



KAUNAS UNIVERSITY OF TECHNOLOGY
SCHOOL OF ECONOMICS AND BUSINESS

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**USAGE OF INFORMATION TECHNOLOGY IN NEW PRODUCT
DEVELOPMENT PROCESS**

Final Master Thesis

Supervisor

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Technology Management (621N20032)

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Usage of Information Technology in New Product Development Process

DECLARATION OF ACADEMIC INTEGRITY

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Kaunas

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Summary

“Information technology” (IT) is used in this study to mean any computer, networking, storage, infrastructure, physical devices and software used to create, store, process, exchange and distribute any form of data. As there are advances in the capabilities of IT, companies and businesses involved in the creation of products leverage these capabilities to innovate and create new products. New product development (NPD) is a defined process of developing new products for the market and it is considered the primary step to developing a product. To keep up with the market, firms must continue to innovate and develop new products to meet their customers’ dynamic needs.

The Purpose of the thesis: To highlight Information Technology (IT) used in new product development (NPD) process. To meet the aims and objectives of this study, an empirical research by qualitative analysis, using semi-structured interview methodology was conducted with nine start-up product development leaders.

The Outcome of the thesis: A conceptual model for the use of IT in NPD was created based on scientific theoretical literatures and the NPD framework for defining the stages of the NPD process developed by Booz, et al (1982). These NPD stages include: New Product Strategy Development, Idea Generation, Screening and Evaluation, Business Analysis, Development, Testing and Commercialization. The study highlighted the importance of IT at each stage of the NPD process and the use of various groups of IT tools in the NPD process as a whole. The study revealed that dependence on IT in NPD increases along the NPD process and the complexity of the IT tools employed also increases, needing more expertise and knowledge to maximise their use. The conducted study further revealed that the development methodology adopted by firms in their NPD activities informed the choice of IT tools they employed in the NPD process.

The main limitation of this study is that only start-ups were used to conduct the research. This is a homogeneous group and at such, some findings for the use of IT in NPD within this group may slightly differ from the experiences of mature firms.

The thesis consists of seventy-seven (77) pages, excluding annexes. Five (5) tables and five (5) figures were used for illustration.

Santrauka

Šiame darbe "informacinės technologijos" (IT) apibrėžiamos kaip kompiuteris, informacijos tinklas, saugykla, infrastruktūra, fiziniai įrenginiai ir programinė įranga, naudojama kurti, saugoti, apdoroti, keisti ir platinti bet kokius duomenis. Kadangi IT nuolat vystosi ir jų panaudojimo galimybės plečiasi, įmonės nuolat naudoja IT priemones, kad galėtų diegti naujoves ir kurti naujus produktus. Naujų produktų kūrimas apibrėžiamas, kaip rinkai naujų produktų kūrimo procesas. Siekiant išlaikyti rinką ir patenkinti klientų dinamiškus poreikius, įmonės turi nuolat atnaujinti turimus ir kurti naujus produktus.

Darbo tikslas: atskleisti kokios informacinės technologijos yra naudojamos skirtinguose naujo produkto vystymo proceso etapuose.

Kad būtų pasiekti šio tyrimo tikslas ir uždaviniai buvo atliktas kokybinis tyrimas, naudojant pusiau struktūrizuotą interviu metodiką, apklausiant devynis su naujų produktų vystymu dirbančius vadovus.

Baigiamojo darbo rezultatai: Konceptinis IT naudojimo modelis naujo produkto vystymo procese buvo sudarytas remiantis mokslinės literatūros analize, akcentuojant Booz ir kt. (1982 m.) išskirtus naujo produkto vystymo proceso etapus, kurie įvardijami, kaip naujo produkto strategijos kūrimas, idėjų generavimas, atranka ir vertinimas, verslo analizė, kūrimas, testavimas ir komercializacija. Tyrimo metu atsiskleidė IT svarba kiekviename naujo produkto vystymo proceso etape ir įvairių IT priemonių grupių naudojimas šiame procese kaip visuma. Be to, remiantis tyrimo duomenimis, galime teigti, kad IT svarba didėja kiekvieno naujo produkto vystymo etape bei auga naudojamų IT priemonių sudėtingumas. Todėl reikia vis daugiau patirties ir žinių, kad būtų kuo labiau išnaudotos IT galimybės.

Pagrindinis šio tyrimo apribojimas yra tas, kad empirinis tyrimas buvo atliktas tikrai įmonėse „startuoliuose“. Tai homogeniška respondentų grupė, todėl tyrimo išvados negali būti naudojamos apibendrintai, o gautieji rezultatai gali skirti, jei tyrimas būtų atliktas brandžioje įmonėse.

Šį magistro baigiamąjį darbą sudaro septyniasdešimt septyni (77) puslapiai be priedų. Darbui iliustruoti pateiktos penkios (5) lentelės ir penki (5) paveikslai.

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INTRODUCTION

New Product Development (NPD) is simply the development of a new product. It is a process and activity that is an integral part of any organisation. Opportunities in business spring up daily and for every opportunity to develop a new product, there is also an opportunity to assemble a competent and proactive team and tools that can analyse and understand the scope of the NPD process. NPD requires tactical, strategic and technical skill and approach to manage the whole process. This is well pronounced in the marketing and financial risk that is inherent in NPD (Pons, 2008). Thus, cogent project planning and control are beneficial for managers to make decisions.

In NPD, it is a common practice to use various information technologies systems such as; email, document management systems, computer aided design etc. to manage different aspects of the NPD process such as communication. Firms always want to reduce cost and enhance quality by spending more money on information technology (IT) to improve the process of developing new products (Durmuşoğlu, Calantone and Sambamurthy, 2006). For a firm to compete in the 21st century global economy, they must have the ability to develop and deliver innovative products and services (Durmuşoğlu and Barczak, 2011). Consumers have always had an appetite for innovation and the demand for variety in products and services is on the increase than ever before (Nielsen Global New Product Innovation Report; NGNPD 2015). New products cannot be said to be successful until they meet the needs of these consumers and churn in profit for the firms. In recent years, we see an increase in the adoption of information technology (IT) to improve the outcome of NPD (Nambisan, 2003).

Previous studies have shown that information technology is effective for NPD. In fact, studies by Durmuşoğlu, et al. (2006) backs the assertion that more IT infrastructure enhances NPD in terms of the flexibility of the process even though it may amplify cost. However, there is still ambiguity as to how much is more IT and what exactly is the threshold before there is a need for more IT in the NPD process. It is important for managers to know what IT tools provide more value to their cause. The basis of the decisions taken by managers to develop new products is always on the capabilities, resources and the return on investment on the product (Petrick and Echols, 2003)

The fundamental problem of the thesis: What Information Technology (IT) is used at different stages of new product development (NPD) process?

The aim of this thesis is to highlight Information Technology used at different stages of new product development process.

Objectives of this thesis:

1. To highlight stages of NPD process with scientific literatures
2. To reveal IT implemented in NPD process from scientific literature reviews
3. To present a theoretical model of IT used in different stages of NPD process;
4. To make empirical study to highlight IT used in different stages of NPD process.

This study will serve as a basis for helping product developers, companies and managers that intend to develop new products understand the leverage, roles, process, models and factors of IT that can be tremendously effective for managing and implementing NPD.

Research method: Qualitative research method is used to gain insight on how NPD leaders make use of IT in the NPD process and to gain insight on their perspective of using IT at every stage of the NPD process. In addition, the results of the empirical findings were analysed using coding context analysis. Analysis methods in this study also include research through secondary sources such as scientific literatures, papers and journals and other theoretical resources from books and web pages.

1. IMPORTANCE OF INFORMATION TECHNOLOGY'S USAGE IN NPD PROCESS

NPD processes are activities carried out from the conceptual stage of a new product to when it is launched. It is a process that evolves. NPD is a project, and project management strategy may be employed all through the process. The NPD process may differ depending on the industry (Bhuiyan, 2011). In all its peculiarities to the industry of the product, the project still has to be managed effectively in order to achieve the project deliverables. Technology is an integral part of the NPD process, from decision making to conceptualization and prototyping of new products. Technology changes rapidly and this is expected to continue in an exponential style. However, NPD decisions that do not take into careful consideration the dynamics of technological evolution may result in unsustainable investments. Some firms may view new product options in the short-term as being profitable but a careful consideration will reveal the investment may lack long-term potential. Therefore, firms tend to reinvest in subsequent available technologies to remain viable.

NPD choices that consider the evolution in technology and long-term potentials can be said to be more meaningful to the firms' success in the future than relying on the short-term benefits based on economic indices only (Petrick and Echols, 2003). Computers are great at enumerating receivables but we tend to lose sight of all the promises and speculations over the past decades about the role of computers in management. Undoubtedly, there have been giant strides in basic information retrieval, processing and display technologies. Since the 1980s, it is common knowledge that the NPD process has evolved from conventional engineering teams working together in one place to virtual teams working together from different locations across the globe; this has been made possible by IT and further encouraged by the low prices of some of the IT based tools being deployed.

IT takes the lead in effecting changes in the structure of NPD process; In theory, NPD always begins with first identifying a problem and an idea to mitigate the problem but practically, it is not always a linear stop-by-step process starting from the initial problem to the solution in a clearly defined format (Nambisan, 2010), consequently, the development of IT-based tools to support the NPD process is far from being straightforward. For IT-based systems to enhance the decisions of managers and the work of NPD teams, they should be developed in response to the requirements of NPD teams. The success of NPD revolves around many decisions taken by NPD managers and the teams they work with. Some importance of IT in NPD as outlined by the studies of Ozer (2000), Carvalho and Marta (2001), Daim *et al*, (2009) and a host of others can be summarised into these major subheadings: *productivity, versatility, knowledge sharing, communication, speed, decision quality and product quality.*

Productivity

The development of new products requires efficiency and productivity from companies just like other business activities. To be better poised for competition in the market, a shorter NPD life cycle is highly desirable by NPD managers and teams because this will significantly have an influence on the returns of the company. Consequently, companies are forced to make financial and non-financial commitments towards the development of new products. Simple things such as file transfer between production units in a company can accelerate and improves the system of production. Some studies have presented that IT is not important in terms of productivity. However, most studies have concluded that increase in productivity may be attributed to the use IT in a business. Ozer (2000) asserts that IT can increase the productivity of a companies' new product development process through *eliminating redundancies* and *problem investigation*.

Eliminating Redundancies

Since NPD spans across different departments, and teams and requires collaborative efforts, sometimes with other teams and individuals across the globe, the tendency for roles to be duplicated is high.

Problem investigation

For instance, different kinds of softwares are being used at different phases of NPD, occasionally they malfunction during use but *problem log* which is a useful IT tool for tracking and coordinating problems may be used to get relevant data associated with the problem. This enables the software developers to track the causes of problems and solve them easily. Ozer (2000) gives an example of a software developer who used an electronic system to track software problems which enabled the company increase productivity from 30% - 50%.

Versatility

The process of NPD is multi-dimensional. At the early phases, the objective is to evaluate the viability and market analysis of the new product while the later phases are about actually developing, testing and commercializing it. Along these phases as the new products proceeds, the NPD teams and their modus operandi changes. There is need for versatility and flexibility to accommodate different needs such as in communication and organization (Ozer, 2000). Consequently, IT tools should be flexible enough to accommodate some of these variations. Some IT products could be tailored or customized for specific purposes and teams, this is some of the leverages IT offers. It is also important for companies to adopt strategies that are flexible.

Knowledge Sharing

Another important aspect of the NPD process is generation and sharing of knowledge with stakeholders involved in the process. Developing a new product gives the opportunity to accumulate knowledge, apply knowledge acquired from previous or other projects and make new findings throughout the project. Technology may not be the main component of knowledge management but it is almost impossible to implement knowledge sharing strategies without the use of IT and relevant technologies today (Carvalho and Marta, 2001). Companies can transfer knowledge from one team to another with the aid of IT knowledge management solutions. The capability for IT tools to be used in knowledge management also helps in documenting every step of the project in a timely and organized fashion, this will enable more efficiency in similar future projects for reference and information. For instance, “Real-Time Knowledge Systems” is an application that requires individuals or teams to input “cases” as a series of characteristic problems with solutions. When another user presents his problem to the application, its characteristics can be compared against a set of already inputted cases in the application and the closest match is chosen (Egbu and Botterill, 2002).

Communication

The need for communication among NPD teams arises from the multidisciplinary nature of teams working on product development projects. Keeping everyone informed and aligned with the strategic goals of a project can only happen when there is a free flow and exchange of information. (Messmer, 2005). While managers may not share all the details about a project and decisions, striving to keep team members updated on critical matters should be a priority (Messmer, 2005). Effective change of any process, operation or focus should be well articulated so that the whole organisation and team can prepare for it. The use IT tools is a very potent method to keep up with effective communication on NPD projects. The right style of communication can help decrease the time and money spent for development of a product. Effective communication among product developers will leave no room for ambiguity of any kind, eliminating fear and anxiety which ultimately paves more room for active project involvement.

Speed

To keep up with competition in a market place that is dynamic, firms and companies are always under pressure to introduce new products into the market before their competitors amass a large chunk of the market share. The implication of this is that new products becomes out-dated over a very short period of time, an example of this is in the mobile phone industry, Apple Inc. released four iPhone models (iPhone 7s, iPhone 8, iPhone 8plus and iPhone X) between September 2016 and September

2017. This means that for mobile phone companies to compete at the highest level in the industry, they need to develop new products faster. Stalk (1998) asserts that a company that can churn out new products thrice as fast as its competitors will have a huge advantage. Empirical studies have proved that fast development of new products give rise to greater competitive advantage and profitability (Stalk, 1998). There is also a need for companies not to compromise with the quality of their product in the bid to accelerate product development.

Decision Quality

NPD is influenced by adopting a well-defined process of development with metrics that are linked to the goals of the company for decision making (Daim *et al*, 2009). The decision taken throughout the NPD process impacts on its overall outcome and result. At the idea phase, decisions are made on the choice and evaluation of new product ideas, while at the concluding phases, decisions about market positioning and strategies are taken. Many things should be decided, such as choice of technology to be used, who will be involved in the development of the new product and timeline for implementation. Empirical evidence from research has revealed that decisions can be prone to error due to bias (Ozer, 2000). For instance, team decisions can be highly influenced by individuals on the team who are more outspoken and stern on their views and ideas which may not necessarily be the best-informed opinion. There are many IT and project selection methods that can assist the decision-making process, these tools can help decisions to be made faster and more efficiently. IT can also be used to provide anonymous group discussions platforms which can help reduce bias in the decision-making process (Ozer, 2000).

Product/Service Quality

Studies have shown that delivering differentiated product with exclusive benefits for the customer results in successful new product and leads to a high market share and profitability (Ozer, 2000). There is a need for companies to place more emphasises on superior product throughout the NPD process so that achieving product superiority becomes a common goal in the NPD team. For instance, Globacom; a telecommunication giant in Nigeria uses a communication network to get feedback from customers about the service they provide. The network allows them to rapidly get information from the market which it incorporates with the opinion of its customers into the new product/service. Consequently, they develop and offer better services. From the research carried out by Durmuşoğlu, et al. (2006), low IT was associated with low new product quality and high IT was associated with higher new product quality. In addition, Armstrong and Sambamurthy (1999) asserts that there might not be significant results showing the effect of IT on new product quality because

some companies may not be capable of assimilating the IT they need. Not all companies are able to apply IT with equal effectiveness, hence application of the same IT tool in NPD process by different companies might give different results.

The marketplace in the 21st century is being saturated with new products on almost a daily basis, and these products are increasingly developed with much more technological and innovative improvement. This has brought about value creation not just to the consumers of these products but to the organisations and stakeholders that have deployed a lot of resources to add more value to their products. However, a problem is that NPD is risky, this is well pronounced in the alarming failure rates and the huge amount of required venture capital (Monsef and Wan Ismail, 2012). We see more industries being driven by technological innovation. Organisations and companies that allocate more resources for research and development into the improvement of their existing products and NPD process through technology in all its forms are the front runners of their industries and market.

The needs of consumers and the entire market place are changing, so are the needs and objectives of the managers, stakeholders and organizations. As the lines between technology, engineering and business are almost non-existent; researchers, academics and industry practitioners across a wide variety of disciplines are beginning to take more interest in the dynamics of NPD and how much role their areas of discipline has impacted the NPD evolution process. In the field of management for instance, research issues are increasingly becoming interdisciplinary and such links across disciplines are becoming more relevant and significant than the fields themselves. (Nambisan, 2003). According to resource based perspectives, a firm's resources include IT. Some IT literatures as referenced by Marion, Barczak and Hultink (2014) argue that technical platforms, physical IT assets, databases and architectures all count as assets. From the firm's perspective, these technology assets are believed to be highly valuable to them, helping them create competitive advantage. From the knowledge-based perspectives, knowledge is a resource firms can apply to develop new product and guide managerial decisions (Marioan *et al*, 2014), but extant research doesn't say much on the contribution of IT-based systems or tools to the managerial decisions in the NPD process compared to the comprehensive studies on why the use of various IT tools in NPD increase performance.

Before the third industrial revolution, conceptual models had been fashioned for product developments, the application of information technology to automate production which characterised the third industrial revolution fast tracked and improved those NPD conceptual models. Managing the process of new product development in an era of digitalisation and synthesis of different technologies requires an assessment or if you like, an in-depth analysis of the major fields such as IT that have an impact on the process, for a broader understanding of the process and in turn meet the organisational, market, consumer demand and standards of this new paradigm. Daim, *et al* (2009) takes this further by suggesting that it is important for high-tech companies or organizations that depend on technology to

link technological development with product development processes for their organizational growth and competitive advantage. On the flip side, selecting the appropriate technologies to introduce or use in the NPD processes is challenging, this is partly because the complexity and the number of technologies are increasing. Limited financial resources can also add to this challenge by cutting down a company's technological choices.

