey process conducted for other phases, the respondents (that is, private incubators, higher education students, and SMEs) were asked to provide information about their knowledge of any of the DFWs which includes FabLabs, makerspaces, Techshops, Hackerspace, and Repair cafes. The results of this findings will be presented in the following section below.

7.3.1 Knowledge of DFWs by Survey Participants

During the survey conducted during the third phase of this study (private innovation incubators). Figure 7.1 illustrates the knowledge of FabLab by the private incubators in Nigeria. This figure reveals that 57% of the private innovation incubators have heard of FabLab. However, further investigation revealed that only 14% of the private incubators have collaborated with FabLabs before, and these FabLabs collaborated with are situated in neighbouring countries such as Togo and Cote d'Ivoire. Which makes one wonder the possible reasons for neglecting the DFWs within your country for the ones in other neighbouring countries? From the background knowledge of the author, it is easy to identify the technology capabilities of the existing FabLabs in Nigeria as the main impediment to the collaborative activities between the private incubators and local FabLabs.

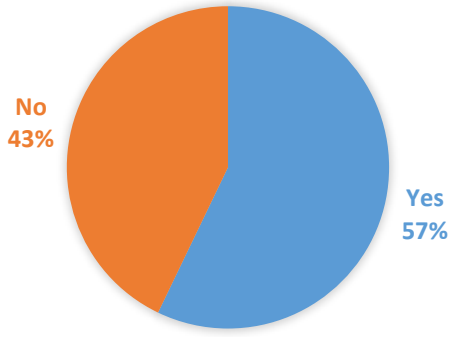

Figure 7.1: Knowledge of FabLab by the Private Incubators

In addition, with regards to the awareness of the SMEs with regards to the knowledge of the DFWs, Table 7.2 reveals that the knowledge of these DFWs among Nigerian SMEs is very low. From Table 7.2, it can be observed that FabLab is the most recognized DFWs amongst Nigerian SMEs, which could be due to the presence of the 4 registered FabLabs in Nigeria. In addition, the respondents were quizzed further to know whether they would be interested in collaborating with any of the DFWs. Their response is tabulated in Table 7.3.

Table 7.2: Knowledge of DFWs by Nigerian SMEs (n = 249)

		Frequency	Percent	Cumulative Percent
FabLabs	No	220	88.4	88.4
	Yes	29	11.6	100.0
	Total	249	100.0	
Makerspace	No	233	93.6	93.6
	Yes	16	6.4	100.0
	Total	249	100.0	
Techshops	No	223	89.6	89.6
	Yes	26	10.4	100.0
	Total	249	100.0	
Hackerspace	No	224	90.0	90.0
	Yes	25	10.0	100.0
	Total	249	100.0	
Repair Cafes	No	232	93.2	93.2
	Yes	17	6.8	100.0
	Total	249	100.0	

Table 7.3: Willingness of Nigerian SMEs to collaborate with DFW (n = 249)

	Frequency	Percent	Cumulative Percent
No	108	43.4	43.4
Yes	141	56.6	100.0
Total	249	100.0	

Moreover, Table 7.3 revealed that almost 57% of the user firms in Nigeria are willing to collaborate with any of these DFWs. Which indicates the possibilities of these workshops to promote user innovation as identified by Svensson & Hartmann (2018) and Halbinger (2018). The possible limitations to the propagation of this workshops in Nigeria are listed below.

1. Insufficient financial capabilities and support
2. Insufficient knowledge or awareness about the initiatives
3. Inadequate technological capabilities
4. Lack of governmental support
5. Insufficient raw materials

The limitations listed above only confirms the lack of cohesion between the elements of the National Innovation System (NIS) observed in previous chapters. Knowing beforehand about the static state of digital fabrication in Nigeria, this study also attempted to initiate one in Nigeria. Therefore, this research study initiated GreenLab Microfactory, which happens to be the first registered FabLab in the Nigeria. A detailed case study review of this FabLab will be presented in the following section.

7.4 Managing User Innovation: A Case Study of GreenLab Microfactory

Drawing from the static state of digital fabrication in Nigeria highlighted in the section above, this study initiated GreenLab Microfactory, which is renowned as the first established FabLab in Nigeria, in order to study how DFWs can be utilized as an adequate user innovation management toolkit. GreenLab was launched on the 20th of April 2017 in Ibadan, Nigeria. The aim of GreenLab is to encourage small-scale development of valuable artefacts, by providing access to digital fabrication tools and technologies that encourages learning, rapid prototyping, ideation, innovation, and small scale development of artefacts. Furthermore, GreenLab aim to encourage the utilization of dormant, recycled and abundant eco-friendly materials and resources in rural areas to encourage innovation and sustainable development.

Figure 7.2: Logo of GreenLab Microfactory. Source: Author

From prior research studies, and in the recent published world's innovation index, human capital was identified as the most important resources on which the sustainability and growth of an economy is dependent. Without doubt, we purport that investment in human capitals and capabilities should be the stringent focus of third world countries in order to transcend beyond its poignant developing stage status. From a recent research survey conducted, Osunyomi et al (2016) discovered that a well implemented social DFW not only enhances human capital, but it also provides various empowerment opportunities for the populace irrespective of their social status. Therefore, the envisaged benefits of GreenLab microfactory in the community and country are very enormous, some of which are given below:

- Aid the development of endogenous technologies through communal learning, sharing, rapid prototyping, frequent oriental workshop conduction, and active engagement of the community
- Development of localized innovative strategies
- Enhance the country's educational system by fortifying and reorienting a STEM focus (science, technology, engineering, and mathematics) by initiating the integration of digital fabrication techniques in school curriculums. This has been identified by the innovation index as the major contributor to the innovativeness and competitiveness of a country.
- Adequate development of the human capital by increasing and encouraging more entrepreneurial flair and opportunities.
- Scalability: - The GreenLab micro-factory will use a scalable model, by localizing and reusing materials, such as using shipping containers rather than building real workshop, which means nodes can be added to the micro-factory without disrupting the productivity and quality of work done within the factory. Which also save quite some time and money.
- Replicability, Flexibility, Applicability, and Feasibility: - Due to the usage of localized resources, open sourced tools and technologies, and other eco-friendly / sustainable equipment. GreenLab microfactory can be easily replicated in other locations, and with a fraction of the developmental costs incurred by existing human capital developmental initiatives.

With regards to the technological capabilities of GreenLab, this initiative has one open source 3D printing machine donated by TeeBot 3D printers in the person of Emmanuel Adetutu, one open source milling machine won during the Openbuild international competition, and lots of Arduino electronics components for educational purposes. This will be explained further in the succeeding sections.

However, this phase suffered a major financial setback, as the necessary funds needed to provide a fully equipped DFW (which costs between €50,000 and €100,000), to aid an adequate study of how user innovation activities can be promoted and managed using DFWs could not be acquired. In addition, it is worth highlighting here that 90% of the financial implications incurred on this phase came directly from the personal investments of the founder (the author), while the rest came from donations received from science exhibitions such as MakerFaire Hannover and MakerFaire Rome, as well as little donations from an unsuccessful crowdfunding campaign. In lieu of this critical

challenge, GreenLab utilized several other innovative approaches to aid the accomplishment of the objectives of the study. Such approaches include the establishment of a small functional node called 'Green Garage' in the city of Akure, utilization of an immersive learning approach, development of an innovation strategy which will be discussed further below, facilitation of a community open source hardware development workshop (Ajumose), the introduction of a digital fabrication outreach program (TICK STEM) through the development of a miniaturized DFW, and the STEM primary school education program (One Student One Arduino). The observed significance of these approaches will be presented in this subsection and the ones following.

7.4.1 GreenLab's Innovation strategy

Innovation, irrespective of the type utilized plays a significant role in the competitiveness and economic development of an organization, region, and nation. Moreover, the success rate of an organization's innovation is dependent on the innovation strategy employed (Schilling 2008; Guan et al, 2009; Burgelman et al., 2001). Guan et al, (2009) suggested that having an innovation strategy could be the binding force in creating a compelling vision for organizational sustainability. Which means that the success or sustainability of an organization depends on the innovation strategy it uses to steer its vision. According to Adner (2006), innovation strategy is used by an organization to set performance expectations and to also determine target market. Just like an average organization, GreenLab microfactory has developed its own innovation strategy based on the Nigerian social innovation ecosystem it plans to operate and serve.

An innovation strategy is a plan to grow market share or profits through product and service innovation. When it comes to creating the solution, an innovation strategy must also indicate whether a product improvement, or a disruptive or breakthrough innovation approach is best.

Considering the challenge experienced in the introduction of GreenLab, and also the background experience and knowledge of the writer about the Nigerian community and in the research field. GreenLab was hinged on a strategy iterative strategy called HIDES.

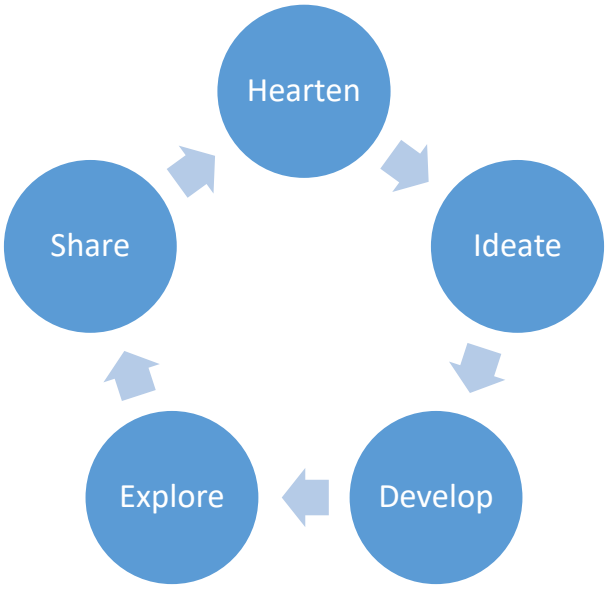

Figure 7.3: Innovation Strategy of GreenLab Microfactory. Source: Author

1. **Hearten**: drawing from the lack of infrastructural development that has marred Nigeria's innovation cycle and growth. The first phase of GreenLab's innovation strategy is to hearten or deepen the interest and expand the member's knowledge. This is a pre-ideation strategy to effectively inform and educate individuals prior to their involvement in the project on the importance of innovation, collaboration, sharing, openness, and every other method that will be utilized at the GreenLab. The study purported that deepening people's interest would give them the necessary flair to utilize their limited resources in creating the adequate value. Heartened people produces great ideas, uses limited resources to get things done, and are also more passionate to work till their objectives or tasks are accomplished.
2. **Ideate**: The ideation phase is where most concepts/ideas are noted and broadly elaborated. The process used during the ideation phase is based on series of brainstorming sessions, or individuals pitching ideas. In any innovation strategy, as depicted by the innovation funnel, the idea generation phase is very significant to the innovation process and its output thereof.
3. **Develop**: The development phase is where selected ideas will be gratified into tangible products. This could include a rapid prototyping phase, or a small scale production of the ideas.
4. **Explore**: At the exploration phase would, rigorous tests on the artefact produced would be conducted to know the resilience, usability, adaptability, reliability and maintainability of the artefact.
5. **Share**: GreenLab imbibes and aims to function under the structure of some open source organization. A distributive economy where ideas, knowledge, information, techniques and

technologies are shared will be a key factor in our modus operandi. Inasmuch as commercialization of products are encouraged, GreenLab also encourages an open source concept where people can freely interact, collaborate, and share knowledge.

