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PROCESSES AND CHANNELS OF TECHNOLOGY UPGRADING OF KNOWLEDGE-BASED FIRMS IN NIGERIA

Emmanuel Makanjuola Ogunjemilua[1*], Abiodun Isaac Oyebola[2], Ifeoluwa Felicia Ogunjemilua[3], Felix Akinlade Babatola[4], and Ibukun Marcus Falayi[5]

[1]Department of Entrepreneurship, Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State, Nigeria.

[2]African Institute for Science Policy and Innovations, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

[3]Department of Foreign Languages, Faculty of Arts, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

[4]Department of Business Administration, Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State, Nigeria.

[5]Department of Accounting, Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State, Nigeria.

[*]Corresponding Author's Email: makanjuola19@gmail.com

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ABSTRACT: *This study examined the processes and channels of technology upgrading of knowledge-based firms (KBF) in Nigeria. The study adapted OECD (2004) classification of knowledge-based industry in Nigeria context such as low technology-based and high technology-based firms. Questionnaires were administered on fifty (50) selected knowledge firms and 72% of the questionnaires retrieved were used for the analysis of this study. The results revealed that low-tech based firms (47.8%) and high-tech based firms (21.1%) upgraded technology through the process of technology spillover; likewise, low-tech based firms (46.8%) and high-tech based firms (52.4%) upgraded technology through the process of technology transfer. The study further indicated that low-tec based firms (46%) and high-tech based firms (81%) upgraded technology through trading channels. Also, low-tech based firms (47.9%) and high-tech based firms (95.5%) upgraded technology through foreign direct investment channels, likewise, low-tech based firms (38.9%) and high-tech based firms (29.9%) upgraded technology through technology development alliance. The study concluded that low-tech based firms in Nigeria need to improve more on their technology transfer process while high-tech based firms also need to improve on their technology spillover technologies through different systems that are customers' driven.*

KEYWORDS: Technology upgrading, Knowledge-based firms, Nigeria.

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INTRODUCTION

Knowledge-based industries (KBI) are R & D oriented industries and knowledge intensive industries (KII) (Mahdjoubi, 1997). The sub-sectors covered in these industries include telecommunications, pharmaceuticals, chemicals, software, medical equipment, biotechnology, information technology and aviation (Mahdjoubi, 1997; Wang, 2015). The knowledge-based industries are classified based on their R&D intensities viz: high-tech industries, medium-high tech industries, medium low-tech industries and low-tech industries (OECD, 1996; 2004; Smith, 2005). Hence, the examples of the classified knowledge-based industries as reiterated by the identified publications include the following; first, high-technology industries are aircraft and spacecraft, pharmaceuticals, office, accounting and computing machinery, radio, TV and communications equipment, medical, precision and optical instruments. Second, medium-high-technology industries are electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, chemicals (excluding pharmaceuticals, railroad equipment and transport equipment, machinery and equipment among others). Third, medium low-technology industries are shipbuilding, rubber and plastic products, stone, clay and glass, other non-metallics mineral products, petroleum products and nuclear fuel, basic metals and fabricated metal products. Fourth, low-technology industries are manufacturing, recycling, food products, beverage and tobacco, paper and printing, textile and clothing, wood and furniture products. The conglomeration of knowledge-based firms is called knowledge-based industries; hence, knowledge-based firms are the last unit of knowledge-based industries.

Intuitively, knowledge-based firms (KBF) are innovative firms or science and technology-based firms that focus on the making, transferring and the use of knowledge and information for value addition to their economic activities. The aforementioned definition of knowledge-based firms is in line with literature on innovation studies. Though all firms are to some extent dependent on technological knowledge inputs, some firms are knowledge intensive than others (OECD, 1996). According to Milkovich *et al.* (1991), knowledge-based firms have highly educated staff with a larger proportion of their resources based on intellectual human capital. The authors further note that KBF do not depend much on capital-intensive investment as traditional type firms. KBF are essentially technology-based firms. Technology is the motivating factor in transforming resources into goods and services of KBF (Ajagbe, *et al.*, 2012). Knowledge-based firms were distinguished into two major types such as R&D based and non-R&D based firms otherwise called professional service firms (Alvesson, 2004). Non-R&D based firms focus on intangible products and often deal directly with customers while R&D firms produce tangible products with less direct contact with customers. However, these firms must meet up with their customers' needs by continuously upgrading their technology.