New technology selection are germane strategic planning issues, however, the demand for technology evaluation is also on the increase and objective factors such as; profit, revenue, cost and time of completion, alongside subjective factors such as capacity increment, learning and flexibility should be carefully considered in the evaluation of would-be selected technologies. This further shed light on the fact that these challenges take a multiple-criteria decision-making form (He-Yau, Amy, Chao-ChenG and Mei-Sung, 2012). According to Sanayei (2016), evaluating emerging technologies enables businesses to either maintain a technology growth curve or replace the technology that exists in order to be ahead of the competition, retaining a desirable market share. Literatures that deal with technology development have revealed that in some companies, they develop technology from their own research labs (Daim, *et al*, 2009). Notwithstanding, companies still have access to external sources of technologies such as market research, individual engineers, competitors, universities, etc. which can influence their technological choices for NPD. For companies to utilize and maximise their competitive edge, they should invest in the right technology alternatives and be careful not to make too much investment in these right technology alternatives, there has to be a balance.

There are several IT and project selection methods that can be used to aid decision making processes in NPD. These selection methods could be classified under three broad categories; Economic, Strategic and Analytic (Daim, *et al*, 2009). Apart from the challenge in the selection of technologies to be used in the NPD process, there can potentially be a false sense of security after the "best" or "appropriate" technology has been selected. Marion, Fixson and Meyer (2012) in their study on problems with digital design suggests there's a tendency for managers to move on to the next stage in the NPD process before the NPD teams fully understand the technology being deployed, learn the user needs the new product seeks to address and construct alternative solutions to meet those needs. The false sense of security of the selected technologies by these managers can be attributed to this. In their study, Marion *et al* (2012) further suggest that for instance, the ease by which designs can easily be drafted and prototyped using digital design technologies afford product engineers the opportunities to reiterate the process longer than it is useful. Even in the use of virtual prototyping tools, NPD designers may find themselves tinkering around a design for long, rather than go back to primary sketching or foam models before perfecting virtual designs prototypes on the. Therefore, choosing the right technology to use shouldn't be a form of "security" such that it erodes the importance of other variables (i.e. time, the NPD team, etc.) to be considered for a valuable product outcome.

2. THEORETICAL SOLUTIONS OF INFORMATION TECHNOLOGY (IT) USAGE IN NPD PROCESS

2.1. Understanding the NPD Process

The market is being saturated with new products and not just ordinary new products but new products with a twist of innovation. Every organization today that has products in the market are seeking ways to introduce new products to capture and strategically lead the market. The number of new product is exponentially on the increase and there is a challenge of managing the NPD process by firms' due to the time sensitivity of NPD and the human and financial resources needed for optimum results (Nadia, 2011). NPD is arguably one of the riskiest and complicated task that can be embarked upon by most companies and organizations. The disturbing reality is that a large junk or major number of new products never cross over to the market and those that make it to the market have a failure rate of about 25 to 45 per cent (Nadia, 2011). It is no surprise that even well-established organizations have sometimes failed in product development under an ever-changing technological environment as we see it today (Daim *et al*, 2009). Identifying the factors that contribute to the success or failure of NPD continues to be a concern to managers, not just because a successful new product is a source of improved financial performance but because this may point to business and product development opportunities that were hitherto undiscovered.

To further understand the concept behind NPD, the following subheadings will give a background on what product and “newness” means in the context of this study.

Product

A precise definition of a product is anything that is tangible. This is the reverse of services which are intangible (Prabhakar, Marvin and Trond, 2008). The gap between product and service is decreasing in that the general more acceptable definition of product is the combination of the tangible and intangible.

By the definition of the international organization for standardization and a note about this definition quoted below (ISO 9000:2015):

“A product is a tangible or intangible output that is the result of a process that does not include activities that are performed at the interface between the supplier (provider) and the customer. Products can be tangible or intangible. ...there are three generic product categories: hardware, processed materials, and software. Many products combine several of these categories. For example, an automobile (a product) combines hardware (e.g. tires), software (e.g. engine control algorithms), and processed materials (e.g. lubricants)”.

There are many reasons consumers buy products, it could be for household use including products like clothes, kitchen utensils, food items, cosmetics, household furniture's. Consumers also buy products for industrial and commercial use, they include products such as computers, telephones, vehicles, machines, assembly robots, machine components, software programmes and so on.

“Newness” or Novelty

Regularly, new products replace existing products. Classification of new products based on the degree of their newness has a long history (Hans and Ellen, 2008). According to Prabhakar *et al* (2008), there are many reasons why there is an increase of new products in the market which include one or more of the following:

- For differential advantage (product differentiation)
- To support continuous growth for the manufacturer
- To capitalize on breakthroughs technologically
- In response to the ever-changing demographics
- In response to the change in taste of the consumer

There are different opinions on of what a new product is. The “newness” of a product vary depending on whose perspective and what exactly is new. Prabhakar *et al* (2008) outlines the following perspectives of the “newness” of a product:

- New to the world
- New to the industry (could be first application in an industry of a product, sometimes it may have been established in some other industry)
- New to the manufacturing firm
- New to the market
- New to the customer
 - The perspectives in terms of *what* is new are:
 - New Technology
 - New process
 - New features
 - New uses
 - New design

The degree of newness differentiates the new product from the existing one. The changes in the degree of newness varies from the incremental to radical. The newness from the perspective of the customer mainly deals with improvements in the characteristics or attributes of the product.

NPD objectives by Firms.

Research by various scholars have outlined several objectives for NPD by firms and organizations. These NPD objectives are described briefly:

- Develop radically innovative products: From the premise that stems from Schumpeterian rents, continuous or radical innovations and new products brings about a paradigm shift and changes the market structure in the technological cycle of industries (Aniruddha, 2013).
- Rather than competing directly with market leaders in an industry, some firms choose to gain a market share by developing new products that is focused on a specific niche segment, especially when there is low competition and higher rents in this niche segment.
- Improved product quality: Increased use of technology and new production techniques has increased the demand for product with higher quality. For firms to remain relevant and still be competing, they have to churn out not just new products but new products that improves on the quality of the old product (Durmuşoğlu, *et al*, 2006).
- For some firms, to maintain or increase their market share they develop new products. They continuously strive to increase their market share by performing a combination of process, product and business model innovations. The combination of innovations in these areas (process, product and business model) helps these firms to capture market share with unique, cost-efficient, differentiated products (Ozer, 2000).
- Reduce reliance on imported technology and improve existing technology: For techno-centric firms that have depended on external licenced technologies from various sources, their drive is based on the need to develop in-house technological new products that meets their capabilities so that they can unwean themselves from depending on technologies that are external (Jones *et al*, 2001).
- To explore new markets: Many firms continue to innovate and produce new products in other to explore new domestic markets while some others focus on exploring new international markets especially when they have been confined to domestic markets overtime. They do this by delving into emerging markets and economies to increase their sale. They have to customise their products to suit the needs and meet the requirements of the new international or domestic markets (Dargha, 2013).
- Replacement for products being phased out. Sometimes there's a shift in the industry or new technological wave and products become obsolete. Therefore, firms innovate and push new products to replace those being phased out or provide improved substitutes to replace them. i.e. As there was advances in music storage capabilities, companies that produced Walkman Portable Music Players switched to producing MP3 players with more storage capacity. A firm can achieve competitive advantage by replacing phased out products.

Review of NPD Models

There are several NPD models proposed for better understanding and implementation of product development process. NPD begins with an idea to create a product or create new requirements for a radical innovative product, this idea could be defined by the customer and/or the manufacturer. The NPD process ends when the product is introduced into the market. The NPD process is in phases and the phases vary depending on the model. The differences in the number of phases in NPD models and the nomenclature used, including the interpretation given to each phase can be explained in the context of the product type, degree of innovation, complexity of product, process of production, type and number of original equipment manufacturers, technology used, resources available, time and constraints of budget (Prabhakar *et al*, 2008).

Research on NPD models has significantly focused on developments which encourages an approach that is structured. A lot of these approach is linked with stage gate thinking, this suggests that some specific criteria must be met before the development process can move to the next phase (Simms and Trott, 2014). As cited by Prabhakar *et al* (2008), a variety of NPD models have been put forward by various researchers i.e. Model 1 by Roozenburg and Eekels, (1995), model 3 by Fox (1993), model 4 by Pahl and Beitz (1996), model 5 by Cooper (2005), model 6 by Blanchard (2004), model 7 by Pugh (1990) and model 8 by Andreasen and Hein (1987).

The table 1 gives a brief phase summary of NPD models that has been highlighted from several works on NPD.

Table 1: Different phases for illustrating samples of NPD models. Source: (Prabhakar, Marvin and Trond, 2008)

Model	Phases
Model 1	Analysis → Concept → Materialization
Model 2	Concept and definition → Design and development → Manufacturing and installation
Model 3	Pre-concept → Concept → Design → Demonstration → Production
Model 4	Clarification of task → Conceptual design → Embodiment design → Detail design
Model 5	Scoping → Build business case → Development → Testing and validation → Launch
Model 6	Conceptual design → Preliminary system design → Detailed design and development → Construction → Production
Model 7	Market → Specification → Concept design → Detail design → Manufacture
Model 8	Recognition of need → Investigation of need → Product principle → Product design → Product preparation → Execution

2.2. NPD Stages

NPD begins with the identification of an opportunity in the market to explore and ends with the acceptability of the product by the consumer or end user. This process is continuous in stages going between the idea phase to the value in-use by the consumer and back to the idea phase. (Yenicioglu, 2015). Many researchers have put in much work and effort towards developing NPD models that captures stages of the NPD process (Bhuiyan, 2011). One of the frameworks or model for managing the activities of developing new products was developed by Booz, Allen and Hamilton (1982) as illustrated in **Error! Reference source not found.** below. NPD process was divided into seven sequential stages namely; *New Product Strategy Development, Idea Generation, Screening and Evaluation, Business Analysis, Development, Testing, Commercialization.*

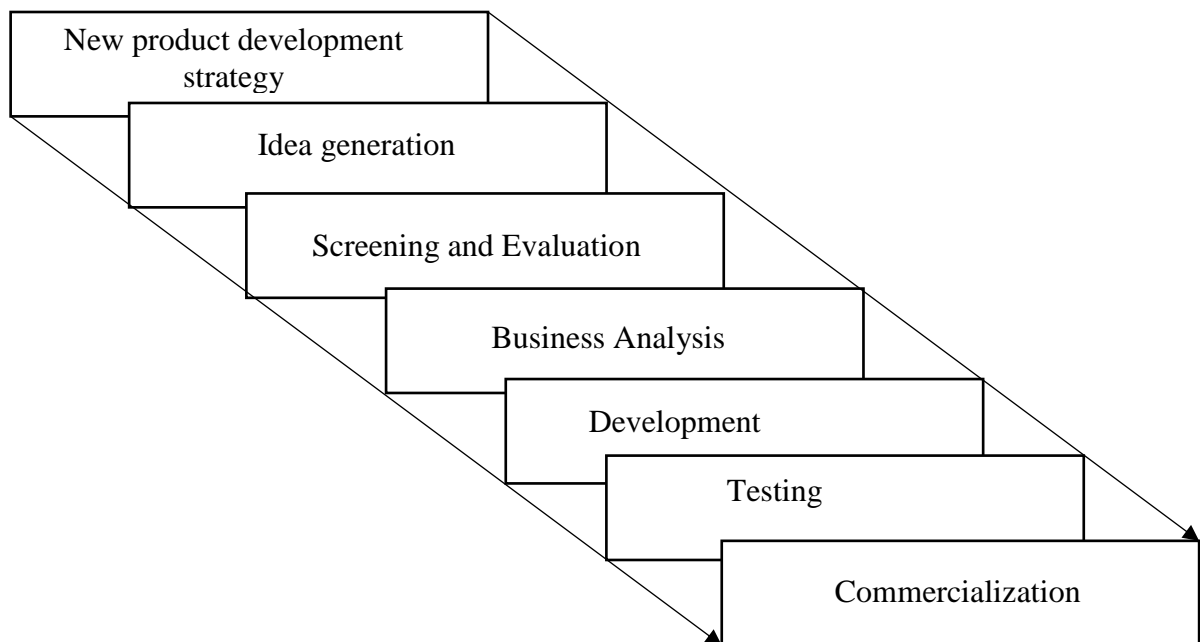


Figure 1: Stages of NPD process. Source: (Booz, Allen and Hamilton, 1982)

Stage 1: New Product Strategy Development

According to Booz *et al* (1982), the NPD process begins with putting in place strategies for the new product. Managers and executives define the base and structure for the NPD process by reviewing the missions and goals of the organisation and understanding the role the new product will play. All great products begin with a clear strategy that is customer driven and/or market driven. It ensures you work on what matters and that you can communicate what matters to the NPD working team.

Stage 2: Idea Generation

This is a stage where new product opportunities in the market are identified and new ideas are generated to meet the need of the customer (Hauser and Dahan, 2007). Hauser and Dahan (2007) identifies employees and suppliers as a source of new ideas. Feedback from the suppliers and those who are closer to the final consumer in the supply chain can be a foundation on which new ideas are created. The research and development team can play an important role in idea generation and ideas could be generated from research results, especially when the results meet a specific new or existing need which would eventually solve a problem (Zaharis, Kourtesis, Bibikas, and Inzesiloglou, 2011). Zaharis *et al* (2011) places more emphasis on team effort and managing of ideas in this stage. The idea gathering process should be devoid of criticism of team member's ideas because the goal is to generate as many ideas as possible. Booz *et al* (1982) views idea generation through the perspective of goals, missions and objectives of the organisation.

Stage 3: Screening and Evaluation

This is the in-depth analysis of the ideas gathered in the previous stage in determination of which ideas should be investigated further (Booz *et al* 1982). The ideas gathered in the previous stage is screened and downsized to product concepts that have the best market potentials. For evaluation, a survey approach may be used with sample respondents, which in this case could be consumers presented with a sizeable number of potent product concepts to satisfy customers' needs and asked to evaluate them (Hauser and Dahan, 2007). Only ideas that have the potential to succeed in the market proceeds to the next stage for further development.

Stage 4: Business Analysis

This is where investigations and all the questions that deals with the business aspect of developing the product concept further is being asked. Such questions include; availability of funds to implement and backup the project, investigation into how much returns the product can yield if or when implemented, what it will cost to get this product to the final consumer and methods of promotion (Booz *et al* 1982). Investigations into the barriers of entry into the market is carried out, definition and recognition of target and potential target markets is identified. Also, the market share the product can hold and potential market/industry competitors are thoroughly examined (Zaharis *et al*, 2011). Preliminary recommendations are formulated with outcomes and results of the business analysis. These results from this stage act as stage gate for making decisions to move forward with development of the product.

Stage 5: Development

Having taken inputs from the consumers, all stakeholders and having analysed requirements with features for the product, the ideas on paper are translated into tangible substance. For products, it's the physical assembly of resources and procedures to form the product, for service it is the assembly of all components required to deliver the service (Booz *et al* 1982). According to Booz *et al* (1982) it's pertinent to appreciate that the product may not necessarily come out as the on-paper idea, there may be necessary alterations during development. This is very typical with this stage and even further.

Stage 6: Testing

This stage seeks to validate the projections with the tangible product through testing in various forms depending on the kind of product. Trials are conducted to determine suitability in market, conformity with industry standards and customer satisfaction (Booz *et al* 1982). The feedback gathered from this stage provides more insight and information into what the product truly offers, what its limitations are and the degree of acceptability in the market.

Zaharis *et al* (2011) makes a case for a well-defined testing strategy and plan which details how, when and where it will be tested including what conditions it will be tested in. Tests also include risk assessment. Zaharis *et al* (2011) further recommends that results should be evaluated against the pass/fail criteria.

Stage 7: Commercialization

This is the full introduction of newly developed product into the market, continuous customer feedback is ideal to monitor if the product meets or exceeds customer expectation (Booz *et al* 1982). It is also imperative to monitor competitor's reaction to the introduction of the new product in the market in order to take counter measures to competitor's response.

2.3. Grouping of Information Technology (IT) tools used in NPD

Research suggest that IT tools are viable instruments for connecting a company to its customers, IT tools are seen as a platform to build a relationship between company and users of their products/service (Jespersen and Buck, 2009) and the rise in self-service technologies backs this assertion. A way of building relationship with customers and motivate them to collaborate in the development of new product is by using virtual environments. IT tools shorten the distance between the users of developed products and the company, consequently increasing the user engagement in the development of the new product. Companies can provide a range of online services to the customer that facilitates the involvement of the user in NPD by combining various new technologies. (Nambisan, 2002).

IT tools can be used to assist managers to monitor and control the NPD activities. Durmuşoğlu *et al* (2006) carried out a research using eight items to measure the frequency of IT tools used in the activities of NPD. The items used are the most popular group of IT tools used in NPD activities, they are; *NPD process management tools, communication technologies, collaborative project management tools, financial analysis software, virtual prototyping tools and marketing tools.*

NPD Process Management Tools

There are firms that have adopted structured NPD management process models to establish stability in their NPD activities (Nambisan, 2003). The overall process metrics and structures to manage the different stages of NPD are provided by these models. Other than general and customised process models and standards in the industry, there are many proprietary process models. NPD process management tools are organised systems that manage the process or workflow of NPD activities. IT tools that support management process may prescribe a comprehensive and holistic process model or make it possible for firms to adopt flexible process frameworks to tailor their own unique process model (Elliot, Gill and Nelson, 2001). According to García, Vizcaíno, and Ebert, (2011), NPD process management tools support NPD teams in three ways; *Modelling*; defines a consistent process model about how the work should be done, reducing ambiguity because a process that is well defined and documented must be followed consistently. *Collaboration*; sharing information among different NPD teams, to avoid inconsistencies and contrasting versions of information. *Automation*; provides the capability to automate process by means of workflows to further increase engineering and productivity development. Examples of known NPD process management tools are *Agile Program, Sopheon Accolade* and *Aanza*. IT process management tools could also go on to support cross enterprise process specification and management, integrating processes such as supply chain and organizational processes.