Moreover, in order to accomplish this strategy, the initiative resolved that majority of the technologies used at GreenLab will compose of open sourced or self-made technologies. Which this study envisioned will provide lots of advantages to the longevity, sterility, management, and accomplishment of the goals and objectives of the project, considering the experienced limitations. The benefit of homemade technologies helps with the technological knowledge acquisition, retention and distribution. Moreover, it also helps to overcome some infrastructural limitations such as, inadequate electrical power supply. Which by building the technologies in-house means the workshop would utilize energy saving components during the development phase of the technology, which would give us a greater control on power consumption rate of the workshop. Most importantly, GreenLab also plan to harness the abundant renewable energy resources to generate 99% of the electricity used within the facility. The following section provides a description of one of the community workshops (Ajumose) facilitated by GreenLab to access the state of innovation in Nigeria. It will also detail the contribution of GreenLab in promoting an innovative ecosystem in the rural settings of Nigeria.

7.4.2 Green Garage

As indicated in the introductory section of this chapter, in order to solve the financial issues faced during the implementation of the phase of this study, GreenLab Microfactory proceeded with the establishment of a small functional node called Green Garage, at a rented garage closer to the Federal University of Technology Akure (FUTA). Green Garage was officially opened to the general public on the 10th of September, 2019. In this node were all the technologies possessed by GreenLab implemented. This includes a 3D printer, a CNC milling machine, a battery operated drilling machine, lots of Arduino electronic components, and other basic tools such as hammer, screwdriver sets hand saw. With regards to the capacity of Green Garage, the space can comfortably occupy a maximum of 30 users, which is presently used up to 50% of its capacity by 2 staffs, 3 interns from the university, and 12 users.

As of at today, there are 4 start-ups utilizing the services available at Green Garage for the development of their projects. 3 of these start-ups will be understudied and analyzed for the purpose of cementing the proposed agenda of this section to prove that user innovation can be effectively managed by using DFWs as the effective user innovation toolkits. This will be properly highlighted in section 7.5.

7.4.3 Ajumose – Open Source Solar Panel and 3D printing workshop

From the 20th to the 22nd of April 2017, a community development, awareness, Do-it-with-others (DIWO) program titled Ajumose was conducted in Ibadan, a city in Oyo state Nigeria. The word Ajumose in the Yoruba language means collaboration, teamwork, co-working, and cooperation. The objective of this workshop was to empower and educate the community about DFWs and open-source technologies, to enlighten the community about the envisioned benefits accrued to a collaborative and distributive economy in emerging economies, to provide access to open-source technologies that can be used by individuals to create adequate values, as well as an attempt to fortify the feeble educational standard by injecting digital fabrication techniques into the curriculum of some schools. Two disruptive technological objectives were set, which were:

1. to build a solar panel system using outsourced and recycled components
2. to assemble and educate the community about a 3D printing technology

These objectives were perceived as a sustainable response to some of the social issues in the community i.e. epileptic power supply, access to new technological resources, and spatial distribution of knowledge of digital fabrication in Nigeria. As highlighted earlier, the DIWO workshop was held for 3 consecutive days, with the numbers of participants ranging between 80 and 90. The professional backgrounds of the participants range from, pupils, high school students, tertiary students, traders, teachers, artisans (car mechanic and photographer), engineers, and Financial managers or accountants. Moreover, the youngest participant was aged 4, while the oldest was 69 years of age.

This workshop was not facilitated using the traditional teacher and student approach. In order to test the virility of HIDES, the participants were encouraged to demonstrate their teamwork spirit,

and effective utilization of available resources to accomplish the objectives of the project. One of which includes, learning how to build a solar panel using tutorials available on YouTube coupled with collaboration and expertise of other participants. This in particular was observed to have a positive effect especially on the young participants, as some were enlightened about the significance of utilizing other overlooked resources to solve problems. Thus were able to collaborate together to accomplish the task of the project without too much interference from the workshop organizer.

In addition, after the workshop, a feedback survey was conducted on some participants of the workshop, to assess their level of innovation, knowledge of DFWs, and the knowledge of inventors. From this short survey, it was discovered that the level of innovativeness among the participants are either average or low, as only 20% of the participants have worked on some sort of innovation and only a minority of 14% of the participants know someone who has innovated a product. The types of products developed by the innovative participants which are tertiary institution students, include a low cost solar power bank, and small-scale a solar panel. From further questioning, it was observed that according to the participants the major reason for their lack of innovation is as a result of inadequate infrastructural development and awareness programs which is surprising as one would naturally expect inadequate access to funds as the major reason.


Figure 7.4: Solar Panel developed by the workshop Participants. Source: Author

Moreover, with regards to the knowledge of DFWs, all the respondents reported a vivid knowledge of FabLabs, 11% indicated knowledge of the repair cafes which this study found surprising since Repair café are not well known like other DFW initiatives in Africa, and this study assumes this to be due to a confusion with the word Cyber café. While 6% of the participants indicated the knowledge of hackerspace. However, it is worth noting the contribution of Ajumose towards the dominant number of the knowledge of FabLab, because prior to the event, majority of the participants had no knowledge about FabLab and its concept.

From observation, this study highlighted the importance of the first phase of the innovation strategy in the innovative abilities of the participants who reported the creation of an innovative product. In addition, through this innovation strategy, GreenLab was able to launch two other projects which has already been utilized to nurture innovation and train at least 2000 primary and junior secondary school students in three states in the south west region of Nigeria. One of which is the 'One Student One Arduino' project which will be briefly discussed in the following subsection.

7.4.4 One Student One Arduino

'One Student One Arduino' (1S1A), a free immersive educational program, initiated by GreenLab microfactory. The initiative was inspired by various other initiatives for example 'One student one

Laptop' in countries such as Nepal, Cameroon and Bangladesh. Moreover, Inspirations were also drawn from other initiatives aimed at enabling children in low income countries with increased access to software and hardware technology skills, thereby enabling them to utilise and manufacture single-board microcontrollers, and microcontroller kits for building digital devices and interactive objects that can sense and control objects in both the physical and digital world. The aim is to improve access to technological education for participants of a primary and junior secondary school age by using Arduino, an open source electronic hardware kit. This immersive educational program was implemented at the interested school's premises, which gives us another means to overcome the limitations encountered with regards to the physical location of the proposed GreenLab facility. Depending on the arrangement with the school authorities, these projects were carried out every Saturday using the 1S1A learning kit provided.

The 1S1A project, sought to engage over 30 participants locally in Ibadan and Akure Arduino on a weekly basis for a period of 4 months. Participants would attend Arduino classes taught by a member of the GreenLab's team using the assembled 1S1A learning kits provided. During the implementation of the program, the Participants would each have a personal access to the Arduino kits and the 'Cartooino' project book. Which is an adapted cartoon version of the Arduino project book, so as to ensure a relatable and adequate learning experience for participants. The study curriculum consisted of 13 individual projects, 10 of which were drawn from the original Arduino project book, while the 3 projects were presentation projects called 'YouNiversity'. Where each participant was required to search online (YouTube) for an Arduino project, replicate the project, then defend the project in class in front of at least 3 panel of judges. The aim of 'YouNiversity' was to encourage the participants to effectively utilise the Internet service for productive purposes.

Figure 7.5: A display of students utilizing 1S1A kits in Akure and Ibadan. Source: Author

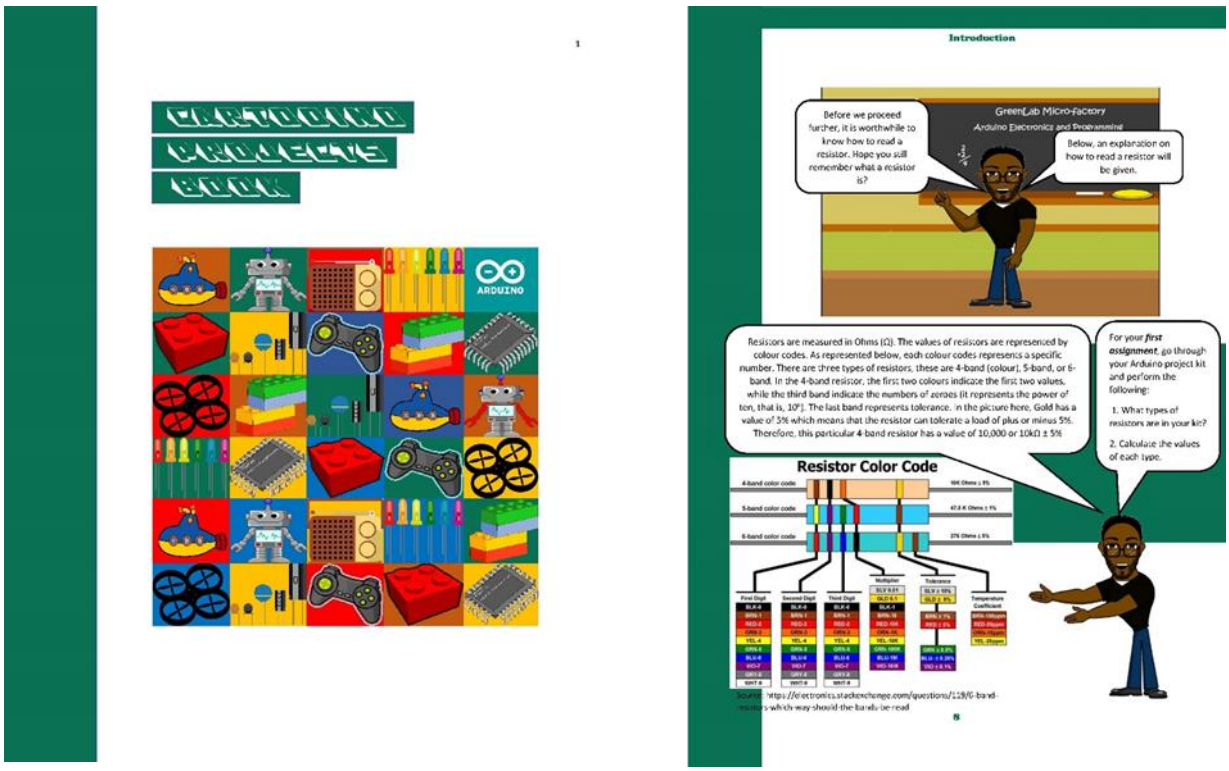

Figure 7.6: Front cover of the Cartooino book and an extract of a project. Source: Author

Up till date, a total of 150 primary pupils have participated in the 1S1A project. Collins (2017) highlighted that digital fabrication initiative has the ability to develop and boost students' skills and interest in STEM. Which, with regards to creating an innovative culture and user innovation, is one of the objectives of the 1S1A project and also the next project which will be discussed in the following section.