Firm level technology upgrading deals with improvement in their technological knowledge (disembodied technologies) and technology artifacts (embodied technologies) (Scarso & Bolisani, 2010). These embodied and disembodied technologies are the two basic forms of 'inter-agent or inter-industry flows' (Smith, 2000). Embodied technology entails knowledge instilled into capital projects such as equipment and machinery while disembodied technology involves application of knowledge acquired via periodicals, literatures, educational systems, consultancy, experience, and movement of personnel among others (Smith, 2000). The 'firm-level' technology upgrading during fierce competition needs institutional change and resource reconfiguration in high tech infrastructure, and increased global integration (Rasiah, 2015). Firms improve their technology through innovation activities such as in-house or outsourced R&D, paying for embodied and disembodied technology transfers and patents, buying capital

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goods with new embodied technologies such as change in the production processes, products, commercialization or organizational forms, buying of computer hardware and software, spending on machineries and equipment, paying for materials and labor related to innovation activities carried out in the firms (Bustos, 2005). In addition, technology upgrading involves the training and re-training of personnel to effectively and efficiently use adopted equipment, the purchase of new machinery and equipment (Khan, 2007). Despite the fact that these firms are continuously upgrading their technology, they still face challenges that are both internal and external.

LITERATURE REVIEW

(a) Technology upgrading

Firms are under pressure to improve their technology due to tense competition. Rasiah (2015) notes that technology upgrading at the firm level during competition needs institutional restructuring and increased global integration among others. Technology upgrading at the firm level occurs through different innovation activities such as R&D, disembodied technology transfers and patents, acquisition of technology with new embodied technologies such as change in the production processes, products, commercialization or organizational forms, buying of computer hardware and software, spending on machineries and equipment, paying for materials and labor related to innovation activities carried out in the firms (Bustos, 2005). Also, firms upgrade disembodied technology by training and re-training personnel to effectively and efficiently use acquired embodied technology (Khan, 2007) i.e to effectively use adopted/acquired machinery and equipment.

Technology upgrading can be defined at national, industry and firm levels depending on the focus or the intention of the scholar(s). At firm level, technology upgrading is defined as improvement on existing firm level resources (tangible and intangible) that enabled effective and more efficient performance relative to the earlier performance. Technology upgrading was also defined by Scarso and Bolisani (2010) as improvement in the embodied technologies and disembodied technologies of firms. These improved technologies, embodied and disembodied, are the two basic forms of inter-agent or inter-industry flows (Smith, 2000). Embodied technology entails knowledge instilled into machinery and equipment or product while disembodied technology involves the application of knowledge acquired via periodicals, education systems, experience, and personnel turnover among others (Smith, 2000). In other words, disembodied technology involves the application of knowledge acquired via formal education, informal education or both forms of education.

Meanwhile, human capital is synonymous to disembodied technology to be measured with level of human competence. The embodied technology produced by non-service knowledge-based industries (KBI) enter as intermediate inputs or capital into other firms' production processes informing of machineries or materials and such leads to the improvement in the performance of the receiving firms (Smith, 2000). By implication, improvement in the performance of KBF or KBI will result in quality or productivity improvements in another. The receiving firm needs to improve their absorptive capacity to effectively absorb the acquired knowledge-based products into their system (Smith, 2000). The essence of improving the ability of a firm to either improve process or product or organizational knowledge is to be more

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profitable (Gereffi, 1999). The improvement of product and process technology of firms is a gradual process that requires a shift from lower value activities to high value activities in their business environment (Radosevic & Yoruk, 2015).