Communication Technologies

In NPD process, communication plays an important role in the idea generation stage which demands a high level of creativity and innovation, different policies that support open communication are employed to allow the free flow of ideas and information among the NPD teams and departments (Kanter, 2000). Communication technologies are IT tools that help, boost and broaden the interaction and communication among teams during NPD activities (Durmuşoğlu and Barczak, 2011). Based on research in this area, email and web meeting technologies are the most frequently used IT tools for communication among product development teams because there could be frequent communication at a reduced cost, consequently aiding information sharing. NPD teams use IT tools in communication all through the stages of NPD and it is expected these tools have an impact on every stage of the NPD

process. Some IT tools for communication are e-mail, instant messaging, listserv, videoconferencing, teleconferencing, website and extranet (Cameron, 2006).

Collaborative project management tools

These are sets of tools necessary to make collaboration in NPD process a reality, also having a view of how things are in the project, mirroring the overall performance metrics of the project in real time. These tools are for task scheduling, resource management and task coordination. Project management models that are sophisticated enable firms to manage project portfolios and cross-project resource management that is based on real time project data (Nambisan, 2003). These tools also have capabilities to provide workflow management for coordinating activities on task groups in real time. They could be web based or cloud based collaborative software's, a self-service tool that provides the ability to create a browser-accessible workshop for supporting a project, facilitating online visibility of project data, resource monitoring, control and automated task. Emerging IT-based project management systems for NPD are not only designed for the provision of a virtual command centre through a common interface with access to all the project information but they also integrate project management with process management of the firm. Examples of known project hosting tools are IBM Connections Content Manager, WebGroups, 1Workrout and eRoom, ProjExec, eProject, TeamPlay Paradigm, CommonOffice.com and MS Project Central.

Financial Analysis Software

Financing is a huge part of NPD. No activity geared towards developing a product can take place without a well thought out plan and strategy about the financial implications of implementing the new product idea. There are various techniques that can be used to analyse financial involvements in NPD process. The financial analysis tools integrate all these techniques into an application and can be used to evaluate and help in the computation and interpretation of financial data in any form that's required. Several financial software packages have financial simulation and projection capabilities. They help reduce the difficulties of tracing investments, financing and operational assumptions through the financial framework of the business (Helfert, 2001). Commercial software's that are not tailored to a firm's specific need or NPD process are built around basic concepts of business financial analysis. IT tools or software's developed for financial modelling expands the ability of NPD financial experts to examine the consequences of different NPD financial assumptions, plans and conditions. The financial modelling software's in the markets evolve constantly and NPD financial players should be conversant with the offerings and packages in relation to the NPD context. They range from very basic spread sheets templates to make basic business calculations to highly customised sophisticated tools that can

be tweaked to meet the firm's business and NPD needs. Example of financial analysis IT tools used in NPD are Sopheon Instatrack, Ready Ratios and Capterra.

Virtual Prototyping tools

Virtual prototyping is the early integration of the entire life cycle requirements, evaluation of the product behaviour and resulting early prediction by simple visualization to more complex application features to prototype products or idea (Rix, Haas and Teixeira, 1995). We are way beyond the era when products were first developed before introducing them to the market or potential customers. Advances in IT have made it possible for ideas to be prototyped virtually. Virtual prototyping tools are used for redesigning concurrent engineering strategies that exist towards interaction between people, tools and the product data, thus overcoming limitations of existing NPD tools and environment where parallel NPD technologies are unaware of each other and are independent. These IT tools are used in NPD to validate designs before executing such designs into a physical prototype. This involves using computer-aided engineering (CAE), computer-aided design (CAD) and computer-automated design (CAutoD). Examples of some of these tools are Autodesk inventor and Optitex.

Marketing tools

These are IT tools for NPD that facilitate promotional strategies so that companies can promote their products with more ease. To be ahead or at least at par with competitors, most companies' make extensive use of some of these tools. For a more effective marketing policy of a firm, some web marketing resources use these tools or systems for sale and advertisement i.e. create Internet shops, run statistics of visits, etc. (Medvedeva, 2008). E-commerce is a major player in the trade industry today and a sound online community for the sales of good and services has been established. Using key internet metrics, internet resources i.e. open systems for e-commerce, can be integrated with these marketing tools of a firm for their business and NPD. They provide valuable data, monitoring the firm's webpage traffic and can be integrated for marketing on various social media platforms. Examples of some of these tools are DemanMore, TagTeam, NuEdge Suite, Triggers and Marketing Materials Management.

Powerful group of IT tools to make NPD activities efficient and effective already exist. Notwithstanding, to deploy these IT resources, NPD managers have to carefully consider the complex interplay of these tools in the NPD context (Nambisan, 2003). It is imperative for firms and project managers to understand how IT shapes and is influenced by NPD processes and their outcomes, relational and social ties within NPD teams, political agendas and cultural systems.

Table 2: NPD stages and IT roles

NPD Stages	Brief Description	The role of Information Technology
New Product Development Strategy	Here, firms do an assessment of their strengths and the strength of their existing products. They do a comparison with the products of their competitors and reach a conclusion about what and how much new products to produce. At this stage also, goals, objectives and boundaries are set for the new product activities, including the target business area and specifics of the innovation involved to reach the set-out goals and objectives.	<ul style="list-style-type: none"> -Information technology can help firms collect, classify analyse and use the information they need for product line planning. -Also, helping firms make important decisions -Can help firms have a better understanding of their market for effective targeting -Can help for a more effective strategy implementation. -Can also help formulate strategies for new products faster.
Idea generation	At this stage, firms generate possible range of new product ideas for consideration. Not all ideas generated will survive the new product development process, therefore a wide variety of ideas have to be generated so that the best may survive. These ideas are generated from different sources.	<ul style="list-style-type: none"> -Can help generate a wide variety of product ideas -Some information technology based tools linked to the internet can enable firms generate ideas from different sources.
Screening and Evaluation	When generation of a wide variety of ideas is concluded, these ideas have to be screened and ideas that are suitable for further development are chosen. This activity is an objective flexible and comprehensive assessment of the new product ideas.	<ul style="list-style-type: none"> -Information technology enhances the screening and evaluation process in a comprehensive manner. -It improves the screening and evaluation process flexibility. -It makes it easier to detect drawbacks of the ideas.

Table 2: NPD stages and IT roles (cont.)

NPD Stages	Brief Description	The role of Information Technology
Business Analysis	At this stage, there is a study that is comprehensive in order to build a business around the new product idea.	-It can help fast track the building of a case for new product ideas.
Development	At this stage, the new product ideas are translated into actual products. This may begin with virtual prototyping or rapid prototyping. The firms manufacture this product effectively and efficiently. At this stage also, manufacturing processes are deployed. A firm that cannot manufacture their products cannot go beyond this stage.	<ul style="list-style-type: none"> -It can enhance production of fine cutting-edge products -Can help in developing good prototypes. -Information technology can improve the efficiency of the manufacturing process, as well as improve the quality of manufacturing. -Can also improve the operational performance of the manufacturing activities.
Testing	At this level, the new products are tested to ascertain if they meet the requirements and specifications as planned, as well as if they function properly. At this stage also, it is tested to determine if the products meet customer's specification and requirements, this is done before mass production.	<ul style="list-style-type: none"> -Can help speed up the testing process -Can enhance the testing and validation quality -Can decrease testing and validation cost to a large extent.
Commercialization	At this stage, commercial activities including marketing, post-launch plans of the new product are carried out.	-IT based tools linked with the internet can help marketing and help the efficiency of the product commercialization

2.4. The link between Information Technology (IT) and NPD

A simple definition of IT is computer hardware, software for storing, retrieving, sending information and communication. In the context of a business or organisation, Ozer (2000) include personnel and resources allocated to support the capabilities of IT in its definition. Beginning from the third industrial revolution, IT was being used to automate production. Its capabilities and possibilities has been and is still expanding. In a typical organizational setting today, IT plays a very important role in the operation of businesses on a daily basis, from communication within cross regional and cross departmental teams, to storing, retrieving of information and vital data. To better appreciate the contribution of IT to NPD, it is imperative to understand the evolution of the NPD field also (Nambisan, 2003). Multiple disciplines have made contributions to NPD research and because of its changing nature, it has brought into focus different disciplines at different times. The roots of NPD research field can be traced to engineering management and R&D literatures of the 1960s to 1970s (Nambisan, 2003). NPD life cycle spans across different knowledge areas and disciplines and IT helps to facilitate all the activities associated with it.

Firms and organizations who continuously seek new ways to have a competitive advantage in the industry and in their markets many a times turn to developing new products, thus the process will always involve high performance routine from the first phase to the final phase (Aleixo and Tenera, 2009) and the success is hinged on managing IT and NPD processes appropriately (Daim, Sener and Galluzzo, 2009). As the role IT played in NPD increased, there was emphasis on organizational processes and elements (including team building and structure, recognition and award systems, leadership conflict management, team culture, communication and group decision-making) in NPD. Therefore, organizational theories, which stem from research of IT and NPD became relevant. There are many theories used in IT research but not all theories are about technology adoption (Oliveira and Martins, 2011). The field of IT has not just borrowed models and theories from other disciplines for NPD but has further adapted them to better suit IT-embedded phenomena. Consequently, this has built a good number of adapted models, theories and concepts. According to Oliveira and Martins (2011) the theories that are used most are the technology acceptance model (TAM) (Davis, 1989), theory of planned behaviour (TPB) (Taylor and Todd, 1995), unified theory of acceptance and use technology (UTAUT) (Venkatesh *et al*, 2003), diffusion of innovations (DOI) (Rogers, 1995) and technology, organization and environment framework (TOE) (Tornatzky and Fleischer, 1990). The DOI and TOE theories are at the firm level (Oliveira and Martins, 2011) and can be adopted for NPD while the rest are at the individual level.

Diffusion of Innovations (DOI)

DOI is a theory about the rate at which new ideas spread and its adoption into the operations at the firm or company. This theory also seeks to explain how the channels of communication and opinion leaders shape its adoption. According to Rogers (1995) this theory sees innovation as being communicated over time through certain channels within a particular social system. According to research, individuals and companies vary in their willingness to adopt innovations, meaning that there is a portion of population that innovation is normally distributed over time (Rogers, 1995). Rogers (1995) went ahead to segment these adopters into five categories: *Innovators*, *early adopters*, *early majority*, *late majority*, and *laggards*.

Innovators: They are the first set of individuals or companies that adopt innovation, they are more than willing to take risk, they have good financial liquidity and most times are in close contact with scientific sources of innovative and NPD idea.

Early adopters: The second group of individuals or companies to adopt an innovation. They usually have good financial liquidity and are more discrete in their adoption choice in order to benefit maximally if it succeeds and hold position of opinion leadership.

Early majority: They adopt innovation after innovators and early adopters, they are slower in their adoption process and extensively study what previous adopters have birthed with their adoption.

Late majority: Those in this category will adopt innovation after average number of industry members does. They approach innovation with a very high degree of scepticism.

Laggards: They are the last to adopt innovation as they are usually focused on “doing it the old way”.

Innovation and NPD in a company or organization is complex, it involves those who are for and against the new idea when it is introduced and they all play a role in innovation and new product idea decisions. Based on the DOI theory (Rogers 1995), NPD is related to independent variables such as individual (managers and team leaders), characteristics of the internal organizational structure and external characteristics of the organization. Individual characteristics refer to the attitude of the leader towards change. Characteristics of the internal organizational structure refers to centralization (the degree of power wielded by few individuals in the firm), complexity (the extent to which NPD team members possess a comparatively high level knowledge and expertise), formalization (the extent to which NPD team members adhere to procedures and rules), interconnectedness (the extent to which various units and departments associated with product development communicate and interact), organizational slack (the extent or level of uncommitted resources at their disposal) and size(number of NPD team members). An external characteristic of the organization refers to how open the system could be.

Since the application of DOI to IT research, it has been applied, adopted and adapted in different ways. This model can be used to identifying marketing materials for different groups when launching new products. It is mostly used in the commercialization phase of NPD.

The table below show some examples of the adoption of DOI IT model that facilitates NPD.

Table 3: Adoption of DOI theory (Rogers, 1995) that facilitates NPD. Adapted from (Oliveira and Martins, 2011)

IT Adoption
Material requirements planning (MRP)
IS adoption (uses at least one major software application: accounting; inventory control; sales; purchasing; personnel and payroll; CAD/CAM; EDI; MRP), and extent of IS (number of personal computers and the number of software applications)
Intranet
Web site
Enterprise resource planning (ERP)
E-procurement
E-business

Technology, Organization and Environment framework (TOE)

The TOE framework identifies three areas of an enterprise context that has an influence on the process of its adoption and implementation of technological innovations (Tornatzky and Fleischer, 1990). These are technological context, organizational context and environmental context. Technological context refers to the internal and external technologies relevant to the firm. These technologies influence the approach of firms towards NPD. These include current technologies, equipment, and practices internal to the company as well as available technologies external to them. Organizational context describes the firm’s organization in terms of scope, managerial structure and size. Environmental context refers to the environment where the firm conducts its activities, the industry, market, competitors and relationship with policy makers or the government (Tornatzky and Fleischer, 1990).

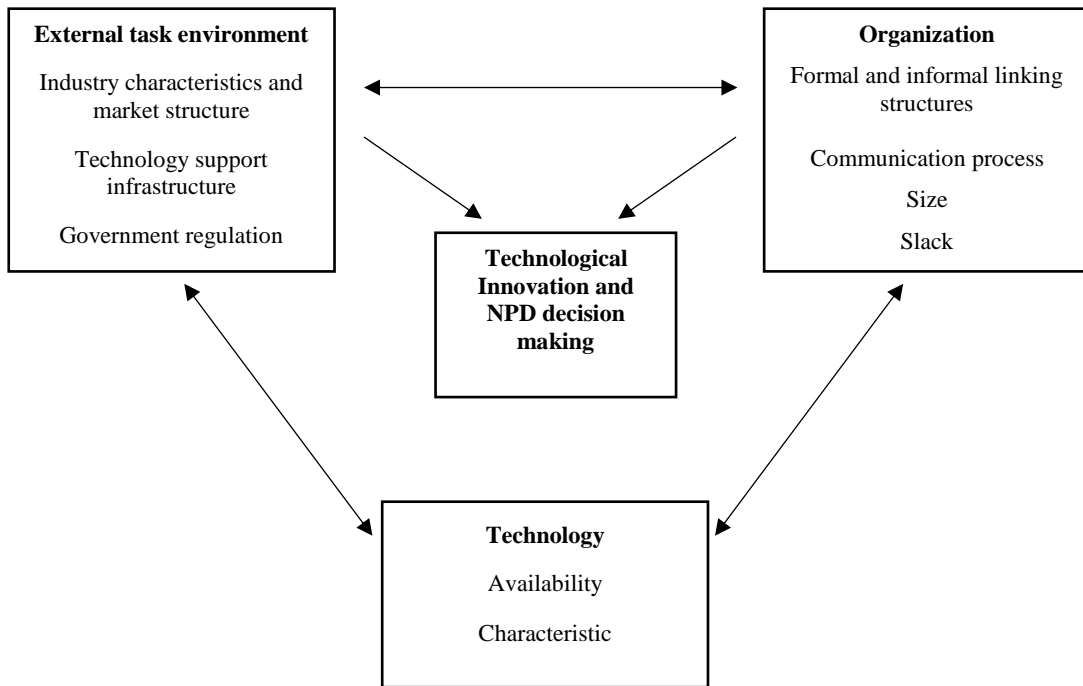


Figure 2: Technology, organization and environment framework. Adapted from (Tornatzky and Fleischer, 1990)

This framework aligns with DOI theory where Rogers (1995) placed emphasis on individual characteristics and both the internal and external characteristics of the organization as drivers for organizational innovativeness and NPD. TOE infuses a vital important component, which is the environmental context. It presents both limitations and opportunities for innovation in the technological context and the use of IT to drive product development.

Other theories such as sociotechnical theory that is general in nature and can apply to any work system has been applied successfully to IT-based information systems that can also be used for NPD (Piccoli, 2012). In specifics, any formal organizational information systems can be represented as having four components which are fundamental and must work together to deliver information processing functionalities required by the organization to meet its information needs. These components are *IT, people, process and structure*. They can be grouped into two subsystems as *technical subsystem* and *social subsystem*. The technical subsystem comprises of technology and processes. It is the portion of IT-based information systems in NPD that does not include human element. The social subsystem comprises of people and people in relation to one another, representing the human element of IT in NPD (Piccoli, 2012).

Information Technology Systems for NPD, enhancing Managerial Decisions

Making decisions is one of the core tasks managers face but they often make these decisions with incomplete information and in duress. They may justify their choices through intuition which stems from facts, evidence, individual and/or group observation (Vishwanath and Farimah, 2012). One of the objectives of managers in the NPD process is for it to be successful, and making good decisions can be said to be the “yellow brick road” that leads to that success (Powell and Buede, 2006). NPD managers and project managers use decisions to predict, control and mitigate problems that arise during NPD. Poor decisions made in NPD leads to products that the consumers will not embrace and many manufacturing firms and managers should understand that decisions made early in the NPD life cycle have an impact on how profitable that product can be through-out its entire life cycle (Hermann, 2002).

There is no singular IT tool that can support all the NPD stages and activities due to the complexity of the processes associated with NPD but rather, there are several IT tools that support specific stages and aspects of the NPD, which in turn enhances decisions taken along the process. Some of the IT tools that are available are designed to be used by single users, while others are for groups and teams (Lilien and Rangaswamy, 1997). IT provides manufactures and managers with Decision support system (DSS) and Artificial intelligence system; when combined, these systems helps managers create information through Online Analytical Processing (OLAP), this is to enhance huge decision-making tasks which require in-depth and complex analysis (Druzdzal J. Marek and Flynn, 2002; Tzafestas and Verbruggen, 1995; Junkic, Junkic, and Malliaris, 2008).