7.4.5 TICK STEM Program – Digital Fabrication On the Go

Figure 7.7: TICK STEM Kit and pupils interacting with it. Source: Author

TICK STEM is the newest program conducted concurrently with the 1S1A project. TICK is an acronym for 'Talk is Cheap Kit'. It is a miniaturized version of a typical FabLab facility, initiated to conduct an effective and low-cost STEM outreach program. Using compact versions of the digital fabrication equipment such as 3D pens to educate pupils about the concept of 3D printing, a compact hand drill machine to replicate milling machine, hand held sewing machine, Makey Makey and Arduino microcontroller electronic components to teach the participants about the basics of electronics, a laptop, as well as its fabricated power station, which consists of solar panels, battery and AC/DC power inverter, to generate electricity to operate the assembled components. TICK STEM kit has been a profound tool, as it enabled GreenLab to partially overcome two critical issues, one being the lack of physical node, and the second being the unavailability of electrical power to operate other equipment.

Up till date, an estimated number of 20000 students, which includes primary and junior secondary school students, in over 20 schools, in 6 different states has been taught with the TICK STEM kit. It is worth noting that the TICK STEM kit on its own is a user innovation, which was created to solve the problems experienced during the implementation of the project. To some extent this can be called a radical user innovation, as it was created out of ingenuity, and at the same time it can also be referred to as an incremental user innovation since most of the components are different commercial products assembled into the kit.

7.5 Impact of Innovative Output from GreenLab

Halbinger (2018) discovered that frequent visit to a DFW enhances the innovativeness of the participants. Despite GreenLab not being able to acquire the critical elements (such as the development of the physical space and procurement of machines) to conduct a full study of how user innovation can be managed using digital fabrication as an innovation toolkit. Through immersive learning and dissemination of information about user innovation and its benefits in promoting an optimal social welfare, this study does reveal the possibilities of DFWs as the most sustainable means for government, private organizations, and academic institutions to promote an effective user innovative culture in the Nigerian environment. However, the major observation made during this study is that the complexities and nature of the innovation will have an adverse effect on the willingness of the user innovator (whether firm or individual) to freely share their

innovation with others. This is not surprising, considering the economic situation in Nigeria, it is normal to expect the user innovator to expect at least some compensations for his or her innovative efforts. Which supports the lack of willingness to share indicated by both the SUIs and SMEs studied in chapter 4 and 5, and the expectation of compensation reported by majority of the SMEs surveyed in chapter 5.

In addition to this, as discovered by Svensson & Hartmann (2018), DFWs support innovations to a large extent in the sense that 60% of the innovations developed in these facilities would otherwise have been non-developed, and 85% of the members of the DFW benefits from the collaborative and openness approach utilized in the DFW. Therefore, this study also concludes that having a DFW will definitely increase the innovativeness of the populace, as well as the open methodology practiced by these DFWs would have a positive effect in boosting the user innovativeness of the members. FabLab is the birth place of affordable and quality indigenous technologies designed mostly by users and according to their specificities, thereby creating adequate values that meets their specific needs. The following section will provide a conclusive remark of the findings of this phase.

7.5.1 Impact of Green Garage on the User Innovation activities

Green Garage was officially opened to the community on the 10th of September 2019. From this, an observatory study was conducted at the facility to understand the possibilities of user innovation being managed through DFW. Though the analysis presented here is too limited to state the overall impact of GreenLab on the user innovation activities in Nigeria. However, it is a pointer to the significance a well-equipped DFW could have on user innovation activities. From the review of the users and projects developed at Green garage till date, there are presently 12 users from 4 start-ups using the facility for their innovative activities. Out of the several projects being developed at the Green Garage facility, a total of 6 ideas are being developed at the facility. These projects are mostly hardware (electronics) related. These product developments will be highlighted in the subsequent subsection.

7.5.1.1 Product Development

Within the first 3 months of operation for Green Garage, a total of 6 projects are been developed by the users of the facility, out of which 3 products innovations were thoroughly assessed for the purpose of this research study. As can be seen in Figure 7.8, only one of these 3 products is considered to be an NPD while the remaining 2 are either an incremental innovation or a radical innovation.

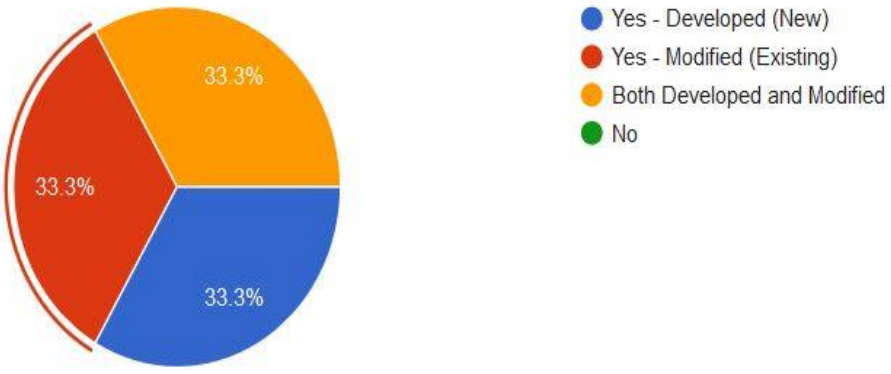

Figure 7.8: Product development at Green Garage

These products are, ***Optobot*** (an educational hardware electronic product developed to spur STEM for children between the ages of 4 and 15), ***Goodmann Sketch board*** (a foldable and compact technical drawing board) see Figure 7.9 below, and ***Cholatrek*** (a clinical support device using anonymous clinical support data to provide solutions that assists or lowers stress profile resulting from clinical activities, such as the use of IoT for effective patients' treatment monitoring and facilitation). These product developments were all identified to be developed from the social aspects which includes two electronic hardware projects (one health related and the other for educational purposes), while the third product is solely based on educational purposes. See appended pictures below

Figure 7.9: Goodmann Sketch Board

7.5.1.2 User Innovation activities

Relative to the user innovativeness of these innovators, as can be seen in the figure below, with regards to the reason why the product was developed all identified that the products were developed in order to solve a social issue, while two out of the 3 innovators also indicated that due to the novelty of their ideas they intended rollout a start-up to harness the economic potentials of their innovation.

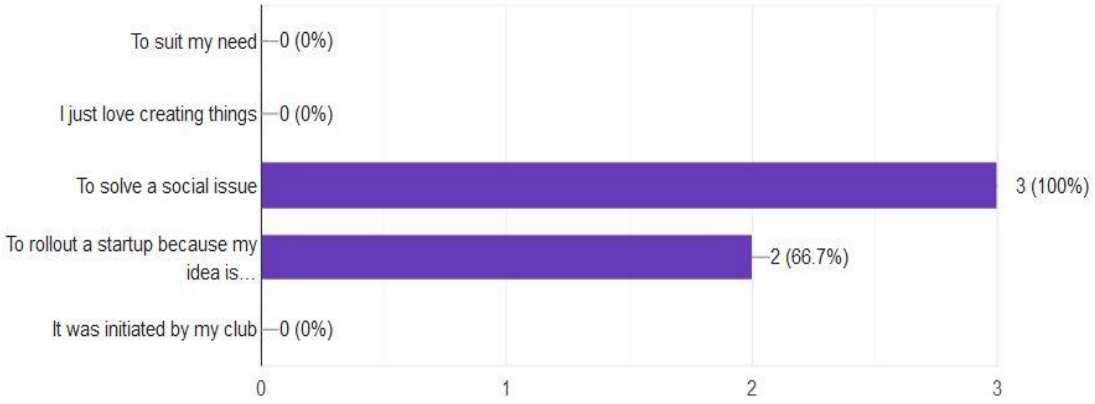

Figure 7.10: Reason for Innovating

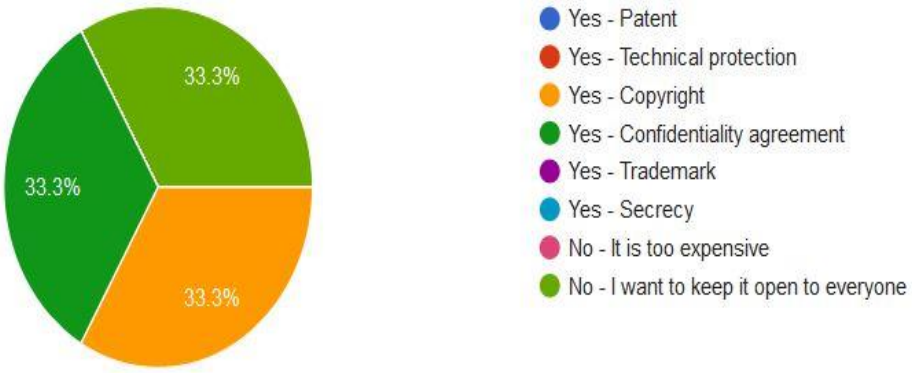

Figure 7.11: Protection of Intellectual Property

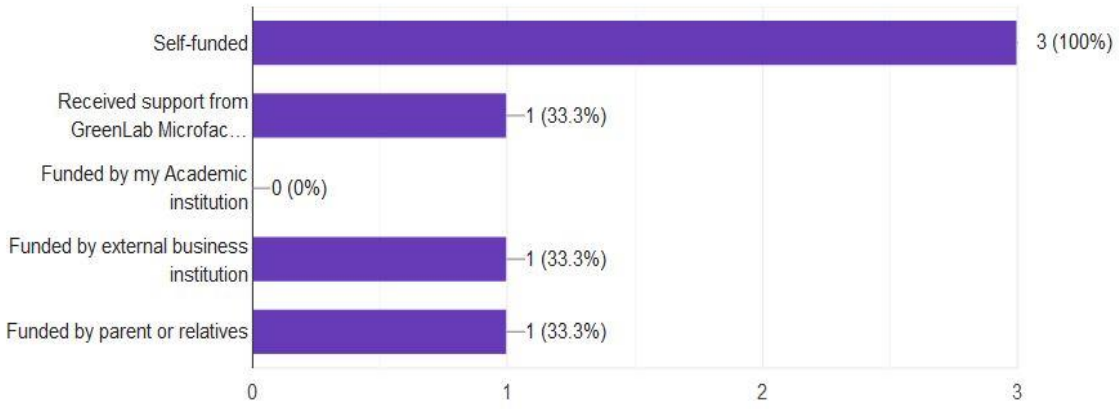

Figure 7.12: Source of Funds

To further solidify the user innovation activities, from Figure 7.11, it was identified that despite majority of these innovators not willing to share their innovation, one exists that is willing to keep the innovation open to everyone. The reason for wanting to share the information can be traced to the source of funds for the project, as it was evident that the innovator willing to share their invention was partly funded by GreenLab, while the rest were solely self-funded. Which testifies to the remark made in the introduction in section 7.5 which states that the user innovation activities in Nigeria is affected by the complexities and nature of the innovation. As can be seen from this section as well, the source of funds could also have an effect on the user innovation activities. Which attests to the fact that for user innovation activities to be encouraged in emerging economies like Nigeria, access to DFWs focused on open source paradigm as well as the source of funding for the innovation expenditure plays a critical role.

7.6 Conclusion

Despite the major financial limitation experienced during the implementation of this phase, drawing from the findings of recent studies conducted by Svensson & Hartmann (2018) on the implications of policies to promote user innovation, several discoveries were made, one of which includes: the envisaged complexities to fully implement the management of user innovation using digital fabrication as a toolkit. From the study conducted by Svensson & Hartmann (2018), an equivalent amount of $9.1 million was spent by the Swedish government and the local hospital to launch 6 new DFW to aid their research studies that spanned for 3 years, which on an average would cost $1.5 million per makerspace for the duration of the project. Therefore, this study found that for user innovation to be effectively managed, there is need for a favourable policy and synergy between

the government and other elements of the national innovation systems. In the absence of such financial buoyancy, GreenLab and other privately owned DFWs in emerging economies will struggle to provide an adequate solution space to nurture and support user innovators. However, observing the approach used by GreenLab to accomplish the objective of this study reveals that, GreenLab as an organization can be regarded as a user firm, by developing unique innovation strategies, approaches and tools to meet their impending needs.

Moreover, another empirical justification to the approach used in GreenLab was indicated by Bosqué (2013) and Morel & Le Roux (2016), according to their arguments, the success of FabLabs and its widespread propagation is not only limited to their technological capabilities, but about the people, and the encouragement and initiation of learning communities which revolves around skills and shared values. Thus signifying the importance of the immersive learning approach used by GreenLab to manage user innovation despite the limitations experienced.

In conclusion, as discovered in the study conducted by Svensson & Hartmann (2018), users innovate due to the existence of unique needs that commercial products could not meet. However, this study argued that what makes user innovation what it is, is not solely on the fact that the innovations are diffused freely, but that one way or the other finds its way to the hands of those who could benefit from using it. This can however, be achieved through free revealing the innovation or through the commercialization process such as user entrepreneurship or manufacturer. However, this study also found that due to the absence of adequate user innovation toolkits such as FabLabs, a significant amount of potentially valuable ideas are not pursued for development, while those developed are posited to be underdeveloped.

8 Summary and Outlook

8.1 Summary

Users have been identified as a rich source of innovation, either radical or incremental, which must be involved in the innovation process in order for product or service providers to enhance their innovation capability (Lettl et al., 2006; Chesbrough, 2006). This forges the concept of user Innovation of a critical necessity to any innovation ecosystem. Despite its high importance, the concept of user innovation and its implications has been explored from the perspectives of developed countries, such as, the Netherlands (De Jong & von Hippel, 2009), Canada (Schaan, 2010), the United Kingdom (Flowers et al., 2010), Portugal (Mendonca, 2012), and least developed countries such as South Korea (Kim & Hyunho, 2010). However, this concept with regards to its implications in developing countries up until now, is yet to be explored. This thesis aimed to address the paucity of research literatures on the notion of user innovation in developing countries.

In addition, user innovations occur due to the unsuitability of existing commercial products in meeting the compelling needs of the users. Therefore, the literature review conducted in this thesis presented a model for user innovation (UIM). This model took into cognizance the implications of the common and unique needs on the user innovation expedition. Unique need was defined as users' needs that can only be solved by User-centric Innovation Model (UCIM), a model where products and services are developed by users or in collaboration with users or by simply using users as sources of information for development (Gault, 2012; Stockstrom et al., 2016; Schweisfurth & Raasch, 2015). While the common needs can be solved by the UCIM and /or Traditional Manufacturer-centric Model (TMCM). TMCM is a model where products and services are developed by manufacturers in a closed way using several protective means such as patents, copyrights, trade secrets, which prevent imitators from having a free ride on their innovation (von Hippel, 2009).

Moreover, this study also explored the possibilities of external elements such as innovation incubators and digital fabrication workshops as an effective instrument to stimulate user innovation activities in developing countries. The narratives of this thesis fundamentally articulated the incidence and prevalent rate of user innovation in Nigeria, by providing information about the

prevalence and incidence rate of user innovation among Nigerian higher education students and Nigerian SME firms. This will be summarized in the succeeding subsections.

8.1.1 Summary of Individual User Innovation

From the consumers' perspectives, Flowers et al. (2010) identified a high prevalent rate of user innovators amongst users with a degree or post graduate degree or other professional qualifications. Hence symbolizing that user innovation is relational to the educational attainment of the innovator. From the quantitative research conducted in the South west region of Nigeria, this thesis identified a prevalent rate of 304 user innovators, one fifth of which developed new products, while the remaining modified existing products. user innovators among the Higher education students.

In comparison to existing studies, this study revealed that from the consumers' perspectives, user innovation was mostly engendered due to the preponderance of the users' personal and social needs. In addition, with regards to the implication of gender on the user innovation activities in Nigeria, the narrative of this thesis articulated that the user innovation activities among Nigerian users are Male dominated, with male users engaging in user innovation thrice more than the female user innovators. This in particular is an improvement over the findings by Flowers et al., (2010) that reported that male user innovators in the UK innovate twice as more as the females.

Moreover, the type of innovation created by the user innovators in Nigeria are predominantly health and medical related equipment as well as household equipment. With regards to the effect of gender on the types of products developed, this study uncovered that female users are more focused on educational technologies than the male SUIs. Thus affirming the findings by Mendonca et al. (2012), that the female user innovators in Portugal develop solutions related to children and education, software and health.

Lastly, this study also indicated that majority of the SUIs are willing to share the information about their invention with other users freely, thus confirming the findings from previous studies (Benkler, 2006; Kim & Hyunho 2010; Henkel & von Hippel, 2005; von Hippel 2005; Allen, 1983; Nuvolari, 2004; Franke and Shah, 2003; von Hippel and Finkelstein, 1979; Morrison et al., 2000; De Jong and von Hippel, 2008, 2009a).

8.1.2 Summary of User Innovation at the firm level

To summarise the prevalence of user innovation at the firm level, this study uncovered a prevalent rate of 206 user firms among the sampled SME firms. therefore, compared to previous studies in developed countries, this thesis identified that the incidence rate of user firms in Nigeria SMEs is significantly low. Moreover, this thesis identified that 61% of the user firms function independently. While 10% of these user firms were identified as user involver. With regards to the connection between the elements of the National Innovation systems (otherwise known as triple helix), this study established that some collaborative activities exist between the user firms in Nigeria with some higher education institutions, which slightly indicated some interactions between the SMEs and other elements in the Nigerian national innovation system.

In addition, this study discovered that the Nigerian SME firms are more oriented towards the development of new products and services than making modifications to existing products or services which contradicts the findings made by Flowers et al., (2009; 2010), which stipulated that user firms are more engaged in product modifications than the development of new products or services.

With regards to the effect of age on the user innovation activities of the user firms, this study identified a mixed discovery based on two different age group:

1. That the age of the firm does not have any effect on the user innovation activities engaged by younger SME firms within the age of 1 and 10 years. This affirms the discoveries made by previous studies which specified that younger firms experience more productive growth than matured firms (Huergo & Jaumandreu, 2004; Coad et al., 2016; Hansen, 1992).
2. Secondly, this study also uncovered the effect of the firm's age on its user innovation activities within the age group of 11 and 20 years old SME firms.

With regards to the innovation expenditure of the user firms, this study reported that Nigerian user firms incurred more user innovation expenditure disclosed by previous studies in developed countries (Morrison et al., 2000; Flowers et al., 2010; Stock et al., 2015). However, this finding is slightly lower than the average incurred by Dutch user firms (De Jong & von Hippel, 2009a). in

addition, this study revealed that majority of the user firms generated a revenue turnover from their innovation expenditure which covers both the radical and incremental user innovation.

Lastly, with regards to the willingness of the identified user firms to freely share or reveal their innovation, this study identified that most SMEs in Nigeria are not willing to freely share their innovation without a form of compensation or trade for their information. Which contradicts the findings from previous studies (von Hippel, 1975; 1988; 2005; 2009; Flowers et al., 2010; De Jong & von Hippel, 2009a; 2009b). however, despite the unwillingness of these user firms to share their innovations, this study also identified a low technological protection rate by the user firms in Nigeria.

8.1.3 Summary of the role of Private Innovation Incubators to User Innovation

With respect to the overall impact of innovation incubators on the Nigerian innovation ecosystem, this thesis discovered that privately owned innovation incubators does contribute to Nigeria's innovation activities. In addition, with respect to the contribution of the private innovation incubators to the user innovation activities in Nigeria, this study revealed that an amount of user innovators has been supported by these innovation incubators. This thesis also revealed that most of these user innovators supported by the private innovation incubators focused more on software development, and have freely shared their innovation with others using the online platform.