According to the work of Lilien and Rangaswamy (1997), one of the classification of IT tools based on how they enhance new product development are *IT tools designed to enhance decision making with NPD*.

IT tools designed to enhance decision making with NPD

These are IT tools that helps managers coordinate, decimate and reach a timely uniform agreement among work groups and teams (Naracapilidis, Papadias and Papadias, 1999). These are idea management software’s such as *ideadrop* for helping managers capture the best ideas from their teams. Other software’s in this category include: *Co:tunity*, for helping work colleagues share ideas; *Crowdicity*, helps harness ideas not just form employees and customers but anyone that can make meaningful contributions for an organization to do things better. *ThinkTank* a cloud based engagement system for facilitating group brain storming among stakeholders, etc. *1000minds*, an online package of processes and tools that enhance individual and group decision-making and to understand the preferences of people through Conjoint Analysis (Hansen and Ombler 2008). These tools enhance decision taken by managers by enabling them to use the information available more effectively (i.e. *Mindlink*) Lilien and Rangaswamy (1997).

Decision Support Systems (DSS) for NPD

There is a good number of empirical studies that suggests intuitive judgment and decision making of humans can be a long stretch from being optimal (Druzdzel and Flynn, 2002), it further deteriorates with stress and complexity, these are typical day-to-day challenges NPD managers face. In the 1970s and 1980s, the concept of decision support systems evolved from two previous computer supports for decision-making, which are management information system (MIS) and operations research/management science (OR/MS), (Kopáčková and Škrobáčková, 2006). DSS definition vary and the concept is broad but to avoid exclusion of different types of DSS, Druzdzel and Flynn (2002) defined them as interactive computer-based systems that help users in activities that involves judgement and choice.

The rapid development of IT we see today has changed the role it played in business and product development prior to the 1980's (Hicks, 1997). From its conventional role of supporting business operations in the past, IT systems have metamorphosed into a strategic tool for making decisions. These systems have been developed for specific purposes and differ from standard electronic data processing systems (Alter, 1976). It is pertinent to note that most of the times, managers have little or no say in the development of some of these decision support systems (DSS) and those who develop them (who are non-managers) may be short sighted on how they can be used in an organization or in NPD activities.

Despite these draw backs, a study by Alter (1976) found that most of the fifty-six decision support systems he studied were successful and that the length to which managers can use these systems to increase their value and effectiveness within an organization, including for NPD activities is the difference between success and failure. While there are undoubtedly advances in information retrieval, processing and display technologies, Alter's (1976) study of fifty-six decision support systems suggest that very few managerial functions have been automated, the study also indicated that most managerial functions cannot be automated. These systems are to support the managers responsible for making and implementing crucial decisions, such as during NPD activities rather than to replace the managers. A growing number of organization and managers use decision support systems (DSS) to improve their effectiveness in their day-to-day activities. Several computers support DSS in one form or the other. In the same vein, many IT systems now exist that gives users the provision for group collaboration, from systems designed for educational purposes such as *Moodle*, *Blackboard* etc. to social software such as *Facebook* (MacCarthy and Pasley, 2014).

According to Power (2004). There are general classifications of decision supports systems, which are: *Data-Driven DSS*, *Model-Driven DSS*, *Knowledge-Driven DSS*, *Document-driven DSS* and *Communication-Driven DSS*.

Data-Driven DSS: This includes Geographic information System (GIS), Executive information Systems (EIS), data warehousing and analysis system and management reporting system (Kopáčková and Škrobáčková, 2006). They take data and process it, which leads to a ranking of options that further drive the decision-making process in NPD. Relying on a model of the expected result and a follow-up decision does not process the data but rather, it is more like summarized data which decision makers can access (Power, 2004).

Model-Driven DSS: This uses data and other parameters that are provided by decision makers to help decision makers analyse a situation, they typically do not need very large databases. (Power, 2000). Based on a prediction that is derived from a model of the situation (a regularly occurring decision problem), a decision can be reached.

Knowledge-Driven DSS: They store and apply knowledge for various specific problems in NPD. They are expert systems not knowledge management systems meaning the knowledge is ingrained in the rules and heuristics in the system.

Document-Driven DSS: Knowledge management and information management allow information to be gathered and indexed in a way that decision makers can make use of the information to take decisions (Power, 2004).

Communication-Driven DSS: This system emphasizes communication, collaboration and support for shared decision-making. i.e. a threaded email is the basic level of such kind of functionality.

Managerial Strategies for effective use of Information Technology in NPD

It is important for managers to have a grasp of how IT shapes the NPD team (including values, norms), the NPD process and the flow and creation/acquisition of knowledge with other functions and objectives of the organization (Nambisan, 2010). Literatures on IT business value seems to suggest that to successfully apply IT in a business or NPD, complementary non-IT resources i.e. organizational structure (Mauerhoefer, Strese and Brettel, 2017). IT revolutionizes the way companies develop new products. Therefore, companies and firms need to put a great effort in implementing IT throughout the NPD stages. According to Ozer (2000), an examination of successful product development cases shows that there are strategies managers, NPD team leaders and companies adopt to make implementation of IT in NPD activities more effective. Some of these strategies are consistent with best organizational structural practice.

Individuals in various departments that the NPD activities span across have different ways to express their views, preferences and values. Hence, it is imperative to appreciate these differences and develop a communication culture that is shared by all. For instance, when the US west communication

developed its Global village which is a computer based medium of communication for exploration of web based technologies potential to generate new product. This was made a company culture, consequently more than 75% of its workforce of 50,000 used Global village, generating as much as 200,000 system inquiries every month (Bhattacharjee, 1998).

There is a human side to technology that cannot be neglected. Just like there is resistance to the use of some technological products, NPD team members may resist the use of some IT tools in product development, especially if the change or switch to a new technology is radical. For more effectiveness, all and not some workers involved in the NPD process must adopt IT tools. To reduce resistance to change, managers and NPD leaders should have open and sincere conversation with employees and team members about the changes. Also, timing matters too. Trying to implement a radical change all at once or too quickly may be counterproductive and may meet resistance from workers. Training is the standard and best practice in organizations especially when it has to do with implementing IT or any new technology. Training can make IT implementation more effective. Companies need to adopt flexible strategies to adjust their system based on the unexpected outcomes the implementation of IT can pose. Vertical and horizontal knowledge flow and management within an organization is a lead-in for sharing and learning. Vertical learning is important in the NPD process as managers need to make decisions about various issues i.e. NPD portfolio (Marion, Barczak and Hultink, 2014).

A common problem associated with technologies isn't technological but social. In a survey, five hundred users of a group conversation software submitted that the most important hitch to its adoption was the lack of support from the managers rather than technical problems. (Ozer, 2000). Companies that have used IT in the development of their new product also submit that it was made possible because of the full backing of their top management. For a successful implementation of new product development, managers place emphasis on group effort. According to Ozer (2000) research has shown that group based reward system can improve group performance tremendously. The reward system should be designed to support the goals of the company. For instance, if the goal of a company is to get its product faster to the market and it is achieved even faster than scheduled with the group effort, there can be a reward system in place for such collective effort and result.

Conventional project characteristics justifying the use of IT in NPD

The application and subject of project management has existed and is still relevant in conception, planning and execution of NPD projects today. As innovation in product development is the new normal, there is a need for project management techniques that can best handle NPD. Some models of NPD may be extremely challenging, most especially when a high level of innovation is involved, this in itself is a problem (Dirk, 2008). Project management has been around for long, and an appreciable number of projects employ its tools and elements, suffice to say that the results may not have been fully satisfactory, implying that project management methods in its totality is not a complete solution for managing NPD projects. Some schools of thought believe project management principles are not adhered to the letter or project team members maybe on a zero-motivation level. Dirk Pons in his paper on project management for NPD suggests that uncertainty in the outcomes of NPD trumps even the most diligent project manager (Dirk, 2008). The complexities of NPD especially when innovation is involved reflect when defining scopes and outcomes in conformity with conventional project management practice. NPD activities are projects and as such, it is not far-fetched that characteristics of conventional projects or the NPD itself also apply and could determine or justify the use of IT in NPD activities. Adapted from the study of Silva, Mathrani and Jayamaha (2014), the following factors are project characteristics determinants that moderate the IT – NPD relationship; *Project Uncertainty*, *Project Complexity* and *Project urgency*.

Project Uncertainty

The more uncertainty surrounding a task increases, the more the amount of information to be processed during the execution of the task will increase (Silva *et al*, 2014). In the NPD process, there are many uncertainties that exist such as in the market, the competition and in the technical and collaborative environments. These uncertainties may have an influence on some certain aspects of the NPD effectiveness (i.e. prototype development proficiency). The highly volatile conditions of the market and the proliferation of technology riddled with uncertain conditions require a more consistent and valuable information stream for making quality decisions in the NPD process, as highlighted earlier, this is where IT could play an important role in the NPD process. The full scope of an NPD project may often not be envisaged especially when it has a high degree of novelty. However, the scope of the NPD centres on the features and functions that characterise the outcome, therefore, it shouldn't be taken with levity. A little grasp of the scope defines what is not in the scope, helping to put away assumptions of steps to be executed which were not planned for, or accounted for in the NPD project schedule and budget. Furthermore, there are IT based systems used to manage uncertainty in NPD by using a “check point” kind of technique at the end of every major stage or milestone of the NPD process. Again, this approach doesn't differ from traditional project management methods where gates or stages are represented with milestones. These IT based systems or tools help in breaking down

problems into small units, this is in conformity with project management theories which require that problems be decomposed into smaller sub problems so that solving one of them does not disturb the other. This will create room for flexibility to accommodate changes to the breakdown of the work structure as challenges unfold.

Project Complexity

Complexity seems to be an inherent characteristic of NPD, complexity in this context is on the whole process and not on the characteristics of the product. Even environmental factors increasingly intensify the pressure on NPD and add to its complexity. The key indicators of an NPD project complexity are the number of tasks involved and the degree of interdependency of these tasks. For instance, virtual teams rely more on IT and according to Dube and Pere as cited by Silva *et al* (2014), eight characteristics make managing NPD projects by virtual teams more complex, they include; size of the team, task or project duration, member's assignment, geographic dispersion, prior shared work experience, task interdependence, cultural diversity and member's stability. Extant research asserts that different levels of collaboration between external and internal partners affect the NPD performance.

Project Urgency

Project urgency is a determinant that is significant in the need for processing information and the use of IT in NPD (Silva *et al*, 2014). Project urgency can be assessed in terms of the priority given to the project and the time pressure is felt during execution of the NPD project. Firms also process information based on the urgency of the NPD project, using information from the market and the about the competition.

The characteristics (uncertainty, complexity and urgency) of projects justifies and increases the need for IT (i.e. in gathering and processing information) in the NPD process. In NPD, the objective is to develop a design and the complexity of the quality is reflected from its measurement of multiple points, including functional, aesthetic and production. Many industries take into cognisance the customer's perspective, they seek the customers view and translates those views into the design of the product. Again, this is a very basic level of quality in project management scope which essentially means meeting the needs of the customers and stakeholders. Going further, popular tools used in NPD such as Quality Function Deployment (QFD) which essentially translates the customer's requirements into engineering specifics are now embedded into IT systems or software's, enabling quality control of the NPD process.

2.5. Theoretical model of Information Technology's usage in different stages of NPD process

It is no secret that many companies operating in the competitive atmosphere of today's markets are in one way or the other compelled to develop new products that can accomplish a variety of products that could simultaneously accomplish several objectives. If these products are introduced at the right time and they offer good value by meeting customers demand, they will enhance the strategic positioning of the company or organization. Internally, many companies rely on IT infrastructure, IT tools and software to aid them realise value added new products at every stage of the NPD process. Some of these tools are custom made; tailored to suit the peculiarities of the company and their products, some others are premium tools with or without redistribution rights, and some are freemium while others are open source tools. IT tools used for NPD process were adapted from traditional or old methods of developing products. For instance, electronic brainstorming which is discussions online used to generate ideas and solve problems was adapted from the conventional face-to-face meetings. As outlined by Lilien and Rangaswamy (1997), some research reveals that the use of electronic brainstorming systems improved efficiency and effectiveness of idea generation compared to face-to-face meeting.

The growth of IT tools to facilitate and support NPD processes has been on the increase, however, there is little research reporting the role of these individual or collective tools on each stage of the NPD. In an attempt to formulate a theoretical model for this study, major categories of IT tools that are available for supporting NPD were identified and classified vis-à-vis examples of software tools that can be used at each NPD stage also. The following are examples of IT tools used at every stage of the NPD process;

Stage 1: New Product Strategy Development

IT tools that can be used in this stage are: Basic Software packages that allows you to outline and document your strategy, mission, vision and goals (i.e. MOST, PEST) using tools like Microsoft packages i.e. word, excel, visio etc. text editor, pages, Google drive document etc.

Stage 2: Idea Generation

IT tools that can be used in this stage are (Zaharis et al, 2011):

- Survey Analytics tool for Conjoint Analysis
- *Sawtooth Software Inc.* provides a range of tools to do conjoint analysis, this includes the capability to write web-based surveys where you can build your own questionnaire and analyse the result.
- *@Risk*, is a software offered by *Palisade*, which is basically an ass-on for MS Excel. It gives users the ability to do probability distributions and Monte Carlo simulations for conjoint analysis.

Stage 3: Screening and Evaluation

IT tools that can be used in this stage are:

- *Mesydel* - Online Delphi

Ideawake, a software to collect, evaluate and implement ideas (“Idea Management Software”, 2017)

Stage 4: Business Analysis

IT tools that can be used in this stage are (Zaharis et al, 2011):

- Microsoft Visio
- Microsoft Excel
- Rational Requisite Pro

In these tools; Gantt Charts – Planning and Scheduling, PERT (Program Evaluation and Review Technique etc. can be utilised.

Stage 5: Development

IT tools that can be used in this stage are (Zaharis et al, 2011):

- *Materialise Software*, which is used to develop application enabling the advanced used of tooling and rapid prototyping techniques.
- *Computer-aided design (CAD)* used in physical product design or *Computer-aided manufacturing (CAM)*

Stage 6: Testing

IT tools that can be used in this stage are (Pohjolainen, 2002):

- *Caliber-RBT* (Technology Builders)
- *Certify* (WorkSoft)

Stage 7: Commercialization

An IT tool that can be used in this stage is:

- *Salesforce*; a cloud based platform for building and running business applications) (Choi, McGuire and Roth, 2016).

Summarised information is presented in **Figure 3**. Empirical study of this research is conducted based on this model.

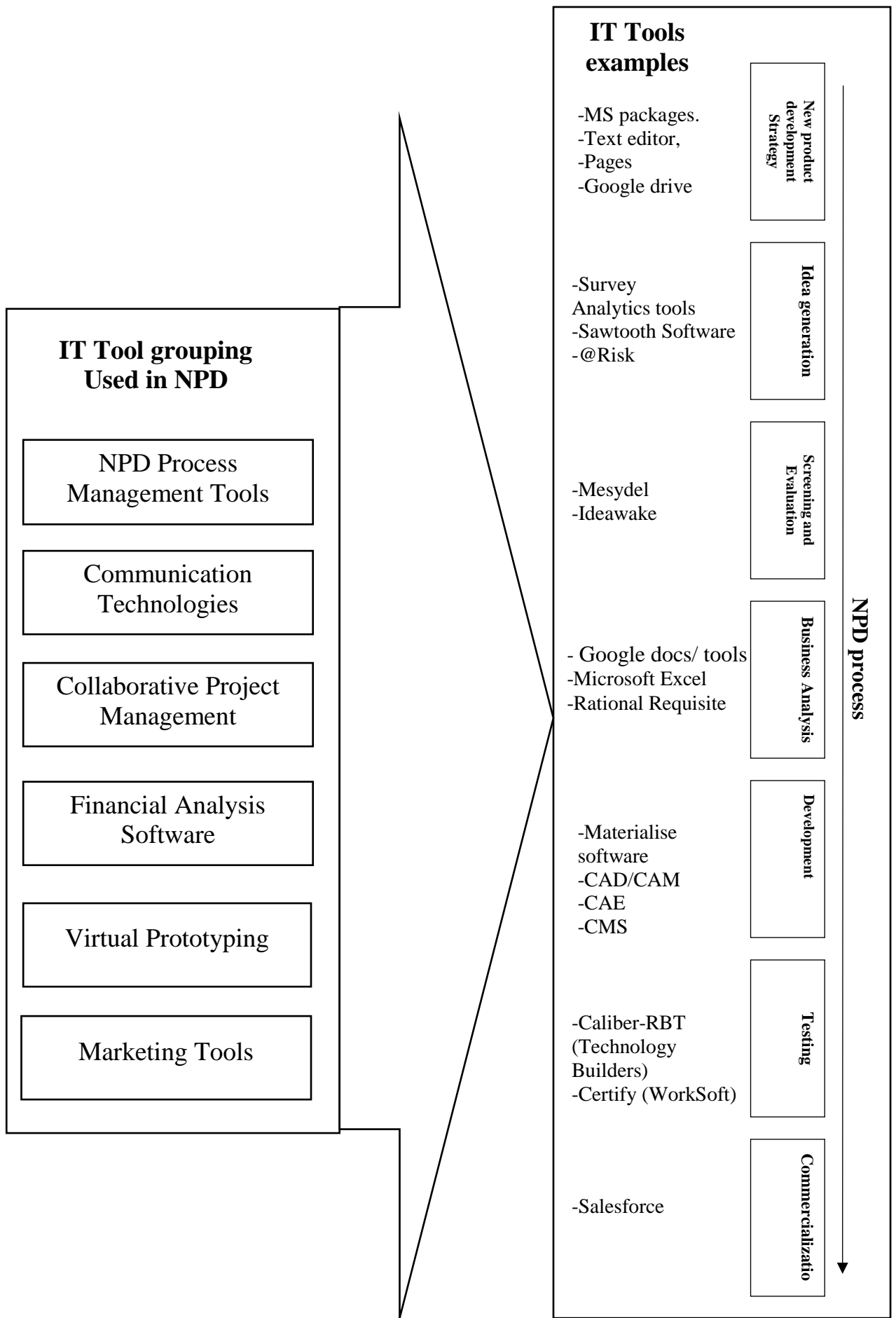


Figure 3: A Conceptual model grouping of IT tools used in the NPD Process

3. RESEARCH METHODOLOGY

According to Crotty (1998), research methodology is a comprehensive strategy that forms our choices and the use of methods that are specific which relates to the outcome anticipated. The features and type of the research problem is what the research methodology is based on. The strategy or architectural design by which researchers map out an approach to finding problems and solving them is defined as a research methodology (Buckley and Chiang, 1976).