8.1.4 Summary of Managing User Innovation

After having uncovered the existence of user innovators and user firms in the Nigerian innovation ecosystem, this thesis took cognizance of the basic limitations faced by innovators, especially in resource-constrained settings. Therefore, based on the need to manage user innovation through the provision of user innovation toolkits as recommended by von Hippel & Katz (2002). This thesis explored the possibilities of digital fabrication workshops (DFWs) as a formidable user innovation toolkit. User innovation toolkits was highlighted to enable lead users to design new products through trial-and-error experimentation, as well as to deliver constant and instant feedback to manufacturers on the viability of their project design

For this study, GreenLab Microfactory, a community-oriented FabLab, was initiated as a supportive means to manage the user innovation activities in Nigeria. Despite the financial constraints which limited the overall implementation of the project, and hence the elicitation of required data to ascertain the efficacy of DFWs as an effective user innovation toolkit. This study uncovered vital information from the review of the product developed at Green Garage as well as some other project executed in Sweden (Svensson & Hartmann, 2018), and also from the few innovative projects and approaches executed at GreenLab Microfactory, which demonstrated that DFWs with adequate support is indeed an effective means by which user innovation activities can be cultivated and managed.

8.2 Implications for Practice

The survey conducted in this study has uncovered that both at the consumer and firm level, user innovation does exist in Nigeria. which if properly harnessed by the provision of innovation toolkits (von Hippel & Katz, 2002), favourable governmental innovation policy (von Hippel, 2005), could eventually a positive resultant effect on a nation's economic state. However, due to some envisioned complexities to this study with regards to SMEs in Nigeria, this study did not ask the respondents direct questions that would have reflected their user innovation activities. Thereby using a deductive approach to uncover the state of user innovation among the Nigerian SMEs. Therefore, there is need for further investigation directly uncover the state of user innovation in Nigeria, and also to understand their willingness to reveal their innovation. In addition, further investigation of the state of user innovation both from the consumer and firm level in the whole country is worthy of being conducted.

In addition, due to complexities of insufficient financial injection experienced during this research study, the research was restricted only to the South-weste region of Nigeria. Therefore, there is need for a countrywide survey to provide statistically significant information about the overall state of user innovation in Nigeria. Which based on the information spillover it generates would have a positive effect on the economic state of the country.

Moreover, this study by exploring two variations of user innovation (User Product Innovation, and user Involver), has highlighted the existence of user product innovation among Nigerian SMEs, as well as the identification of some user involvers. However, the study did not provide any information

about the state of user process innovation among the Nigerian SMEs. Therefore, there is need for further investigation to explore the state of user process innovation among Nigerian SMEs.

This study supports the claims by previous research studies (von Hippel, 2005) that stated that the lack of favourable policy hampers the growth of user innovation. Therefore, this study suggests the propagation of more DFWs in Nigeria, through which the country can adequately nurture more user innovator in Nigeria.

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10 Appendix I: Additional Tables of General Innovation in SMEs

Table A1: Time Investment

Statistics	
	Cost Investment
Mean	29.30
Median	12
Mode	12
Std. Deviation	76.66
Range	809
Sum	7296

	Frequency	Percent	Cumulative Percent
1 - 10	90	38.5	38.5
11 - 20	63	26.9	65.4
21 - 30	34	14.5	79.9
31 - 40	5	2.1	82.0
41 - 50	3	1.4	83.4
51 - 60	5	2.1	85.5
> 60	34	14.5	100.0
Total	234	100.0	

Table A2: Innovation Expenditure

Statistics	
	Time Investment
Mean	6024125.69
Median	12.00
Mode	12
Std. Deviation	23841188.905
Range	99999999
Sum	1500007296

	Frequency	Percent	Cumulative Percent
1000 - 50000	17	6.8	6.8
50001 - 100000	30	12.1	18.9
100001 - 200000	24	9.6	28.5
200001 - 500000	32	12.9	41.4
500001 - 1000000	36	14.5	55.9
1000000 - 10000000	36	14.5	70.4
> 10000000	74	29.6	100.0
Total	249	100.0	

Table A3: Revenue Turnover from Radical User Innovation

	Frequency	Percent	Cumulative Percent
1 - 50000	35	14.1	14.1
50001 - 100000	33	13.3	27.4
100001 - 200000	10	4.0	31.4
200001 - 500000	99	39.7	71.1
500001 - 1000000	6	2.4	73.5
1000000 - 10000000	0	0	73.5
> 10000000	66	26.5	100.0
Total	249	100.0	

Table A4: Revenue Turnover from Incremental User Innovation

	Frequency	Percent	Cumulative Percent
1 - 50000	35	14.1	14.1
50001 - 100000	7	2.8	16.9

100001 - 200000	32	12.8	29.7
200001 - 500000	74	29.7	59.4
500001 - 1000000	4	1.6	61.0
1000000 - 10000000	37	14.9	75.9
> 10000000	60	24.1	100.0
Total	249	100.0	

Table A5: Sources of Information for Innovation (n = 249)

		Frequency	Percent	Cumulative Percent
Internal sources	High	151	60.6	60.6
	Medium	65	26.1	86.7
	Low	21	8.4	95.2
	Not used	12	4.8	100.0
	Total	249	100.0	
Universities	High	105	42.2	42.2
	Medium	85	34.1	76.3
	Low	41	16.5	92.8
	Not used	18	7.2	100.0
	Total	249	100.0	
Governments	High	142	57.0	57.0
	Medium	62	24.9	81.9
	Low	31	12.4	94.4
	Not used	14	5.6	100.0
	Total	249	100.0	
Conferences, trade fairs	High	29	11.6	11.6
	Medium	37	14.9	26.5
	Low	40	16.1	42.6
	Not used	143	57.4	100.0
	Total	249	100.0	
Scientifics journals	High	28	11.2	11.2
	Medium	36	14.5	25.7
	Low	15	6.0	31.7
	Not used	170	68.3	100.0
	Total	249	100.0	
Professional and industry Associations	High	25	10.0	10.0
	Medium	36	14.5	24.5
	Low	22	8.8	33.3
	Not used	166	66.7	100.0
	Total	249	100.0	
Suppliers	High	59	23.7	23.7
	Medium	61	24.5	48.2
	Low	41	16.5	64.7
	Not used	88	35.3	100.0
	Total	249	100.0	
Customers	High	27	10.8	10.8
	Medium	40	16.1	26.9
	Low	49	19.7	46.6
	Not used	133	53.4	100.0
	Total	249	100.0	
Consultants or Private R&D	High	108	43.4	43.4
	Medium	53	21.3	64.7
	Low	36	14.5	79.1
	Not used	52	20.9	100.0
	Total	249	100.0	

Table A6: Collaboration and Support Received by the SMEs

	Frequency	Percent	Cumulative Percent
None	15	6.0	6.0
Yes, from government	20	8.0	14.1
Yes, from the producer or supplied of the modified product	23	9.2	23.3
Yes, from higher education institutions	4	1.6	24.9
Yes, from other competitors or enterprises in your sector	9	3.6	28.5
Yes, from clients or customers	13	5.2	33.7
No Answer	165	66.3	100.0
Total	249	100.0	

Table A7: Support from governmental structures

		Frequency	Percent	Cumulative Percent
Local government	No	240	96.4	96.4
	Yes	9	3.6	100.0
	Total	249	100.0	
State government	No	237	95.2	95.2
	Yes	12	4.8	100.0
	Total	249	100.0	
Federal government	No	242	97.2	97.2
	Yes	7	2.8	100.0
	Total	249	100.0	
National funding agencies	No	243	97.6	97.6
	Yes	6	2.4	100.0
	Total	249	100.0	
Foreign government agencies	No	248	99.6	99.6
	Yes	1	.4	100.0
	Total	249	100.0	

Table A8: SMEs Means of Engagement

		Frequency	Percent	Cumulative Percent
In-house R&D	No	139	55.8	55.8
	Yes	110	44.2	100.0
	Total	249	100.0	
External R&D	No	212	85.1	85.1
	Yes	37	14.9	100.0
	Total	249	100.0	
Acquisition of Machines	No	70	28.1	28.1
	Yes	179	71.9	100.0
	Total	249	100.0	
Acquisition of External knowledge	No	101	40.6	40.6
	Yes	148	59.4	100.0
	Total	249	100.0	
Others	No	233	93.6	93.6
	Yes	16	6.4	100.0
	Total	249	100.0	

11 Appendix II: Nigeria's 2018 Ranking on the Global Innovation Index

Country: Nigeria				
Indicator	Rank	Score		
Global Innovation Index	**118**	**22.4**		
Innovation Efficiency Ratio	**96**	**0.5**		
Innovation Input Sub-index	**116**	**29.85**		
Innovation Output Sub-index	**115**	**14.89**		
Index	Property	Rank	Score	Strength / Weakness
1	**Institutions**	**119**	**44.65**	
1.1	Political environment	125	19.37	Weakness
1.1.1	Political stability and absence of violence/terrorism	122	21.75	
1.1.2	Government effectiveness	123	18.18	Weakness
1.2	Regulatory environment	81	58.89	
1.2.1	Regulatory quality	117	20.54	
1.2.2	Rule of law	118	15.01	
1.2.3	Cost of redundancy dismissal	1	100	Strength
1.3	Business environment	111	55.7	
1.3.1	Ease of starting a business	98	80.8	
1.3.2	Ease of resolving insolvency	114	30.6	
2	**Human capital and research**	**116**	**12.86**	
2.1	Education	109	29.53	
2.1.1	Expenditure on education	n/a	n/a	
2.1.2	Government funding per secondary student	n/a	n/a	
2.1.3	School life expectancy	108	19.38	
2.1.4	Assessment in reading, mathematics, and science	n/a	n/a	
2.1.5	Pupil-teacher ratio, secondary	91	49.82	
2.2	Tertiary education	110	7.76	
2.2.1	Tertiary enrolment	102	7.76	
2.2.2	Graduates in science and engineering	n/a	n/a	
2.2.3	Tertiary level inbound mobility	n/a	n/a	
2.3	Research and development (R&D)	103	1.28	
2.3.1	Researchers	94	0.32	
2.3.2	Gross expenditure on R&D (GERD)	88	4.82	
2.3.3	Global R&D companies, average expenditure top 3	40	n/a	Weakness
2.3.4	QS university ranking average score top 3 universities	78	n/a	Weakness
3	**Infrastructure**	**114**	**26.48**	
3.1	Information and communication technologies (ICTs)	108	31.07	
3.1.1	ICT access	109	31.6	
3.1.2	ICT use	111	15.8	

3.1.3	Government's online service	98	41.3	
3.1.4	Online e-participation	105	35.59	
3.2	General infrastructure	122	18.33	
3.2.1	Electricity output	114	0.57	
3.2.2	Logistics performance	89	26.13	
3.2.3	Gross capital formation	119	23.3	Weakness
3.3	Ecological sustainability	93	30.04	
3.3.1	GDP per unit of energy use	81	20.17	
3.3.2	Environmental performance	83	54.76	
3.3.3	ISO 14001 environmental certificates	122	0.32	
4	**Market sophistication**	**95**	**41.74**	
4.1	Credit	81	32.14	
4.1.1	Ease of getting credit	6	90	Strength
4.1.2	Domestic credit to private sector	115	4.53	
4.1.3	Microfinance institutions' gross loan portfolio	57	1.88	
4.2	Investment	95	34.62	
4.2.1	Ease of protecting minority investors	32	66.67	Strength
4.2.2	Market capitalization	78	4.21	
4.2.3	Venture capital deals	73	0.94	
4.3	Trade, competition, & market scale	70	58.47	Strength
4.3.1	Applied tariff rate, weighted mean	120	26.13	
4.3.2	Intensity of local competition	67	68.18	Strength
4.3.3	Domestic market scale	22	69.77	Strength
5	**Business sophistication**	**104**	**23.53**	
5.1	Knowledge workers	72	33.14	
5.1.1	Employment in knowledge-intensive services	49	46.79	Strength
5.1.2	Firms offering formal training	49	36.02	Strength
5.1.3	GERD performed by business enterprise	n/a	n/a	
5.1.4	GERD financed by business enterprise	93	0.1	
5.1.5	Females employed with advanced degrees	n/a	n/a	
5.2	Innovation linkages	118	16.59	
5.2.1	University/industry research collaboration	118	25.26	Weakness
5.2.2	State of cluster development	88	40.24	
5.2.3	GERD financed by abroad	91	1.97	
5.2.4	Joint venture/strategic alliance deals	78	6.44	
5.2.5	Patent families filed in at least two offices	114	0.01	Weakness
5.3	Knowledge absorption	102	20.85	
5.3.1	Intellectual property payments	57	14.63	Strength
5.3.2	High-tech imports	98	15.32	
5.3.3	ICT services imports	80	14.95	
5.3.4	Foreign direct investment, net inflows	110	35.41	
5.3.5	Research talent in business enterprise	n/a	n/a	
6	**Knowledge and technology outputs**	**119**	**10.26**	
6.1	Knowledge creation	111	3.52	
6.1.1	Patent applications by origin	118	0.24	
6.1.2	PCT international applications by origin	106	0.04	Weakness
6.1.3	Utility model applications by origin	n/a	n/a	

6.1.4	Scientific and technical publications	115	3.7	
6.1.5	Citable documents H index	62	10.09	Strength
6.2	Knowledge impact	113	13.83	
6.2.1	Growth rate of GDP per person engaged	110	27.96	Weakness
6.2.2	New business density	78	2.78	
6.2.3	Total computer software spending	82	10.25	
6.2.4	ISO 9001 quality certificates	123	0.18	Weakness
6.2.5	High-tech and medium high-tech output	n/a	n/a	
6.3	Knowledge diffusion	104	13.44	
6.3.1	Intellectual property receipts	n/a	n/a	
6.3.2	High-tech exports	121	0.04	Weakness
6.3.3	ICT services exports	112	2.06	
6.3.4	Foreign direct investment, net outflows	78	25.82	
7	**Creative outputs**	**99**	**19.52**	
7.1	Intangible assets	97	33.56	
7.1.1	Trademark application class count by origin	87	8.49	
7.1.2	Industrial designs by origin	72	4.07	
7.1.3	ICTs and business model creation	67	58.73	Strength
7.1.4	ICTs and organizational model creation	85	48.21	
7.2	Creative goods and services	90	10.58	
7.2.1	Cultural and creative services exports	n/a	n/a	
7.2.2	National feature films produced	13	41.09	Strength
7.2.3	Entertainment and media market	60	0.7	
7.2.4	Printing, publications & other media output	n/a	n/a	
7.2.5	Creative goods exports	120	0.27	
7.3	Online creativity	113	0.36	
7.3.1	Generic top-level domains (gTLDs)	106	0.46	
7.3.2	Country-code top-level domains (ccTLDs)	102	0.27	
7.3.3	Wikipedia yearly edits	112	0.18	
7.3.4	Mobile app creation	83	0.51	

Source: https://www.globalinnovationindex.org/analysis-economy

12 Appendix III: Questionnaire for the Private Innovation Incubator Survey

Date of Interview/ Observation:
Name of Organization:
Interviewee(s):

1. General Information

1.1 When was your founded? _____

1.2 What is your role in your organization?

1.3 How many people are working in your facility?

1.4 What is your professional background (engineer, architect, artist etc.)?

1.5 Is your organization private/independent or does it form part of

☐ Public organization ☐ Private organization

☐ Academic institution ☐ Non-profit organization

☐ Non-governmental organization

Other, please specify

2. Motivation, vision and identity

2.1 What is the motivation for the establishment of your organization?

2.2 What is/are the main agenda/objective(s) of your organization?

- What are your main services?
- How has your organization been achieving its goals?
- What is the impact/contribution of your organization in the Nigerian innovation space?

2.3 How do you publicize or market your organization in order to attract the innovators?

2.4 What are basic interests of your clients?

- Are the users' interests in line with the focus of your workshop?

2.5 Do you think providing access to means of production and the participation in value creation is a promising model (for the future)?

3 Business model/viability

3.1 Where are your financial and material resources derived from?

- ✓ If you receive support from your government and/or private organization
  - How often?
  - What level (e.g. local, regional, or federal)?
  - What kind of support do you receive (e.g. financial, material, subsidy etc.)

3.2 Do you charge your clients for consulting your organization? If Yes, how much?

3.3 From inception, has your organization generated any revenue turnover?

3.4 What are the major challenges to the growth and viability of your organization?

- How are you mitigating the challenges?
- Has it been easy to establish your organization (have there been any legal or social obstacles in the foundation process?)

4 Contribution to Nigerian Innovation space

4.1 Are there any selection criteria/requirements that your clients must meet during the application process? If yes, what is/are the criteria?

4.2 How many startup companies have been rolled out by your organization? Please give an estimate of the numbers of organizations/initiatives/workshops you have supported?

4.3 Do you conduct community-oriented initiatives to encourage participation in your local community?

- If yes, name some and their focus.
- Was it free or were participants required to pay a fee?
- What was the community's response to the initiative?

4.4 Is your facility in close collaboration with government agencies, or private companies in solving the local/regional issues?

4.5 Was it easy to establish a collaboration with the government or private agencies?

4.6 How valuable is the close collaboration with the government agencies or private companies in solving these social issues?

4.7 How do you estimate innovation politics' influence on your organization activities on a national (e.g. Ministry of Research and Development, Environment, Economics or others) or regional/ local level (e.g. municipality, universities others)

4.8 Do you use /do you have an idea whether your clients use materials or resources from your local/ regional community (NOTE: this is for ecological reasons)?

- If any, name some

5 Inventing and Innovating

5.1 Do you have a clearly defined innovation agenda / strategy?

5.2 Have you heard of FabLab? What is/are your opinion on the FabLab idea(s)?

5.3 Have you ever collaborated/supported the digital fabrication workshop (If they have a knowledge of FabLab or digital fabrication)?

- If yes, how often and how many?
- If no, why?

5.4 Up till date, has any products/artefacts been developed with the support of your organization?

- If yes, what type of products have you produced within your facility? (Technologies, Arts, Health, Agricultural etc.)
- Estimated numbers (How many)?
- Which organization(s) developed it?

5.5 Has any of your clients filed for intellectual property rights (patent or copyright) for any artefacts created?

- If yes, at which patenting office/body was the patent filed? (local, or international)

5.6 Openness/Open Innovation has been identified as one the means for an economy to attain development. What is/are your opinion(s) on the 'open' concept?

5.7 How many of your clients would you tag as a User Innovator? (Innovators that created products because they couldn't find the product off the shelf, or because the off the shelf product do not meet their needs)

5.8 How many of your clients has made their inventions open or shared their inventions on the open source platform?

5.9 From your opinion what do you envision as the impact of '*openness*' (e.g. open source licenses, open access, open source hardware, etc.) on your company's output?

6 SWOT Analysis

6.1 Are there any aspects/fields of activity of your organization you would improve (i.e. organizational structure, opening up financial resources, know-how of users/ members/ collaboration/ others?

6.3 What are the identified strengths, weaknesses, opportunities, and threats of your organization?

6.4 How are you utilizing the strengths?

6.5 How are you responding to the weaknesses?

6.6 How are you harnessing the opportunities?

6.7 How are you responding to the threats?

13 Appendix IV: Questionnaire for Higher Education Survey

MEASURING USER INNOVATION IN NIGERIAN HIGHER INSTITUTIONS SURVEY 2017

Name of Survey Participants	Contact details

About this survey

This survey collects information about product and process innovation most importantly on the rate and state of user innovation. This survey is towards to the partial fulfillment of the PhD requirements of Mr. Babasile Daniel Oladele-Emmanuel at the Helmut Schmidt Universität (HSU) Hamburg. The survey could take between 10 to 20 minutes to complete.

Scope

The statistical unit for the survey is the higher institution students, which includes Universities, polythecnics, and colleges of education. For this exercise, there will be no restrictions on the numbers of employees that the organization must have.

For ease of comparisons, we request ALL enterprises with or without innovation activities to respond to ALL questions, unless otherwise instructed.

Authority

Mr Oladele-Emmanuel, GreenLab microfactory, and the Helmut Schmidt Universität (HSU) Hamburg coordinated this survey using direct contact of the survey particicipants, either by email or other social mediums.

Confidentiality

All information gathered by this survey will be held in strictest confidence. Under no circumstances will Mr. Oladele-Emmanuel or other recognized authorities release or disclose any information on, or identifiable with, individual firms or business units.

Assistance

If you have any problems in completing this form and/or meeting the due date, please do not hesitate to contact the survey developers listed below for assistance:

Name of Contact	Telephone	E-mail
Babasile Daniel	+49 40 6541 2599	babasile.daniel@hsu-hh.de
		babasile.daniel@greenlab-microfactory.org

Q1. Please provide us with your email address in case we need to contact you for additional information (optional)?

Q2. What is the name of your Institution?