3.1. The description of a study

Purpose-based on presented theoretical model (see *Figure 3*), to highlight the main IT used in different NPD stages. This study aims to answer research questions related to the use of various IT systems and infrastructure at different stages of the NPD process by utilizing qualitative research methods. One of the goals is to observe the trends of IT used at different NPD stages and in-depth understanding of why some IT based systems are chosen by managers in the NPD process and to have an overview of the ones they consider important to the NPD outcome in their own context. According to Bryman and Bell (2007), qualitative research places more emphasis on words rather than quantification when data is being gathered and analysed. In qualitative research, the focus is on understanding and seeking answers to the “whys” and “hows” rather than interpreting numbers (Kent, 2007). The major difference between quantitative and qualitative data is the difference between numerical and non-numerical data (Kent, 2007). In quantitative research, gathering of numerical data that can be studied with less bias is required (Bryman and Bell, 2007). The major advantage quantitative research has is the ability to gather data for the implementation of statistical models, characterized by deductive relationship between theory and research. Meaning that the researcher should have a good grasp of the researched issue before implementing measurements (Bryman and Bell, 2007). This leads to statistical analysis and result interpretation. Compared to the quantitative data, qualitative data is more detailed and richer, having information from fewer respondents (Kent, 2007). Qualitative research reaches parts that other methods may not reach, most particular in research that is focused on the links between processes and their outcomes (Shaw 2003), they are used to understand how things are scoped in different context, to have an in-depth understanding of the phenomena and explanations in its context (Yin 2011; Eriksson and Kovalainen 2008).

3.2. Context of study

Decision-making is a critical managerial function (Berisha, 2010), not just in the day-to-day running of an organization but also in product development and project implementation. Information is needed for managers to make decisions in NPD; therefore, it is common practice that one form of IT or the other is required to make decisions with little margin of error during NPD activities. Managers do not have all the time to be fixated on one problem, their attention is divided along the spectrum of the NPD process, so when problem arises, there is little or no time for managers to go neck deep into

the range of concerns. According to Henry Mintzberg as cited by Berisha (2010), there are three separate roles managers play, which are interpersonal, informational and decisional, IT can support these roles in various forms (Applegate, Cash and Mills, 1988). Interpersonal role of managers stems directly from their authority and status that involves coordinating and dishing out directives to subordinates. In the informational role, managers accumulate and process large quantum of information and distributes them to others in the organization. In the decisional role, managers initiate and monitor new projects and makes changes where and when needed. (Hicks, 1997).

Advances in the development of IT in its various forms i.e. computer-based IT, information systems etc. in the past decades has led to a variety of changes to the economy, organizations and in how managers make and implement decisions (Berisha, 2010; Alter, 1976). This has made it possible for managers to access required data in a timely fashion; different types of information technologies are being used to provide reports and information, enabling managers to take more effective NPD decisions alongside being a tool for managerial support.

Also within the context of this study is a focus on start-ups. Start-ups are newly founded entrepreneurial ventures or companies that are in the development and market research phase (Čalopa, Horvat and Lalić, 2014). Start-ups are usually associated with high-tech projects even though they are not necessarily only high-tech projects. The products of Start-ups are mostly software, they also include technology-oriented projects. By their very nature, start-ups have a potential for growth, they usually have novel ideas, are flexible and also willing to take higher risk. (Čalopa *et al*, 2014; Wieblen and Chesbrough, 2015). One of the goals of business development is to create a long-term value for a company through the relationship between customers and other variables in the market as a whole. This is how start-ups approach business development but in mature companies, there's a difference because the role of business development in a company changes as the company matures. This is due to the fact that what is valuable in the long term also changes as the company experience growth. A start-up is faced with much more resource constraint than a mature firm, they experience a lot of pressure for survival and need a sustainable growth for the future (Sinha, 2015). There is numerous research on the use of IT in NPD which focuses on some mature companies. Even though the product development process between mature companies and start-ups may be similar, the uniqueness of start-ups in their size and flexibility (Čalopa, Horvat and Lalić, 2014) means that there could be some major differences in how they apply the same tools, techniques or even processes.

Therefore, this study is conducted with managers of start-ups as they are responsible for making decisions for the use of IT in the NPD process.

3.3. Research instrument presentation

The goal of this research is to have a broader understanding of how IT interacts with or is being used at every stage of the NPD process. This research also aims to capture the unique application of IT in NPD based on the context of the product or firm and from the perspective of those involved in implementing NPD. To have a homogeneous group, this study is focused on start-ups only. The query of this research stems from the theoretical aspect of this study where IT is highlighted at each stage of NPD and how IT infrastructure or apparatus are also grouped according to their similarities or functions. The findings will be based on the answers and views from the interview participants. The theoretical model in *Figure 3* represents the factors involved in the research query and analysis. On the left side of the model, is the grouping of IT tools involved in the NPD process based on various past research and studies. These group of tools apply to the whole NPD process. On the right, you have the NPD stages and examples of IT tools that can serve each stage. For this research, the opinions, experiences and views of the research respondents will be used to expand the use of IT in NPD process and the various factors that comes into play with this process, their usefulness and challenges.

Justification for the use of interviews

An interview is gathering information form a conversation. In research, this involves the interviewer coordinating the process of the conversation by asking the interviewee questions. It could be conducted over the phone or face-to-face. It is common for these five steps to be followed in a research process: reviews of existing theories, formulation of research questions, data collections, data analysis and discussion of findings. This might sometimes differ especially in qualitative methodology of research as you might have to always refer to the previous step to make more reviews or analysis after going forward. (Eriksson and Kovalainen 2008). In interview qualitative methodology, the goal of the researcher is to get a detailed and rich answer (Bryman and Bell, 2007) and this study aims to get as much detailed answers and results as possible. Also, the approach to the interview for this study was semi-structured interview, this approach was chosen because it is more flexible and gives the interviewer the opportunity to probe and expand the response from the interviewee, thereby achieving depth (Alshenqeeti, 2014). Also, since the interview format was semi-structured, this gave an opportunity for additional questions in order to further expand or clarify certain issues. It is recommended that when undergoing this kind of study, a basic checklist should be used to help cover all the relevant areas. This allows the interviewer to keep the conversation within the ambit of the main study (Barbour and Schostak, 2005). In as much as the study had a context and the interviewee was guided to stay in that context, this study was conducted with an open mind, trying not to feed the interviewee with expected answers but accepting the answers from the interviewees based on their unique experience even though it might not appear to tally with what the theoretical analysis of the study might suggest in those unique cases.

Recruitment of Participant

Several researchers recommend the use of between eight to fifteen participants and that fewer participants are needed when more than one interview is conducted per participant or when the group of participants are homogeneous (Hill *et al*, 2005). The group of this research is homogenous and the focus is on product leaders from start-ups that were at most five years old. Focusing on start-ups in this study was advantageous in the sense that the NPD process in these organizations are not lengthy and complicated. In recruiting the participants, we also insisted the company must have deliverable products as part of their criteria, meaning they should have gone beyond the alpha and beta phases and are at the launch or sales phases. This was to prevent start-ups that only had alpha or beta product prototypes from participating as it will not suit the context of the study. Twelve interview sessions were conducted and one session of interview per participant.

The decision for the interview selection was primarily based on the experience of the product managers and their availability for the interview. Participants for this study were drawn from start-ups in Lithuania, Spain and Nigeria. Also, the criteria for participating was clearly stated in the respondent recruitment emails. The recruitment of respondents was most challenging as direct email addresses of the product leaders was not on public posts or websites of these companies, emails first had to be sent to the general email accounts of the companies. When the emails get a positive reply, they either referred or copied the relevant person in the company to it. A total of thirty-three emails were sent to companies and start-ups in the aforementioned countries. The email informed the potential participants of the identity of the researcher, purpose and method of the study. Only twenty-five responded to the emails of which fifteen declared interest in participating in the study. Three out of the fifteen that declared interest did not commit to the interview appointment but twelve respondents were interviewed and only nine out of the twelve is used for the study. As for the remaining three, one respondent was not able to provide tangible answers to the questions posed, two interviews couldn't be used due to the poor output of the recorded data (the interview was conducted over Skype and the network was poor). The names of the start-ups are not included to protect the confidentiality of the participants. Participants were given the chance to study the questions and a brief summary of the study context. The nine product managers/leaders who participated in this study had occupied their portfolio for at least two years as at the time of the interview.

Research interview formulating process

According to Hill *et al*, (2005), the interview protocol should consist of about eight to ten questions and should be probed in less than an hour. They also recommend that a minimum of two pilot interviews should be conducted to test the questions. The theoretical analysis of the study was used to formulate the questions. As opposed to using "do you" or "does your", the interview questions were in "whats" and "hows". This was to avoid a "yes" or "No" answer from the participant. The aim

was for participants to expand on emerging themes from their answers. Only one pilot interview was conducted and analysed, after which some questions were tweaked. The pilot interview also gave the interviewee an opportunity to review his probing technique in terms of pronunciation of words and phrases. The interview was a set of ten questions. An interview questionnaire is presented in

ANNEX 1 .

Interview Procedure

Out of the nine interview sessions:

- two took place at the participant's office
- one took place at a public café
- The remaining six took place over a Skype call.

In summary, there were three face-to-face interviews and six Skype interviews. When one participant made a choice for the interview to take place at a public café, issues bordering on confidentiality was discussed. The interviews were conducted over a period of two months (October 2017 – November 2017). All the interviews were audio recorded and informed consent for the interview and audio recording was sought from the participant before commencing the interview and audio recording. As Hill et al, (2005) suggests, the interview protocol should begin with some background questions, this is to help the participant feel comfortable and to be at ease in the process. Before the interview, a brief background check of the company and the secondary information about the respondent was carried out and this information were verified with the respondents in a brief chat trying to familiarise with the respondents. The interview started with questions about an overview of the company and the background of the participant as a product development leader. This was followed by questions that were open-ended, allowing the participant to discuss IT tools, infrastructure, software's and apparatus that were more relevant to them in their NPD process.

A series of probe was used to help the participants broaden their mind about the topic in discuss based on the context of the research study. The participants were also encouraged to share their experience from other companies or organizations they worked for in the past. The interview varied in length and was between twenty to thirty minutes each. Notes were made during the interview to document emerging themes and impressions of what the participant was divulging. More notes were made after the interview so that key point could be remembered. The audio recording was later transcribed which totalled a fifteen-page document of texts. In keeping with the agreement of confidentiality, the document does not have the identities of the participant. After asking all the interview questions, participants were given the opportunity to ask the interviewer any question regarding the study. They either declined or asked for more details about the aim of the study. At the

end of every interview session, participants were asked if they needed a copy of the transcript or audio recording, only two requested for the audio recording.

3.4. Data Collection Analysis

In addition to the note taking during and after the interview, the transcripts were reviewed several times to outline and document patterns and themes. After the completion of this process, themes and ideas that were similar were grouped together and given a conceptual label based on the conceptual modelling of the study. This also served as a source for the prospective code names. After establishing conceptual codes, the coding process began. After this step, the data from all nine interviews were sorted in files using code names and data within each of the files was reviewed to identify and summarise subthemes and their relationships. Unique data or contradictory data was outlined within each summary.

Table 4: Profile of Interview respondents and their Companies

	Respondent profile			Company Profile		
	Gender F/M	Portfolio	NPD Experience (in years)	Company Product(s)	Date Established	No of Employees
R1	M	Project Manager	4	Software (Website, Mobile and web App) for start-ups	2014	10
R2	M	Product Manager	2	Mobile Apps	2012	40
R3	M	Lead Software developer	3	Website, Mobile and web Apps, TV shows, documentaries	2012	54
R4	F	CEO/Project Manager	5	Websites, Advertisement, Posters, Web/Social media administration.	2012	11
R5	F	Lead developer/Product designer	3	Website and Web Application	2015	7
R6	M	Product Manager	5	Furniture (Tables, chairs, bed, benches, boards)	2013	30
R7	M	Product Manager	5	Green Plastic Packaging	2012	35
R8	F	Product Manager	4	Customized Clothes, Textile Production	2014	40
R9	M	Product Manager	2	Smart Bin	2015	25

4. RESEARCH FINDINGS AND DISCUSSIONS

To make analysis for the results of this research, information was collected from the interview with NPD leaders according to the theoretical part of the study. All the interviews were transcribed and the texts were coded and categorized. Furthermore, these analyses were made based on carefully analysing the transcribed texts. In analysing this result, content analysis technique was applied.

Hseih and Shannon (2005) defined content analysis methodology as "*a research method for the subjectivist interpretation of text and data through the systematic classification process of coding and identifying themes or patterns*". The reason for this choice is because the interviews conducted were in a semi-structured fashion and they were similarities between each other. According to Silverman as cited by Darasteanu and Moskalenko (2010) which may apply to this study, in content analysis, main issues for the discussion has to be defined, then gathered data can be allocated to some of the defined groups. Thus, contents from all the conducted interviews were divided into groups based on the questions discussed. This provided an enlightening information about the use of IT in every stage of the NPD process from the perspective of the interviewed product leaders in start-ups, what IT infrastructure or apparatus or group of tools they consider vital to the NPD process and how IT in NPD process informs their NPD decisions. Finally, the data gathered was analysed based on the theoretical model in *Figure 3*.

4.1. Results of IT usage in NPD stages

New Product Development Strategy

In chapter 2, it was highlighted that at the very beginning of NPD, strategies have to be outlined in line with the goals and missions of the organization viz-a-viz their product offering and the customers they want to satisfy. According to studies referenced in previous chapters, firms assess the strength and weakness of existing products if any, and also consider what innovations can be introduced by identifying the market needs. Some identify the needs of the market by first consulting the market through simple surveys, asking questions or even observing trends. Furthermore, we saw that IT can help gather and classify the data needed at this NPD phase. IT can be used to interpret the data and inform their strategy formulation process and that some of the IT tools that could employed here are MS packages, text editors and other open word documents. During the interviews with the product managers, different examples of IT tools that help in this regard were discussed. As outlined in the study, most tools highlighted were echoed by the respondents as well as being the main IT apparatus employed at this stage. One respondents, expanded more on how cloud based open text/word documents has increasingly become a choice for them at this stage as they can share their thought through comments on Google docs for example. The words of respondents put it into better perspective:

“cloud based word documents like Google drive helps us outline our strategy in way that the whole team is involved, as people can drop ideas and suggestions as they pop up in their minds for everyone to see” (R9)

There are other uses of cloud based computing and its adoption in businesses as they support an interactive and user-friendly web applications. From the perspective of some of the respondents, cloud computing is virtualized IT resource, software deployment and dynamic development. While some others see it as a technology that helps them stay competitive and brings so much benefits to their business and NPD process. I.e. services like Google analytics can be useful in this regard. We also see that some of the respondents revealed that they had saved templates on some of these IT apparatuses i.e. MS word or other premium software packages for carrying out SWOT and PEST analysis.

Also, it was observed that sometimes not everyone in the NPD team is involved in the NPD strategy phase. This phase is being driven by the strategy team or arm of the business which could range from just 1 person to 20 or more people depending on the size of the firm or the complexity of the new product. And the strategy team is usually smaller than the rest of the NPD team but higher on the NPD team ladder, they determine the direction the NPD process will take. In using these IT tools for this stage of the NPD process, they help the strategy team outline their goals at a faster pace and can be used to present a summarized break down of the strategy to the operational team or the others in the NPD team. For instance, a respondent from a start-up divulged that they use smart board (which may not be a technology that gets a lot of attention) during meetings and discussions to break down and analyse strategies with the whole NPD team when they congregate.

Venkatraman (1990) best describes how strategies in a business or in NPD development could benefit from IT. According to his study, IT at this stage could bring about transformation to a business or product in terms of what the firm does and how they do it, i.e. redesigning business process (the use of IT to align NPD activities and the organizations activities to achieve breakthroughs in performance), redesigning business network (a new or different approach from the way information and data is used by the organizations and their partners, thereby dumping the traditional use of information in the industry and beginning a revolution on how the industry as whole carry out processes that add value) and redefining business scope (developing new products or extending their market based on available data or completely changing the organization’s role in the industry). All these have an implication on the identification of new products, the planning to develop and the implications that follow. Some respondents that work with teams in other locations alluded to the fact that IT communication tools are beneficial to NPD teams that are virtual i.e. they have video conference calls like a face-to-face meeting to discuss strategy. In terms of cost to the firm, most IT apparatus employed at this phase of the NPD process cost the firm little or nothing and has no significant direct impact on the price of the new product.