Q3. Which Faculty or Department are you? *

Q4. What academic level (year) are you? *

Q5. Gender *

☐ Male ☐ Female

Q6. Have you developed (new) or modified (existing) any invention/equipment/technology for your personal use or for the usage of others? * (if no, kindly go to question 26)

☐ Developed (New) ☐ Modified (Existing product)
☐ No

Q7. If you answered yes to the question above, when was the invention/product developed or modified? *

☐ Between 1 and 3 years ago ☐ 3 to 5 years ago
☐ Above 5 years

Q8. Are you a member of a club or web community where people share information related to your invention? *

☐ Yes ☐ No

Q9. If you answered yes to the previous question, what is the name of the club, social groups, or online community?

Q10. In the past 10 years, how many inventions or modifications have you made? *

Q11. What type of invention/product did you create and/or modify? *

☐ Agricultural technologies/equipment ☐ IT/Software applications
☐ Electrical technologies/equipment ☐ Educational
☐ Health/Medical ☐ Household fixtures

☐ Others, please list below

Q12. Why did you develop or modify the product? *

☐ To suit my need ☐ I just love creating things
☐ To provide solution to a social issue ☐ It was initiated by my club or web forum
☐ It was initiated by my institution as part of my school project
☐ Other reasons, please list below

Q13. To the best of your knowledge, how novel is your invention? *

☐ To few people ☐ To many but not all
☐ Basically to everyone, it has never existed before

Q14. How much did you spend in developing or modifying the product (in Nigerian Naira)?

Q15. How was your invention funded? *

☐ Self-funded ☐ Jointly funded by collaborators
☐ Funded by academic institutions ☐ Funded by external business institution
☐ Funded by government agencies ☐ Funded by NGOs
☐ Other funding, please state below

Q16. How long did it take you to develop or modify the product (in weeks)?

Q17. Did you (or do you plan to) commercialize the product (invention)? *

☐ Yes, in exchange for something of value ☐ Yes, for a fee
☐ No, I made it open on the online open source platform
☐ No, but I plan to make it open on the online open source platform
☐ Other, please state below

Q18. Did you file for patent or Intellectual property rights for the design/Product? *

☐ Yes, Patent ☐ Yes, Technical protection

☐ Yes, confidentiality agreement ☐ Yes, Trademark
☐ Yes, Copyright ☐ Yes, secrecy
☐ No
☐ Others, please state below

Q19. Did any other people work with you or contribute to developing the design/Product? *

☐ Yes, members of a club or web community ☐ Yes, other course mates/students
☐ Yes, family members ☐ Yes, external professional contacts
☐ Yes, Friends ☐ No

Q20. To what extent was the invention successful?

☐ A complete success ☐ A partial success
☐ Not successful ☐ Not yet tested with other user

Q21. Did you or are you willing to share the knowledge about your invention with others? *

☐ Yes with anyone for free ☐ Yes, but only with selected individuals or firms
☐ No, I would like to keep the knowledge to myself

Q22. What are your reasons for sharing your invention? *

☐ Contractual obligation ☐ Nothing to lose (no direct competition)
☐ Enhance reputation ☐ Gain feedback and expertise
☐ Allow other users to learn from the invention and also modify it
☐ Allow suppliers to build more suitable products
☐ Others, please state below

Q23. To the best of your knowledge, has your invention been adopted or utilized by others?

☐ Yes ☐ No

Q24. Have you started or trying to start a new business (either alone or with others) from your invention?

☐ Yes ☐ No

Q25. Did you encounter any problems during the developmental process of your invention? *

☐ Yes, please state below ☐ No

Q26. Are there any particular reasons or limitations behind not inventing/innovating?

Q27. Do you think having a platform/workshop that facilitate research and development of indigenous technologies/innovations would have helped solve some of the problems encountered during the development phase? *

☐ Yes ☐ No ☐ Maybe

Q28. Do you have any suggestion on how user innovation and other forms of innovations can be spurred in Nigeria?

Q29. Do you know any of the following digital fabrication initiatives and their objectives?

	Yes	No
FabLab (Fabrication Laboratory)	☐	☐
Makerspace	☐	☐
Techshops	☐	☐
Hackerspace	☐	☐

Repair cafes ☐ ☐

☐ Other, please state below

14 Appendix V: Small Medium Enterprise Questionnaire

MEASURING USER INNOVATION IN NIGERIAN SMALL AND MEDIUM ENTERPRISES SURVEY 2018

Enterprise/Organization	**Address**

About this survey

This survey collects information about product and process innovation most importantly on the rate and state of user innovation. This survey is towards the partial fulfillment of the PhD requirements of Mr. Babasile Daniel Oladele-Emmanuel at the Helmut Schmidt Universität (HSU) Hamburg. The survey will take between 15 to 30 minutes to complete.

Scope

The statistical unit for the survey is the Small Medium Enterprises (SME). An SME is a business, company or firm with a workforce between 1 and 250 persons. For this exercise, there will be no restrictions on the number of employees that the organization must have.

For ease of comparison, we request ALL enterprises with or without innovation activities to respond to ALL questions, unless otherwise instructed.

Authority

Mr Oladele-Emmanuel, GreenLab microfactory, and the Helmut Schmidt Universität (HSU) Hamburg coordinate this survey using direct contact of the survey participants, either by email or other social mediums.

Confidentiality

All information gathered by this survey will be held in strictest confidence. Under no circumstances will Mr. Oladele-Emmanuel or other recognized authorities release or disclose any information on, or identifiable with, individual firms or business units.

Assistance

If you have any problems in completing this form and/or meeting the due date, please do not hesitate to contact the survey developer listed below for assistance:

Name of Contact	Telephone	E-mail
Babasile Daniel	+49 40 6541 2599	babasile.daniel@hsu-hh.de

In collaboration with the:

Q1. **Name of Enterprise** *

Q2. **Which state are you located?**

Q3. **What are the main activities of your enterprise?** * (e.g. manufacture, etc.)

Q4. **What year was your enterprise established?**

Q5. **Is your enterprise part of a larger group?**

- ○ **Yes, subsidiary of a group in Nigeria**
- ○ **Yes, subsidiary of a group outside of Nigeria but within Africa**
- ○ **Yes, subsidiary of a group outside of Africa**
- ○ **No**

Q6. **In which geographic markets does or did your enterprise sell their products and services?** *

- ☐ **Within Nigeria**
- ☐ **Outside Nigeria, but within ECOWAS**
- ☐ **Outside Nigeria, but within other parts of Africa**
- ☐ **Outside Africa**

Q7. **What is the total number of employees within your enterprise?** *

Q8. **During the past three years, did your enterprise introduce new or modified products/services?** *

- ☐ **Yes, New products**
- ☐ **Yes, new services**
- ☐ **Yes, modified products**
- ☐ **Yes, modified services**
- ☐ **No**

Q8.1. If you answered Yes, please give the numbers and examples of each type of new or modified products and/or services below

Total number of new or modified products and/or services

Types of new or modified products and/or services

Q9. **Who developed (or modified) these products/services?** *

- ○ **Your enterprise**

- Your enterprise with its customers/clients
- Your enterprise with a higher education institution
- Your enterprise with other enterprises
- Your enterprise by modifying existing products/services developed by other enterprises or institutions
- External enterprises or institutions

Q10. Were any of developed (or modified) products/services new to your firm? *
- ☐ Yes
- ☐ No

Q11. Were any of developed (or modified) products/services new to your market? *
- ☐ Yes
- ☐ No

Q12. Do you know other enterprises doing similar innovations?
- Yes
- No

Q13. During the past three years did your enterprise have any innovation activities that were abandoned or still ongoing?
- Abandoned
- Still ongoing

Q14. If you ticked 'Abandoned', at what stage were the activities/projects abandoned: (1 - Yes, 2 - No)

	1	2
Abandoned in the concept (early) stage	○	○
Abandoned after the activity or project began	○	○
Seriously delayed	○	○

Q15. Did you collaborate or receive any assistance (e.g. finance, design, prototype etc.) while developing or modifying the products/services?
- ☐ Yes, from government
- ☐ Yes, from the producer or supplier of the modified product
- ☐ Yes, from higher education institutions
- ☐ Yes, from other competitors or enterprises in your sector
- ☐ Yes, from clients or customers
- ☐ No

Q16. Has your firm generated a revenue turnover from the developed (or modified) products/services? *
- ☐ Yes
- ☐ No

Q17. Please give the average monthly revenue turnover from the new or modified product/services:

Products/services introduced by your enterprise that were new to your market

Products/services introduced by your enterprise that were new to your firm

Products/services modified by your enterprise

Q18. Please give the estimate of resources (including finance and time) invested to develop or modify the innovation (products/services). *

Estimated amount invested to develop or modify the products/services (value in Naira)

Estimated time invested to develop or modify the products/services (value in weeks)

Q19. During the past three years, did your enterprise engage in the following:

- ☐ **Yes, intramural or in-house research and development (R&D)**
- ☐ **Yes, extramural or outsourced R&D**
- ☐ **Yes, acquisition of machinery, equipment, and software**
- ☐ **Yes, acquisition of other external knowledge**
- ☐ **Other, please list them in the box below**

Q20. During the past, how important are the following information sources to your enterprise's innovation activities? (1 - High, 2 - Medium, 3 - Low, 4 - Not used)

	1	2	3	4
Sources within your enterprise or enterprise group	○	○	○	○
Suppliers of equipment, materials, components or software	○	○	○	○
Clients or customers	○	○	○	○
Consultants, commercial labs or private R&D institutions	○	○	○	○
Universities or other higher education institutions	○	○	○	○
Government or public research institutes	○	○	○	○
Conferences, trade fairs, and exhibitions	○	○	○	○
Scientific journals and trade technical publications	○	○	○	○
Professional and industry associations	○	○	○	○

Q21. How important were each of the following types of outcomes for your innovations introduced during the past three years? (1 - High, 2 - Medium, 3 - Low, 4 - Not important)

	1	2	3	4
Increased range of goods or services	○	○	○	○
Entrance to new markets	○	○	○	○
Increased market share	○	○	○	○
Improved quality of products or services	○	○	○	○
Improved flexibility of production or service provision	○	○	○	○

Increased capacity of production or service provision	○	○	○	○
Reduced production costs per unit of labour, material, energy	○	○	○	○
Improved environmental standard compliance	○	○	○	○
Improved working conditions on health and safety	○	○	○	○
Met government regulatory requirements	○	○	○	○

Q22. During the past three years, how important were the following factors in hampering your innovation activities or projects or influence a decision not to innovate? (1 - High, 2 - Medium, 3 - Low, 4 - Factor not experienced) *

	1	2	3	4
Lack of funds within your enterprise or group	○	○	○	○
Lack of financial support from external sources (including government)	○	○	○	○
Innovation costs too high	○	○	○	○
Excessive perceived economic risks	○	○	○	○
Investment in environmental friendly R&D is too expensive	○	○	○	○
Lack of qualified personnel	○	○	○	○
Lack of information on technology	○	○	○	○
Lack of information on markets	○	○	○	○
Difficulty in finding co-operation partners for innovation	○	○	○	○
Market dominated by established enterprises	○	○	○	○
Uncertain demand for innovation products/services	○	○	○	○
Innovation is easy to imitate	○	○	○	○
Inadequate basic infrastructure e.g. electricity	○	○	○	○
Inadequate facilities e.g. laboratories etc.	○	○	○	○
No need to innovate	○	○	○	○
Organizational rigidities with the enterprise	○	○	○	○
Insufficient flexibility of regulations or standards	○	○	○	○
Limitations of public policies on science and technologies	○	○	○	○

Q23. During the past three years, did your enterprise: (1 - Yes, 2 - No)

	1	2
Apply for a patent in Nigeria?	○	○
Apply for a patent outside Nigeria?	○	○
Secure a patent in Nigeria?	○	○
Secure a patent outside Nigeria?	○	○
Register an industrial design?	○	○
Register a trademark?	○	○

	1	2
Claim a copyright?	○	○
Grant a license on any intellectual property rights resulting from innovation?	○	○
Protected a trade secret?	○	○

Q24. Are you willing to share the knowledge about your innovation? (1 - definitely not, 2 - probably not, 3 - neutral, 4 - probably yes, 5 - definitely yes)

	1	2	3	4	5
Other parties (including competitors) interested in this innovation are welcome to inspect it and imitate it	○	○	○	○	○
Willing to share the design of this innovation with others	○	○	○	○	○
Willing to actively help others adopt this innovation	○	○	○	○	○
Prepared to share this innovation for free	○	○	○	○	○

Q25. Are you aware of any firm that has adopted your innovation?

- ○ Yes
- ○ No

Q26. If you answered yes to question 24 above, did you receive any compensation from the producer firm for transferring the innovation? *

- ○ No compensation has been received, but compensation is expected
- ○ We willingly revealed/transferred the innovation for free
- ○ We received a royalty
- ○ We received discounts or subsidies on other products/services
- ○ Innovation was exchanged for other products/services
- ○ No compensation

Q27. During the past three years, did your enterprise make use of government support in its innovation activity (e.g. financial support etc.)? (1 - Yes, 2 - No) *

	1	2
Local government	○	○
State government	○	○
Federal government	○	○
National funding agencies (e.g. RMRDC etc.)	○	○
Foreign government and/or other foreign sources (e.g. EU commission, UNIDO etc.)	○	○

Q28. Are there any government policies that hindered your innovation activities during the past three years?

- ☐ Yes
- ☐ No
- ☐ If yes, please state some below

Q29. Do you have any suggestions on how your level of innovativeness can be increased?

Q30. Do you know any of the following digital fabrication initiatives and their objectives?

	Yes	No
FabLab (Fabrication Laboratory)	○	○
Makerspace	○	○
Techshops	○	○
Hackerspace	○	○
Repair cafes	○	○

☐ **Other, please state below**

Q31. If you answered yes to Question 30, how did you hear about it?

Q31. Have you engaged with any of the digital fabrication initiatives or would you be interested in engaging with any of them?

Babasile Daniel Oladele-Emmanuel

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Geburtsdaten: 17.09.1983
Zivilstand: Verheiratet

■ Schulbildung

01/2005 – 06/2011 **University of South Africa**
Bachelor of Science
Information Systems and computer science

01/2012 – 04/2013 **University of Pretoria**
Bachelor of Science (Honours)
Technology Management

01/2013 – 04/2014 **University of Pretoria**
Masters of Science
Technology Management

■ Computerliteratur und Fähigkeiten

❖ **Computer Aided Design (CAD)**

- Autodesk Fusion360
- Autodesk Inventor

❖ **Qualitatives und quantitatives Datenanalyse**

- ATLAS.ti
- R/RQDA
- SPSS
- Stata 14

❖ **Microsoft Office Suite**

- Excel
- PowerPoint
- Word
- Access

❖ **Projektmanagement**

- Entwickeln, bewerten und wählen Sie die richtige Strategie für Projekte
- Erstellung von Projektplänen auf der Grundlage von Projektstrukturplänen (PSP), Aktivitäten im Knotendiagramm, Netzwerkdiagramm sowie Zeit- und Budgetschätzungen
- Entwicklung eines effektiven Risikomanagement- und Minderungsplans
- Projektdurchführung und -überwachung.

Tools: - Microsoft Project, PRINCE2

■ Berufliche Erfahrungen

03/2015 – heute	**Helmut Schmidt Universitat**, Hamburg: Wissenschaftlicher Mitarbeiter Koordination von Forschungsprojekten und Sammeln von Informationen, Analyse von Forschungsdaten, Verfassen von Berichten / Artikeln, Workshop- / Event-Management im OpenLab Digital Fabrication-Labor, Prototyping und Entwicklung von Artefakten, Lehrer für Qualitäts- und Wissensmanagement.
06/2016 – heute	**GreenLab Microfactory**, Ibadan, Nigeria: Gründer. Organisation und Koordination von Open Source Development Workshops/Trainings, Appropriate Technologie-Prototyp und Entwicklung, Erleichterung der Erforschung sozialer / sparsamer Innovationen.
06/2014 – 02/2015	**Top Notch Tutor and consultant**, Pretoria, South Africa: Lehrer. Projektmanagement, Datenbankmanagement und einige andere Informationstechnologiemodule.
08/2011 – 05/2014	**Ropzide Training Institute**, Pretoria, South Africa: Lehrer. Wirtschaftsinformatik, Mensch-Computer-Interaktion, Projektmanagement, Computertheorie
11/2008 – 02/2009	**Joy Health Services**, Indiana, USA: Dateneingabe Schreiber. Datenbankverwaltung und -überwachung
01/2004 – 12/2004	**VGC Communication Ltd**. Lagos, Nigeria (MTN Nigeria): Switch Engineer (Praktikant) Testen, Konfigurieren, Installieren, Warten und Reparieren von Teilnehmeranschlüssen (analog und digital),

	Überwachen und Beheben von Systemalarmen, Konfiguration und Aktivierung von digitalen Teilnehmeranschlüssen (DSL und ADSL).

■ Sprachen

Deutsch:	Grundkenntnisse
Englisch:	Schriftlich und mündlich sehr gut
Französisch:	Grundkenntnisse

■ Professionelle Zertifizierungen

2016	Management and Strategy Institute Lean Six Sigma Black Belt (LSSBB)™
2015	PRINCE2 Project Management Foundation certification
2009	COMPTIA PROJECT+
2006	International Computer Driver's License (ICDL). Einführung in Computer- und Microsoft-Anwendungsprodukte
2005	University of South Africa. Pretoria, South Africa. Entwerfen und Implementieren eines Telekommunikationsnetzes

■ Publikation

1. Oladele-Emmanuel, B. D., Abiodun, A. Egbetokun, Redlich, T., & Wulfsberg, J. (2019, April). Measuring User Innovation: Case Study of Nigeria Higher Education Students. ISPIM - International Society for Professional Innovation Management Conference Innovation for Local and Global Impact. Ottawa, 7 – 10 April. Ottawa, Canada.

2. Oladele-Emmanuel, B. D., Rejeb, H. B., & Redlich, T. (2018, June). Strategic Management: SWOT Analysis of the African Digital Fabrication Laboratories. In 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp. 1-7). IEEE.

3. Oladele-Emmanuel, B. D., Redlich, T., & Wulfsberg, J. (2018, June). Measuring Innovation: Insight from Nigeria's Innovation Incubators. In 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp. 1-9). IEEE.

4. Basmer-Birkenfeld, S. V., Branding, J. H., Buxbaum-Conradi, S., Oladele-Emmanuel, B. D., Redlich, T., & Wulfsberg, J. (2018). Cui bono? Nodes of Participation in the Maker Movement. Nordisk Tidsskrift for

Informationsvidenskab Og Kulturformidling, 7(2), 19-31.

5. FabLab in Nigeria's Innovation Space: A Report from GreenLab Microfactory's DIWO Event. Conference: FAB13: Fabricating Society. July 31 - August 6 2017. Santiago De Chile.

6. Buxbaum-Conradi, S., Basmer-Birkenfeld, S. V., Branding, J. H., Osunyomi, B. D., Redlich, T., Langenfeld, M., & Wulfsberg, J. Local Embedding and Global Collaboration of Open Innovation, Production and Maker spaces. Wulfsberg● Redlich● Moritz, 37.

7. Redlich, T., Buxbaum-Conradi, S., Basmer-Birkenfeld, S. V., Moritz, M., Krenz, P., Osunyomi, B. D., ... & Heubischl, S. (2016, January). OpenLabs--Open Source Microfactories Enhancing the FabLab Idea. In 2016 49th Hawaii International Conference on System Sciences (HICSS) (pp. 707-715). IEEE.

8. Osunyomi, B. D., Redlich, T., & Wulfsberg, J. P. (2016). Could open source ecology and open source appropriate technology be used as a roadmap from technology colony?. International Journal of Technological Learning, Innovation and Development, 8(3), 265-282.

9. Osunyomi, B., Redlich, T., Buxbaum-Conradi, S., Moritz, M., & Wulfsberg, J. (2016). Impact of the fablab ecosystem in the sustainable value creation process. OIDA International Journal of Sustainable Development, 9(1), 21-36.

10. Osunyomi, B. D., & Grobbelaar, S. S. S. (2015). Integrating eHealth in HIV/AIDS intervention programmes in South Africa. South African Journal of Information Management, 17(1), 1-10.

11. Osunyomi, B. D., & Grobbelaar, S. S. (2014, July). Exploring the current and future role of ICTS in HIV/AIDS intervention programs in South Africa. In Proceedings of PICMET'14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration (pp. 3522-3538). IEEE.

12. Osunyomi, B. D. (2013, December). Potentials of Renewable Energy for the Sustainable expansion of Nigeria’s agricultural sector and Economic Growth of Nigeria. In Proceedings of NSE’13 Conference: Nigerian Society of Engineers 2013.