Idea generation

In the NPD process, this stage is where the life of the new product is being conceived. During the interview sessions, different sources of new ideas were discussed with the respondents. As outlined in the theoretical section, there are different sources of new ideas. Ideas could be generated from within the firm or outside the firm. Opportunities in the market are identified at this stage and new ideas are generated to meet the needs of the market. For the bigger firms, the marketing department is considered an important source for idea generation because they are closer to the customers and they always gather information about the competition. As we saw from the work of Hauser and Dahan (2007), feedback from those who are close to the consumers and suppliers could be the source of new ideas, one of the respondents interviewed said they get new ideas in this way using Jobs-to-be-done (JTBD) methodology. In the words of the respondents:

“we just started using Jobs-to- be-done as one of our idea generating methods, where we do an analysis of our products/service and outline what jobs our products do for our customers and what other complementary jobs our products or new products could do for our customers” (R3)

The JTBD theory suggests that in order to create products that customers will be willing to buy, the firm has to understand the fundamental measure of how customers measure performance or success when getting jobs done (Ulwick, 2017). When the focus is on the job-to-be-done, there’s a possibility for the firm to determine the unmet needs of the customers based on how these customers perceive or measure value. Not all the ideas at this stage will survive the idea filter which is the next NPD stage, therefore, a lot of ideas has to be generated. According to some respondent interviewed, IT tools may not play a huge significance at this stage of their product development process, these are the words of one of the respondent:

“Our products always come from our customers demand, our customers have the ideas, they bring it to us, while we refine these ideas in agreement with the customer and then implement the ideas, turning them into products. We are always keen on giving the customers exactly what they want so we do not do so much at this stage but wait for the customers to make their demands. We let the customers know the best approach to implement their idea from the standpoint of the industry and based on our experience and strength. We offer them choices, and we implement whatever choice they make irrespective of how good or bad their choice is by our standard and expertise” (R1)

It is important to state here that the view of this respondents was based on the model of their firm and the nature of their products. They do not produce goods in mass quantities for customers, they develop products for other start-ups as these customers make demand for them. Therefore, this stage of the NPD process is being carried out by customers or users of the product and not the firm. For respondents that employ IT tools at this NPD stage, examples of tools used include; Survey analytics tools (as mentioned in the theoretical part of this study), MS excel and Balsamiq.

Screening and Evaluation

After ideas are generated, this is the stage where they go through a funnel to ascertain their feasibility and relevance. A pool of many ideas is reduced to few numbers and more importantly, ideas that show potential for success at the market is given more priority and subsequently implemented. Without careful consideration given to this stage, the product is bound to fail on reaching the market. In this study and some other research in NPD, the idea generation stage and the Screening and evaluation stage are two distinct stages of the NPD process but from the answers by some respondents, they treat these stages as the same or one process. This could be deduced by some of the answers from the respondents as to what tools they employed to generate ideas. These are some of their words in regard to this question; “What IT tools, infrastructure or software’s do you use in the following NPD stages: Idea Generation”

*“We have tools like Balsamiq which helps us in our **idea generation** process and to also **filter** the best ideas from the good ones” (R2)*

and another stated

*“As we **generate** our ideas from our customers, we equally use survey tools with our customers to screen these ideas generated on the basis of their importance..... the **ideas are generated and measured or screened** by the customers simultaneously” (R3)*

It could be gathered that they do this to minimise the process and save times, as one respondent said, *“for us, making the process shorter is important...we have a standard procedure for creating products but our steps and processes are much shorter than what you outlined here (in reference to this study) ...we consider delivering products timely to the customers as our strength, it also dictates our strategy” (R1)*

From the interview with respondents, it was evident that few firms dedicate more efforts towards making increments or improvements to their existing products than creating new products entirely. These firms do not consider this stage of the NPD process as important as other stages. They either skip this stage or merge it with the previous stages as mentioned earlier. Therefore, not many IT apparatus is dedicated or used at this NPD stage. Some of the IT tools mentioned by the research respondents include: *Ideawake* and online survey tools. Some respondents highlighted they do not have any IT apparatus dedicated to this stage or that they employ minimal use of IT at this stage because they screen their ideas using Likert scale. They give generated ideas attributes and allocate a unique number to each of them i.e. using numbers that range from 1 – 10, with 10 being the most

important attribute. They further define the outcome of the ideas and rate them according to their profitability and importance. After this step, ideas with the highest scores are selected. At this point, some firms continue to screen the ideas by validating them through measurement of the customers' response to the ideas. Others, go ahead to make prototypes to test in the market, while some just develop the ideas into products without any further test or screening.

Business Analysis

The business analysis stage of the NPD process has many important components which is crucial to the NPD process as a whole. The business analysis stage of the NPD process is the final assessment before deciding if the idea concept can be developed into a new product (Craven and Piercy, 2005). Referencing the study of Zaharis *et al* (2011), this is a stage where more questions about the business viability of the product is being asked and carefully analysed. Including investigation of the market, market share, potential target market, complementary products and substitute products, forecasting of sales volume, identifying break-even point, determining minimum sale price, considering the long term (forecast product lifespan), the scope of the marketing strategy and risk assessment. At this stage, the financial resources to fund the new product is carefully considered including the possibility to service debts if the firm needs to borrow in order to continue developing the product. Also at this stage, some firms consider partnering with other organizations to minimise cost or they outsource a production step they consider a bottle neck or constraint in their NPD process. If a firm is involved in the business analysis of their NPD process, they can hardly do without using one form of IT apparatus or resource to help fast track this stage. From the respondents interviewed, they consider this stage crucial and that the use of IT is highly important here. From what was gathered, data at this stage is what is crucial. To further explain how important this is, a respondent revealed they had to halt a development of a new product because they couldn't trust the source of the data they had.

“we had to stop developing an app about transportation logistics, we did not have enough information for calculating all the algorithmswe needed some IT based tools to get information.... We outsourced this to an agency to gather these data, but at the end, we decide we couldn't trust the information because it was a technical information about the millimetre of cars” (R4)

Therefore, IT tools that can help track, gather and collate data are extremely useful. These tools help them to easily interpret data. This statement was made by a respondent of a firm that creates website and web apps:

“...to analyse our business, we track data using google sheets and make use of custom tools using JavaScript to sort data. We use Tablaeu to search insights and analyse differences” (R1)

According to Shahrul-Yazid and Nooh as cited by Barrios and Kenntoft (2008), if scrutiny becomes too much, it may slow down the time-to-market for the product. As time is always a factor at this stage and as such, firms have to set a strict time limit for this process. Issues bordering on predicting the success of the new product in the market, reaction of competitors and the reaction from suppliers and customers stem from information about future market dynamics (Barrios and Kenntoft, 2008), and some firms out-source this aspect to experts in the industry for analysis. Most respondents revealed that even after they employ IT to track, gather and collate data, interpreting the data for the future is a totally different challenge. The interpretation of data is what is needed in order to translate or integrate findings in the new product dynamics.

Development

This is the stage where the idea concept becomes a tangible product. Manufacturing processes are deployed beginning from prototypes to the actual useable product. One aspect of product development that came up from the interviews was the aspect of the development methodology, which are: Agile development and Waterfall development. Agile product development is a group of methods that is based on an iterative and incremental development process. The requirements and solutions evolve through the collaboration of cross-functional and self-organizing teams. In agile methods, the emphasis is on productivity and value rather than heavy-weight process overhead (Szalvay, 2004). Waterfall development is a development process that is sequential, where development takes a steadily downward flow. In waterfall, all the requirements are gathered from the beginning before production, designs are completed and the master design is implemented (Szalvay, 2004). A considerable good number of respondents alluded to the fact that they adopted either one of these development methods even though no direct question was asked about the development methodology they use. When discussing about the use of IT at this NPD stage, their development methodology slipped into answers they gave. This was observed in about five out of the nine respondents interviewed. According to a respondent:

“since we adopt agile methodology for the production of most of our software products, we use IT tools such as Tmux. Tmux allows our developers to easily switch between multiple task under one terminal. GitHub also helps our development team store code in the cloud for easy retrieval and for code reviews and discussions (R3)

During discussions with respondents from software firms, it was observed that some firms have templates for developing software products and they use these templates if the product they are developing aligns with the needs for which these templates was built. They use these templates in combination with a software developing frameworks called CMS (content management systems). A CMS is a computer application that supports the modification and creation of digital contents in a collaborative environment (Rockley, Ann and Manning, 2003). These CMS help them develop

products at a faster pace and in a timely fashion. With these templates, they may have no need to draw software wireframes (a three-dimensional skeletal model of just lines and vertices, to create an image that displays functional elements of a software product, used typically to plan the functionality and structure of a software product). The degree of uniqueness of a software product determines if templates with CMS will be used for development. For respondents that produced solid products like textile, furniture and Smart bin, the use of IT at this stage of the NPD process was majorly for product design conceptualization through virtual prototyping or rapid prototyping and to track all and monitor the production progress. These are the word of respondent whose firm produces green plastic packaging,

“During production or development of our product, we use ERP software to monitor and track data. The tracking of this data is automatic, directly from work centres and it updates the production inventory and schedules” (R7)

The IT tool employed here serves as a real-time production monitoring system. These kinds of IT apparatus are highly prized and sometimes custom made for the firm. Also, the respondent indicated that these software’s have a steep learning curve, meaning it takes much effort to learn and use. Therefore, those saddled with the responsibilities of using these systems are the NPD leaders or managers.

Testing

This is another crucial step in the NPD process. As highlighted in the theoretical part, validation of the product occurs through testing in various forms. Depending on the product and its complexity, various tests are carried out using benchmarks to ascertain the suitability of the product, adherence to industry standards, risk or health hazards associated with the product and if it meets the needs of the customers. Also, the tests are carried out to determine if the products meet the requirements as outlined in the idea generation and business analysis stages. As one respondent highlights, various test are carried out at this stage:

“For testing of our web and mobile apps, we do unit testing on each platform and continuous integration test as each development team unit finishes their job. We carryout smoke test to make sure there’s no intended side effect and regression test to make sure that other functions developed haven’t broken. ...after this, the QA (quality assurance) team test the whole product from the perspective of a developer or producer and from the perspective of the user or consumer” (R5)

when asked what IT tools are deployed to test their product at this NPD stage, the respondent said:

“we use automated UI testing, Jasmine framework to track the functionality of our end product, another tool we use is protractor. Protractor is an end-to-end test framework for Angular and

AngularJS applications. Protractor runs tests against the product in a real browser, interacting with it a user would” (R1)

A respondent that creates software products revealed that they move from the idea phase of NPD process to developing prototypes for testing. These prototypes are with lesser functionality, only having the main functions they desire. After this test is complete, they go further into full development of the product. A respondent from a firm that produces furniture said they create prototypes of the product and test at exhibitions. After they measure the interest of consumers in the product, it informs their decision on whether or not to modify or mass produce the new product for sales.

Commercialization

After testing and launch of the product, this stage of the NPD process are activities geared towards bringing the new product to the consciousness of the market. Booz *et al*, 1982 argues that it is important for close monitoring of the customer, suppliers and competitions reaction to the new product in the market. Cooper (1990) states that this stage of the NPD is known for the involvement of marketing experts who understand the market and how to deliver the right product to the right place and at the right time. During the interview, a respondent echoed this view “...*We do not use much IT (except for communication) in the marketing of our products as we are less involved in the marketing or commercial activities of our products. Our marketing is driven by our agents who are close to shop owners and know what the customer wants. They give us feedback about how the product is being received and what the customer needs. It is not that we do not get involved at all, the production department provide inputs towards the marketing execution plan and we educate dealers about our product. That’s how far we go in the marketing activities*” (R6)

It appeared they took this position because they are a start-up and do not have the resources to engage in full marketing activities or they believe it is more effective for their agents to be their “marketing experts”. But according to them, it was a combination of the fact that they are limited in resources and engrossed with development and perfection of their product, therefore, it was more effective to allow their agents to handle the marketing of the products.

When further asked, “Have you not explored online marketing?”

“Apart from our website and off course, our social media pages we haven’t done anything extra for marketing online” (R6)

This is in contrast with some other respondents, especially respondents that dealt with soft or digital products. “*For our marketing, we make use of facebook sdk, google analytics, fire base and Apps spy. These tools are used to identify potential customers and their biographic data, to check click rates on our app and how much we have paid for online marketing*” (R3)

In summary, respondents were unanimous on the fact that taking the whole production process very seriously and ensuring the product meets customers' needs is more important than dedicating lots of resources to commercial activities. *“when we dedicate financial resources to marketing, we always want to be sure we account for it through sales or patronage of our product... we make sure we put the best product out there so the product can speak for itself. The business world today is different, IT helps us spend less on commercial activities”*. (R9)

It was also gathered from the interview that to make appreciable sales, most start-ups choose their marketing projects and campaigns with a geographic environment in mind, while working towards increasing their reach to other markets.

From the respondents, it was gathered that the following IT tools were used at these stages of the NPD process:

Table 5: IT tools used in different NPD stages according to the research respondents

NPD Stage	IT tools/apparatus used
New Product Development Strategy	Open source cloud based word/text documents (google docs, MS SharePoint), Text, MS packages (word, visio), smart board, communication tools
Idea Generation	Survey analytics tools, MS excel, Balsamiq, Ideadrop
Screening and Evaluation	Balsamiq, Ideawake , Ideadrop and online survey tools
Business Analysis	<i>Google sheets, Custom tools using JavaScript, Tablaeu</i>
Development	Zeplin (to design apps), Laravel framework, react JS, Java, Kotlin, Dreamweaver, Notepad, Solid works (3D CAD design), CMS, Bibucket, Visul Studio, <i>Tmux, GitHub, Plastic ERP software and Lota3D fashion design</i>
Testing	Jasmine framework, Protractor, Hitmap
Commercialization	SEO tools, Social media., <i>Facebook sdk, Google analytics, Fire base and, Salesforce</i>

Most of these tools are similar or much more advanced than some of the tools outlined in the theoretical section. Some of the tools can function for 2 to 3 stages of the NPD process but they all have one stage they are tailored for. Many of these tools depend on the internet or resources online to functions, while some could be used offline. As predicted by Lilien and Rangaswamy (1997) that the internet will play a major role in the NPD process in the future, we can now see with verifiable evidences that the internet has a significant impact on the functionality of most of these tools in the

NPD process. One of the most interesting aspect of these tools is the ability to use them for identification of users for your product and to create a community or forum around them. They also help start-ups and companies involve their user community in their NPD process and activities. Company news groups and forums are increasingly becoming part of the product development process as forum members make suggestions towards product improvement. As these tools are integrated into the internet, the issues of security and threats is also a cause for concern. Start-ups that offer software services revealed they carry out periodical upgrades and provide patches in response to threats and security breaches for their IT systems and for their consumer products. They consider this a major part of their product maintenance process.

4.2. Results on Grouping of IT tools used in NPD process

From the theoretical section of this study, popular IT tools used in NPD process were grouped according to a study by Durmuşoğlu *et al* (2006). IT tools were grouped into *NPD process management tools, communication technologies, collaborative project management tools, financial analysis software, virtual prototyping tools* and *marketing tools*.

In carrying out this study, respondents were able to outline major IT tools that were relevant to them based on the aforementioned IT tools groups.

NPD Process Management Tools

In establishing stability in the NPD activities, including managing different NPD stages, these tools are important (Nambisan, 2003). NPD processes need to be designed and supported with the ideal IT apparatus and at the same time controlled. NPD process management supports the whole NPD life cycle. They summarize all the activities including techniques, methods, monitor resources such as human, organizational units and provide information (Bernroider and Bernroider, 2008). During the interview, respondents were asked about the process of product development in their firm and if they used any IT tool to monitor this process. It was gathered that firms that produced solid products such as smart bin, plastic packaging for instance, perceive process management tools as being more important to their development process than firms which developed software products only. These helped them monitor and track data and they could easily see when something goes wrong at a production workstation or unit. From the respondents, it was also gathered that the process management were more expensive than other grouping of IT tools. Some of them are licensed and custom made (flexible or could be easily tweaked to meet their needs). When a respondent was asked “what group of IT tools or IT based system do you use throughout the product development process and which group of tools are more important to you”. His words were “*Our process management tool is one of the most important tools we use in our development process, it was custom made by our*

parent company...I cannot even tell you what it is called because it is proprietary software, I don't have the right to tell you this on record". (R7)

However, from the answers by some other respondents, they do not view these tools as NPD process management tools but collaborative management tools. For those that clearly differentiate process management tools from other tools, the complexity of process management tools also need to be taken into account when deploying them to be used by NPD teams. As Marion *et al* (2014) perfectly sums it up that NPD leaders and teams need to understand the commitment that is needed for an effective implementation of these tools and they should be ready to commit the effort necessary to sustain knowledge and information within these tools over time.

Communication Technologies

Communication tools are vital to the steady flow and alignment of personnel to the NPD process, activities and goals. Effective communication establishes clear expectations, not just for employees but for customers too. When managers and NPD leaders convey a clear message, employees can better understand how their performance will impact the NPD process and what must be done to sustain a good performance. For the customers, a good communication flow establishes a relationship with the firms through positive feedback and complaint. Clear communication helps manage the expectations of customers about product issues. From the interview with respondents, we can deduce that communication tools or technologies are used more often than any other group of tools in the NPD process. As a respondent puts it:

"our technical team is in another location, we communicate through various platforms numerous times in a day, we depend on these communication platforms. Slack, Skype, emails are all important for our communication, ... I think communication tools support our work more than any other group of tools". (R5)

This indicated that communication tools are not just mere tools but are an integral part of the organizational process since communication with team members is a daily affair. They could also be integrated into other tools and could be used to easily share files and resources. In as much as IT helped NPD teams in different location to communicate easily, we also observed that some NPD leaders that are more advanced in age compared to the rest of the team in these start-ups tend to prioritise their choice communication platform over other platforms when communicating with the rest of the team, they mostly choose platforms they felt more comfortable with, which may not necessarily be the choice platform of the rest of the team. *"...our technical team, I mean our developers always want to communicate only through Slack but I personally find it tasking following up threads of conversation on Slack. I prefer to use emails to make directives and Skype conference call when we need to discuss.... maybe because I am older and still traditional..." (R9)*

There are many of these communication platforms emerging every day, it is best for NPD teams and sub teams to agree on the IT communication platforms that meets their needs and stick with them. To determine the right communication channel within the NPD team as they grow and as the NPD process evolves remains a challenge for NPD leaders. To expand more on the various ways IT communication platforms are used, the respondents were asked what IT platforms they use to communicate with their customers and if they differ from what they use internally within the organization. It was observed that apart from emails and phone numbers that customers could use to access these firms, respondents talked about being actively engaged on social media and leveraging it to communicate and form a “bond” with their customers.

“..as our products has to do with fashion, we make use of Instagram more than any other social platform, we have lots of followers and we post photos of amazing designs and fashion concepts, ...our Instagram community is huge and so customers reach out to us directly on Instagram”. (R8)

Another respondent said *“...our social media team jumps on trends or hashtags on twitter and are witty with their social media posts, using memes and posters. In your view, that might be marketing, in our view that’s also communication, we have a young team and we want our young customers who are on these platforms to perceive thisso that they may feel a connection with us”* (R7)

It can be deduced that communication with customers is beyond treating customers complaints or reaching out to customers only when surveys or tests are to be carried out but communication is actively engaging within the space (e.g. social media) of your customers and being part of conversations that is of interest to them.

Collaborative Project Management tools

According to study by Nambisan (2003), a wide range of collaborative tools are integrated into IT based systems which supports a distributed environment and that these collaborations have to cater for various NPD team members, as they differ in their IT needs, the nature of their participatory role in the NPD process, their knowledge of the product, their IT capabilities and their organizational culture. The idea behind the use of these group of tools is to actively involve NPD team members in the planning and control process, it is not just solely reserved for NPD leaders or managers but other team members. Communication tools are also integrated into collaborative management systems (Nambisan, 2003). The process of breaking down projects into smaller units is demanding, as well as keeping track of the time for each task. With these tools, complex tasks are broken down into small units and are assigned to the relevant members or departments in real time. Working in teams could be challenging and the question on how to increase the productivity of the team is what the managers mainly deal with in a project, and collaborative management tools also help to improve the productivity of the NPD

team. These tools also make it possible for professionals or experts in different locations to work together virtually. Collaborative project management tools are built around a central database that provides the NPD planning data and other information to all the NPD teams. They can also help NPD teams easily identify bottlenecks in the NPD process. From the answers by respondents, it was gathered that these tools are always integrated with other communication tools and some respondents that dealt in the development of software products did not seem to view NPD process management tools so differently from collaborative project management tools or they understood both group of tools to do the same job. When asked to list examples of tools under both groups, some listed the same examples. Meaning, they only deploy tools relevant to their job. Also, the new form of these technologies solve more than one problem. Therefore, it is important for NPD teams to only employ IT tools that are relevant to their business or NPD process. As highlighted in the theoretical part, there is an increase in technologies and many more of these technologies are beginning to do the same job. It is imperative for NPD leaders to choose the technology they can afford, that best serves them and is relevant to their needs (He-Yau *et al*, 2012).

Financial Analysis Software

Issues relating to finance is a major part of any product development process. The reason why NPD activities may stall at a certain stage could be as a result of financial constraint and this could greatly increase the chances of a firm exiting the market (Musso and Schiavo, 2008). It is therefore important for firms to undertake their financial analysis for NPD projects with depth and accuracy. This means that designing financial information gathering and interpretation process to make sure the right data for financial decision making are available when needed is important for the NPD speed and pace (Helfert, 2001). A lot of firms are increasingly taking a second look at the structuring of their financial reporting, not just from the standpoint of information but with regard to the whole financial reporting process and the value provided to the firm in terms of the planning, management and control (Rasmussen, Goldy and Solli, 2002), this is where financial analysis software becomes very useful to the NPD process. They help to measure profitability of products, develop proven methods to measure profitability, they improve the consistency of reporting the firm's financial results and improves the reporting process speed.

From the interview with respondents, it was gleaned that financial analysis software helped start-ups track incoming and outgoing finances in their NPD process. A respondent said:

“we use Brightbook. It is an accounting software we use to track our accounting systems, both inflow and out flow records, to send invoices, monitor and management payments”. (R7)

Apart from MS excel or any other form of spreadsheets, most respondents couldn't name the financial analysis software used by their accountant, but were sure their accountant used one form of financial software or the other to prepare periodical financial statements and reports for the firm.

Virtual Prototyping tools

Virtual prototyping in a working environment that is distributed, it expands the meaning of having physical product prototypes to a collection of data that when combined represents the prototype. This information can be accessed by different users in different locations (Rix *et al.*, 1995). Virtual prototyping tools enable a visual conception of the product in the NPD process. They bring about a faster time-to-market result for the NPD process as prototype products can be made more quickly. When early product prototypes are made, it allows for a fast verification of the NPD process assumptions. Notwithstanding, the set of requirements which needs to be evaluated and the complexity of the prototype contributes to the NPD process time. A respondent from a start-up that develops Smart Bins said: “...they enable our software developers to begin development long before the hardware design for our product is complete”. (R9)

It is clear that this tool influences the next development phase, making it more efficient and faster and also act as a stage gate to making decision about moving forward with the development process. These are the words of a respondent:

“before we begin full scale development for our new app idea or any new feature for our app, we use prototyping tools to create a small, downscale version of the app. That way we can see what it looks like and know if it is feasible to go into a full-scale development” (R3)

This appears to agree with position of Rix, *et al.* (1995) which suggests that virtual prototyping technologies is an important tool for NPD decision making, especially when used in the context of rapid prototyping. In rapid prototyping, rapidity is achieved by utilizing virtual prototyping tools with the cooperative effort of the NPD team. A benefit (and challenge) in developing virtual prototypes is that it relies heavily on a good flow of communication with the NPD teams (hard ware and software teams). As a respondent also echoed this view stating that “*virtual prototyping tools help our software and hard ware team know what the other team is trying to achieve*” (R9)

From the respondent that developed Smart Bins, it was gathered that virtual prototyping was used to simulate their entire hardware platform making using of various simulation models of the different blocks in the system. In developing software, it is required that these models are functionally accurate and that they contain all the visible interface of the software. Virtual prototyping tools also can give virtual teams access to information such as schedules of other teams, milestones and the independencies between the teams. A respondent that develops furniture products, said that *Solidworks* (a 3D CAD design software) is the virtual prototyping tool they used in their NPD process. The respondents that produces customised clothes said they use *Lota 3D fashion design* prototyping software for their NPD process. For the software developers, they listed *Invision*, *Balsmiq* and *Sliverstripe*. All in all, they all agreed on the same point that these tools made verification and testing of their new product idea concept faster.

Marketing tools

These IT based tools or systems are created to help firms promote their products to their target customers, they further strengthen the position of the firm in the market by aiding their marketing strategy. These could also be online customer relationship management (CRM) products, used to personalise, customise and distribute marketing materials and to also measure the success of marketing campaigns. The business strategy of using these tools in NPD activities is beyond increasing the volume of transaction but rather to increase revenue, profitability and to satisfy the customers. These tools also promote the relationship between businesses and their customers. When connected with the internet, these tools rapidly can match consumer characteristics with media databases and further evaluate them for various marketing mix (Pullicino, 2002). As highlighted in the commercialization section of this research analysis, social media has increasingly been a major tool for start-ups engaged in NPD activities to market their products at minimal cost. Start-ups that are into internet advertising make use of various technical tools, to push their new products to the customer. From the interview with respondents, it was gathered that there are two major categories of IT based systems for marketing of new products. They include:

Digital media: The use of software technology i.e. CRM software to reach potential customers with measurable communication that is well targeted. They also include search engine optimization (SEO), search engine marketing (SEM), mobile marketing, online advertisement that is interactive, online partnerships (affiliate marketing), opt-in email and the use of web analytics tools that can provide information about an internet users activities online including, location, search key words and IP address, i.e. google analytics.

Social media: A lot of business today are shifting their marketing focus to social media marketing. The goal of using social media as a tool for marketing is to develop an online relationship or bond with customers in an interactive fashion rather than to just get customer data. There are various platforms on social media for marketing and a lot of businesses have social account on major social media platforms. It is better for NPD leaders to realise which platform best suits their needs and place more focus on those platforms. As referenced earlier, one of the respondent from a start-up that is into customised clothing and fashion design, revealed that *Instagram* for instance, helps them more in their marketing than other social media platforms. Other social media platforms include twitter, Facebook, LinkedIn, Pinterest, Blogger, Reddit and YouTube. These social platforms could be used for marketing campaigns and they provide real time data on how well the campaigns are doing. For instance, Facebook pixel (an analytic which allows for the measurement of a campaign's effectiveness based on how people interact with your website) (Meert, 2017) can be used to build advertising audiences. Interestingly, there are software's such as *Hootsuite* (as revealed by a respondent), that can be used to manage all social media platforms in one interface. They are called social media management systems (SMMS).

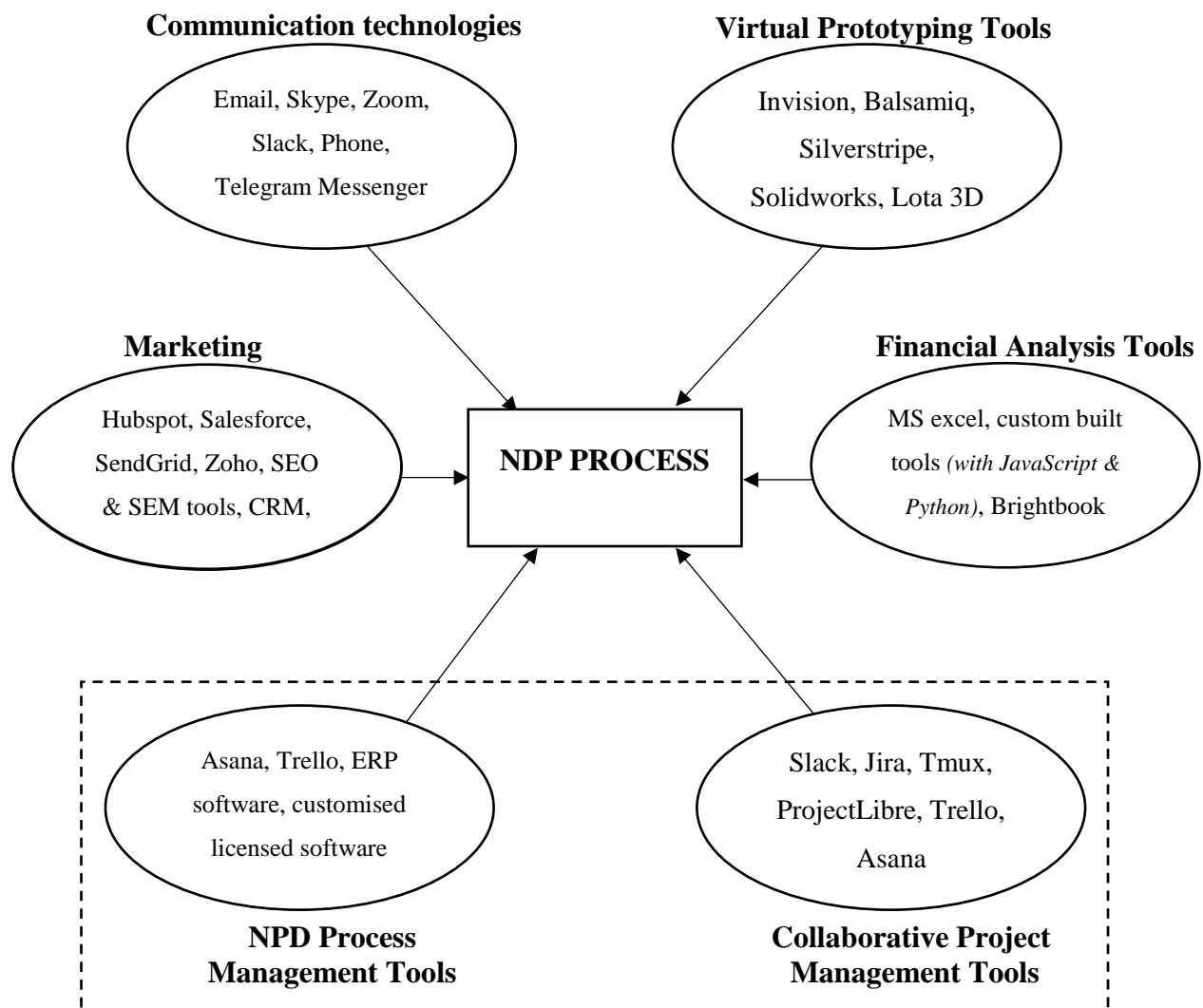


Figure 4: Group of IT tools used in the NPD process from research respondents

Figure 4 is a grouping of IT tools in the NPD process as revealed by the research respondents. As highlighted earlier, it was observed that research respondents that developed software products viewed NPD process management tools and Collaborative tools as doing the same job. This is partly because some of these new IT based technologies are beginning to integrate all functions needed for NPD activities into one system. Some IT based tools now integrate process management, collaboration project management tools and communication tools into a single system. This observation seems to agree with the study of Nambisan (2003), where the infusion of IT tools in NPD was examined along four dimensions. Collaboration tools integrated with communication technologies was one of the four examined dimensions. Also, the use of regular email service and video call technologies remains the main communication technology throughout the NPD process according to information gathered from the respondents. Emails are particularly useful for well written communication and video conference technologies are important for cross-functional NPD teams to hold virtual meetings from different geographic locations

The following subsections are some specific IT based tools that respondents employed for various tasks in their NPD Process. Most of the respondents are conversant with these tools. They include: Slack, Trello, Asana Salesforce and Balsamiq.

Slack: This is a cloud based collaboration and communication tool which provides an open channel for teams to organize conversations on a topic, project or team. This tool provides a transparent view of private channels for sensitive conversations, information, as well as for teamwork. Features that are included in this tool includes; file sharing, direct messaging, comments, stars to reference conversations and also harmonization with other cloud based internet services such as Dropbox and Google Drive. Other software tools can also be integrated into this tool. Files are archived and they could be synchronized on different devices (Slack, 2017).

Trello: This is a visual process management tool that has features for collaboration. This includes: comments, calendar, notification and file attachment. Either for team use or individual use, a user can create a checklist, label them, input dates and invite people to join the task. Other services and applications such as Google Drive, OneDrive and Dropbox could be integrated into this tool. This tool works in real time and could also be synchronized across various devices. Other features include voting, Snooze tasks later and filers (Trello, 2017).

Asana: This tool supports process management and team collaboration with features such as projects, tasks, dashboards and conversations. With this tool, a user can have a quick progress view of projects at a glance without the need to schedule meetings and team updates. The features in this tool include task and project creation, setting up due date and time, task and project conversation, archives of files that is searchable, calendars, a dashboard for checking the progress on projects, team management features and inbox for notification and updates. This tool can also be integrated into other applications such as Slack, Google Drive and Dropbox (Asana, 2017).

Salesforce: This is a cloud based customer relations management system. With this tool, a user can automate sales processes. It has an interface for managing task and for automatically routing and events that are important. Also included in its features are social networking plugins that enable the user to join in on conversation about their products. Integrated into this tool are analytic tools and services such as email alert and Google services (Salesforce, 2017).

Balsamiq: This is a software development wire framing tool that helps to lay out ideas quickly and create prototypes. This tool includes many drag-and-drop elements in forms of buttons and lists. They are styled as a hand-drawing making it intentionally rough and giving it a “natural” look. It also has the ability to collaborate with other team members for final thoughts and feedback (Balsamiq, 2017).

4.3. Findings and discussion

This study expands on the use of IT in the NPD process from the perspective of NPD leaders and highlights IT apparatus or group of tools they consider vital to the NPD process. Overall, the findings support the conceptual model formulated in the theoretical section of this study where the use IT is implemented in all the NPD stages. The results also show a positive dependence of NPD teams on the IT tools and infrastructure available to them. The following subheadings are significant findings from the research:

The Complexity of IT used increased along the NPD process

From this research, it was clear that dependence on IT in NPD increases as the NPD process moves forward. We can deduce this from the new product development strategy phase where less complex IT tools such as MS word are used, to the development stages where more complex IT tools such as CAD software or programing frameworks are used. This also raises the issues of the expertise or knowledge base of the NPD teams to use these IT tools, making a case for a good knowledge management system within the firm. A knowledge management system is a system for managing knowledge within a firm, it supports the creation, storage and dissemination of expertise and/or knowledge (McKenney, Nieveen and Strijker, 2008). Knowledge can be transferred along cross-functional teams and new findings or experiences along the NPD process can be well documented for future reference or use. For instance, in the context of the research carried out with these start-ups, the development phase of their NPD process is usually more technical and involves a lot of expertise. The IT used at this stage has become overspecialized, and in many cases, there are technical team blocks or units in this phase. Having to deal with multiple isolated storage of these IT expertise issues that arise makes the firm prone to enterprise-level errors and could lead to the creation of products that won't meet the customers satisfaction. Therefore, it is important for a good collaboration, communication and harmonization when using these knowledge sharing and storage arrangements. More importantly, standardizing this knowledge sharing and management systems with defined processes won't encourage the dependence on "heroes" within the organization or in the NPD process. Apart from the complexity of the IT tools used at the development phase, it was gathered this phase also relied more on IT. The reliance on IT to implement this stage of the NPD process isn't in the number or quantity of tools deployed but rather, these IT tools themselves are used to develop the new products. In other words, IT tools don't just support this stage, they "create" this stage. Apart from the expertise of the human resource involved, the tools significantly affect the outcome of these products. As all start-ups in this research are technologically driven, we see the use of a programming frameworks or CMS such as *Laravel framework* to write programing languages in the development of a software product.

Development methodology could inform the choice of IT tools used by firms

Another interesting angle of this study that popped out from the research but got little attention in the theoretical section of this work is the development methodology. NPD processes are not uniform across different products and firms. Some of the reasons for this is the degree of product innovation (Ozer, 2003) and the adopted development methodology. From the findings gathered, the development methodology for a product development process firms choose to adopt informs their choice of the IT tools they employ. While conducting the interviews, all start-ups that developed software referenced or made mention of their development methodology. They mostly used agile methodology in the development of their product. It also important to note that the development methodology could have a direct relationship with managing the complexity of the NPD. The choice of agile development methodology by firms that developed software influenced their choice to use an IT tool like an *Agile Software for Scrum* for their NPD management process. Firms that adopt the waterfall methodology for product development employ other forms of IT for managing their NPD process and firms that adopt both the agile and waterfall methodologies use the IT based systems that suits their needs.

IT helps to build a relationship between NPD teams and customers

Apart from using IT tools like online survey systems to involve the customers in screening ideas, the next visible participation of the customer in the NPD process is at the post development phases. Depending on the NPD process methodology, customers can actually be involved at every NPD phase and IT could support this. For instance, it was noticed that the IT tool or framework for the agile methodology supports the integration of the customers into the NPD process. Therefore, it can be said that IT could be used to support customer participation in the NPD process. This is reflected in the study by Jespersen *et al*, (2009), they concluded that IT tools are effective instruments for linking a firm or NPD team to their customers and that they can be used to build a relationship between product developers and product users. Building a relationship with the customer doesn't only have to begin during the commercialization or marketing of the new product but can actually begin at the idea phase and be sustained throughout the NPD process if the right development methodology and appropriate IT tool is used to support the process.

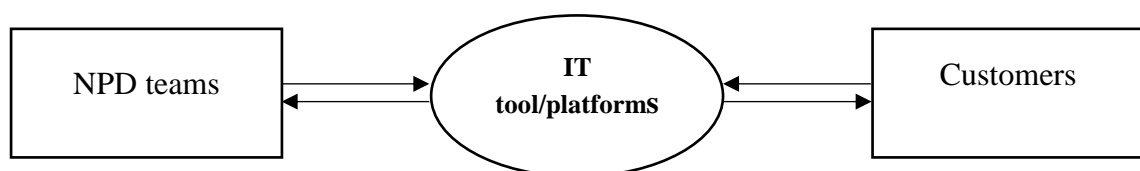


Figure 5: A model representation of using IT to build a relationship between NPD teams and Customers

IT tools with duplicate capabilities or functions

There are group of IT based tools, such as the communication technologies which are relevant to every phase of the NPD process but some IT tools and systems only serve specific phases of the NPD process (Zaharis *et al*, 2011). In the research findings, some tools for specific stages of the NPD can also do the job(s) of other phases of the NPD process. In other words, some group of IT tools basically do double Jobs. For instance, it was gathered from the result of this study that IT based tools used for the idea generation phase of the NPD process were the same IT based tool used for the idea screening and evaluation phases. As opposed to the conceptual model of this study which highlighted different tools for different NPD stages. There is various research into the improvement of different forms of IT and their effectiveness, this brings about the creation of IT products that can do more than one job. For firms that want to reduce the NPD process or make it more efficient, tools that have more than one function are beneficial.

The role of the internet

A good number of the IT based systems used in the NPD process by firms are more effective when linked with the resources on the internet. For instance, as observed in the idea generation phase of the NPD process, firms can use IT systems with the internet to reach target or potential customers to take part in their online surveys and help to generate and/or screen ideas. The internet is what makes the use of collaborative and communication tools possible along a distributed NPD network of teams. Over the internet and other linked resources, teams can collaborate and communicate effectively. The internet also improves organizational learning capabilities (Ozer, 2003), as there are repositories of resources on the web for use and consumption (McKenney *et al*, 2008). At the business analysis phase of the NPD process, information about competitors, the market, product substitute and other relevant data could be accessed over the internet with a click. Considering the convenience, speed, interactivity and coverage of the internet, firms can gather, categorize and store useful information and data for the NPD process. As a respondent describes it “*we use amazon web services for the storage of media files*” (R3). These kinds of internet resource are gaining traction among firms as it is cost effective to store files on the internet with cloud based services than the fast fading tradition of purchasing hardware storage machines. For virtual NPD teams, they are dependent on the internet to function and collaborate, this further translates into the speed and efficiency of the NPD process. As highlighted in the analysis and discussion of marketing tools; using various platforms, the internet is a major resource for the commercialization, marketing and advertisement of new products. However, NPD teams should not lose sight of internet security breaches and issues. Conscious efforts should be made to secure IT based systems used for NPD that are linked to the internet from spywares and malwares so as not to compromise the integrity of the NPD process or product.

Implications for Managerial Decisions

Though the research did not focus on managerial issues in the NPD process, decision making was highlighted in theory as a managerial challenge and that IT could help managers make better decisions. Decision making is crucial for the NPD process and its success. At every phase of the NPD process, decisions have to be made and these decisions have to be sound, posing minimal risk to the NPD process. Some decisions taken by managers are based on their experience, intuition or based on the information available to them at the time. The respondent for this study were managers and the question about how IT influenced their decision making was posed to them. In general, it was gathered from the interviews that data made available by IT systems influenced some of their decisions. A respondent further explained that it was part of his duty to study analytics about how customers are interacting with their application product. According to him, this helps them make informed decisions concerning user designs and user interface for their mobile applications. Based on the interviews, two managerial related issue in the use of IT for decision making was identified.: 1) Interpretation of data. Agreed that IT can be used to gather data, but the ability to translate data into valuable information is a totally different skill. A product manager interviewed, revealed that they outsource the interpretation of complex or technical data. 2) Managerial bias. As this study suggests that managers need to take different variables into account before making choices about the technology to be adopted for the NPD process, managerial bias or “human factor” cannot be ruled out as long as managers are solely responsible for making such decisions. As stated earlier, the need to standardize processes in an organization is important, it reduces the chances of individuals or groups imposing their choices (which may counterproductive) on the rest of the organization. It is never a healthy organizational culture.

Stalling of the NPD process

The discussion about the research findings will be incomplete without addressing the fact that lack of the technical know-how to make use of some IT tools or the lack of the tools can stall an NPD process. Some of the IT used in NPD has a steep learning curve or a foundational knowledge base, therefore, firms pay or employ experts proficient in these tools to deploy them for NPD activities. Some small firms may also lack the resources to procure these tools. As mentioned earlier, a respondent revealed they had to halt the development of a product idea because they lacked the required IT tools to gather the needed data and information for development of the product. Also, there is a need for firms to protect their product ideas. When vital aspects of the NPD process that needs IT to be implemented is outsourced due to the lack of expertise on the NPD team, you run the risk of protected information about the product idea slipping out of the organization into the wrong hands. Therefore, the lack of IT and/or the lack of expertise to operate IT based systems can stall the NPD process.

Limitations of the study

This study found prove in the conceptual model for the use of IT in NPD process. However, the study has some limitations. One of such imitation is the fact that a qualitative research was carried out and low external validity with little ability to generalize results is a common feature of this research methodology (Jalma, 2008). The sample of the participant for this study wasn't a representation of any specific product industry or geographic location, therefore the results primarily reflects the experiences of the interviewed participant in the context of their firm and this study. The interviews for the study was carried out with product developers' in start-ups only. This is a homogeneous group and there are variables that are common to product development in start-ups only which is potentially bound to reflect in the analysis and results. Also within this group, five participants (which is about fifty five percent) are developers of only software products, the remaining participants develop a mix of tangible and software products. Therefore, the results and analysis might be overwhelmingly reflective of the experience of software product development only. Finally, in as much as strong measures were taken by the interviewer to avoid influencing the data collection and analysis, it is possible the personality of the interviewer might have interfered unduly in the interview process, i.e. manifesting in the form of implicit bias towards an expected outcome when probing participants.

Future research directions

First, all the limitations outlined are areas for consideration and caution in future studies of any related work within the context of this study. For instance, as this study was carried out with only nine start-ups, the sample of research participant could be increased for future studies and it should cut across more product industries. There has been a lot of work on the use of IT in the NPD process which are reflective of mature organizations and firms but more comparative studies regarding the use of IT in product development for start-ups and mature industries can be done, observing their uniqueness, similarities and differences and the implications on the outcome of a new product. Information technology capabilities (i.e. internet speed) or infrastructure of a continent or country depends on so many variables (Rohman and Bohlin, 2012), and this study isn't reflective of a specific geographic location. With this background, future research directions can explore the use of IT for product development in the context of specific geographic locations. Finally, this study was carried out with firms or start-ups that have a product unit and/or develop tangible or software products. It should be interesting to have a comparative study with empirical findings about the use of IT in new product development firms and new service development firms, observing their structure, uniqueness, similarities and differences in their business process and approach.

CONCLUSIONS

1. In view of the theoretical context of this study, a framework for defining the stages of the NPD process developed by Booz, *et al* (1982) was the bedrock for which this study was developed. Although there are other NPD frameworks as summarised in the study, the model of Booz, *et al* (1982) is one of the first well known model for NPD. The NPD stages according to this model includes: New Product Strategy Development, Idea Generation, Screening and Evaluation, Business Analysis, Development, Testing and Commercialization.
2. The use of IT at every stage of the NPD process was highlighted, including the benefits and the draw backs of adopting technology in a firm or during a NPD process. Also, the link between IT and NPD was revealed based on the theories used in IT research. They include the technology acceptance model (TAM), unified theory of acceptance and use technology (UTAUT), theory of planned behaviour (TPB), diffusion of innovations (DOI) and technology, organization and environmental framework (TOE). Only the DOI and TOE theories were expanded as they are the only theories that could be adopted for NPD in the context of this study. Examples of IT tools used at each NPD stages was listed based on other studies in this area. Also, IT tools used in the NPD process were grouped into: NPD process management tools, communication technologies, collaborative project management tools, financial analysis software, virtual prototyping ttols and marketing tools. Their unique benefits of these group of IT and how they support the NPD process was outlined.
3. A model was conceptualized for the use IT at NPD stages and the NPD process as a whole based on the grouping and examples of IT tools. This model is built around the NPD stages as developed by Booz, *et al* (1982).
4. Based on this conceptualized model, an empirical study was done with product development leaders of start-ups. This research was carried out with qualitative methodology with the goal to expand on the use of IT at every stage of the NPD process from the perspective of the interviewed product development leaders. It revealed what IT infrastructure or apparatus or group of tools product development consider vital to the NPD process, how they practically employed IT in their NPD process and how IT informs their NPD decisions.

The results from this study could be useful for firms and product development leaders making use of different forms of IT in their NPD process. These results could be adopted and applied to the implementation of different NPD models for product industries. This theoretical aspect of this study also touched some other areas of NPD, which includes: making using of IT for NPD managerial decisions, some project management phenomenon that justifies the use of IT in NPD and a detailed outline of organizational objectives for NPD based on other research work on NPD.

Recommendations

Based on the analysis, results and findings from this study, the following recommendations could be provided.

1. Although by their very nature, some NPD stages are more critical. Notwithstanding, every stage in a product development activity impacts the outcome. Therefore, each NPD stage should be treated with an equal sense of importance. It is also important to understand which stage is more critical for your product and in your industry. Depending on other variables such as the nature of products, the target customer, etc. some NPD stages may not apply to some firms or industries. However, they may not differ entirely. What is important, is that product development requires a careful and detailed process that shouldn't be compromised.
2. As highlighted severally in this study, IT plays an important role in NPD and when employed efficiently, it could give firms an edge over their competitors in the market. In this regard, it is important for firms to understand their industry, their customers and the expertise (competence and knowledge base of the NPD team) at their disposal before they can efficiently employ the use of IT in their NPD process. In other words, an effective outcome for using IT in NPD is as good as the firms' business strategy and their NPD teams. IT in itself doesn't just help firms in their NPD process but how it is used makes the difference.
3. A Successful NPD requires an integration of all elements in the NPD process. Firms that want to realise more benefits from IT can also employ IT to develop cross-functional NPD teams to match their capabilities with complementary expertise they need in other business areas such as human resource, marketing etc. As firms invest in various new information technologies for their NPD, they should also invest in the knowledge base of their NPD teams. NPD is dynamic and unpredictable; the structure of firms should be flexible and have a threshold to adapt to changes required to meet their NPD needs. Organizational processes should be well defined and followed, the NPD process shouldn't be defined by choices of personalities or a group but by the well-defined and laid down organizational processes for the common goal of the product outcome and organization.
4. IT makes it easier for firms to involve their target customers in their NPD activities. So many IT driven digital and social media offer platforms firms can leverage in this regard. Therefore, firms should adopt NPD development methodologies that will afford them the opportunity to fully utilize IT capabilities for involving customers in their NPD process. One of the goals of any NPD process is to meet the needs of customers, firms should use IT to tailor these customer needs in NPD by involving the customers in the NPD process.

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INTRODUCTION

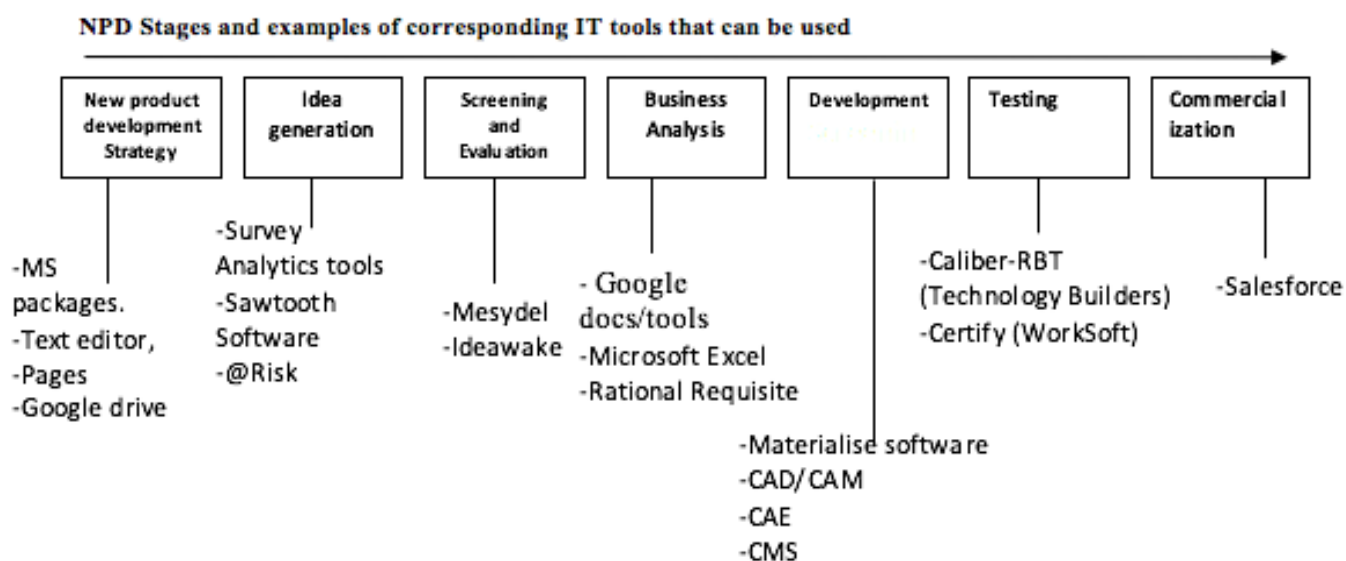
This interview is conducted by *Midohoabasi Essienubong*; a *Master’s Student of Kaunas University of Technology, Lithuania* for a study about “**The Use of Information Technology in New Product development process**”

You were selected as a participant in this study because you have headed/managed product development process or teams. This study is for educational purpose only and information from this interview/study will not be transferred to a third party. In any sort of report we might publish, we will not include any personal or sensitive information about you and the firm/organization you represent, in other words, anonymity is guaranteed. Research records will be stored securely and only researchers will have access to them. This interview will last between 20 to 30 minutes and you are free to decline any question or withdraw at any time.

If you agree, we would like to audio-record this interview and *Midohoabasi Essienubong* will be the only person with access to the audio record file of this interview. Once the interview has been transcribed, the recorded audio files will be permanently deleted.

Study Background Information

The purpose of this study is to explore how Information Technology (IT) is being used in each stage of the New Product Development (NPD) process. IT has become an integral part of NPD, yet little is written about what IT based systems, infrastructures, software’s, tools etc. are being used to support the NPD process. This study seeks to understand the level of participatory role IT plays in the NPD process from the perspective of product development leaders and managers.



INTERVIEW PROTOCOL

1. What is the nature of your firm?
 - How many years have your firms existed?
 - How big is your firm (number of employees, etc.)
 - What is the nature of your product(s)?
2. What is your portfolio?
 - How long have you been working in this sector or portfolio?
3. What IT tools or systems are more important in the NPD process?
4. What NPD stages require or rely more on IT Tools or systems?
5. What IT tools and systems is preferred in NPD and why?
6. What is the standard procedure for new product development at your firm?
7. What IT tools, infrastructures or software's do you use in the Following NPD stages
 - **New Product Development Strategy** e.g. MS packages, text editor
 - **Idea Generation** e.g. Sawtooth software, idea drop, @risk
 - **Screening and Evaluation** e.g. Mesydel, Ideawake
 - **Business Analysis** e.g. Google docs/tools, Rational Requisite
 - **Development** e.g. Materialise software, CAD/CAM, CMS
 - **Testing** e.g. Caliber-RBT (Technology Builders), Certify (WorkSoft)
 - **Commercialization** e.g. Sales force, Social media (facebook, twitter)
8. What IT tools in your opinion do you think is more important in the NPD process?
9. How does IT tools used for NPD influence your managerial decisions?
10. What group of IT tools or IT based systems do you use throughout the product development process and which group of tools is more important to you?
 - **NPD process management tools** e.g. *Agile Program, Sopheon Accolade and Aanza,*
 - **Communication Technologies** e.g. *e-mail, instant messaging, listserv, videoconferencing, teleconferencing, website and extranet, Skype, Slack*
 - **Collaborative Project Management** e.g. *eProject, TeamPlay Paradigm, CommonOffice.com and Microsoft sharepoint,*
 - **Financial analysis software** e.g. *are Sopheon Instatrack, Ready Ratios and Capterra*
 - **Virtual prototyping** e.g. *Autodesk inventor and Optitex*
 - **Marketing tools.** e.g. *DemamMore, TagTeam, NuEdge Suite, Triggers and Marketing Materials Management.*