Technology upgrading is an improvement in the technologies deployed in running the affairs of the business activities. The technologies deployed include process technology and products technology. In addition, the technology upgrading of a firm deals with an improvement in their technological knowledge *(disembodied technologies)* and technology artifacts *(embodied technologies)* (Scarso & Bolisani, 2010). The four pillars that promote critical support for technology upgrading in firms are systemic quadrants namely high-tech infrastructure, network cohesion, global integration and basic infrastructure (Rasiah, 2015). There are two categorical factors to be considered in technology upgrading such as external and internal factors (Nelson, 2008). These internal factors to some extent can be managed and such includes: opportunity cost, priority and goals of the firms, managerial and organizational capability, and financial capability. The external factors influencing technology upgrading include meeting concurrent changes in market demand, government policy on market regulation, functionality and suitability of technology. More importantly, the analysis of socio-economic implication of firm level technology upgrading is highly important in the evaluation of cost and benefits that are associated with technology upgrading. Therefore, the demand for firm level technology upgrading depends on the primary motivation which is either internal or external factor(s) (Nelson, 2008).

The effect of technology upgrading might be visible, but at any event, it can be argued that improved organizational capability will improve management of valuable resources and collaboration will enhance capacity-building for sustainable development in acquisition or development, adaptation, diffusion and transfer of technologies to the appropriate location (Nelson, 2008). There are some processes and channels of technology upgrading which are organizational in nature. The processes and channels are discussed below:

(i) Process of technology upgrading

Process of technology upgrading determines how firms absorb their technologies and their absorptive capacity. Absorptive capacity of firms is a germane factor determining how effective is the technology acquired or absorbed (either spillover or transfer) on the performance of the receiving firm. The influence of technology absorbed from multinational companies (MNCs) depends on technology absorptive capability of the receiving firms (Krogstrup & Matar, 2005). Absorptive capability in knowledge-based firms needs to be high based on the level of innovative nature of the firms. Absorptive capacity is the bedrock of innovative activities that are ongoing in KBF. Absorptive capacity is the firms' ability to integrate and manage knowledge identified in order to improve firms' innovation and competitive performance. Absorptive capacity of an organization needs to be properly managed with the aid of knowledge management techniques. Some of the knowledge management techniques can either be information technology (IT) or non-information technology based (non-IT) (Young, 2010). For IT based, such include "document libraries leading to a document management system, knowledge bases (Wikis), blogs, social network services, voice and voice-over-internet protocol (VOIP), advanced search tools, building knowledge clusters, expert locator and collaborative virtual workspaces. For non-IT methods and tools such as brainstorming, learning and idea capturing, peer assistance, learning reviews,

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after action review, storytelling, collaborative physical workspace, knowledge management assessment tool, knowledge café, community of practice and taxonomy" among others.

There are other factors aside from absorptive capacity that determine technology transfer such as the structural support system of the firm, size and years of operation, ownership or management structure, scalability structure among others. The state of absorptive capacity of receiving firms will determine how they exploit new technology from the multinational companies (MNCs) (Abereijo & Ilori, 2012). Hence, only firms with adequate absorptive capability due to a strong R&D base will benefit from the acquired technology from the MNCs. Also, technology transfer and spillover depend on the absorptive capacity of the localized firms (Pant & Mondal, 2010). Technology transfers, technology spillovers and technology diffusion influence economic growth (Wang & Mu, 2012).

The process of technology absorption could either be formal (technology transfer) or informal (technology spillover). It is formal when the trainer voluntarily transfers its technology to the protégé such as studying manuals, periodicals from manufacturers of such technology, learning from technology frontiers from abroad, receiving technical support, open innovation (knowledge sharing process i.e knowledge donation and knowledge collection) and training. Technology spillover is informal technology transfer and is being done via imitation, interaction and watching. In the case of informal technology transfer, the owner of such technology (technology host) will not be aware of the spillover effect of its technology to the receiver.

Effective technology spillover is the transfer of technologies from the owner and results in improved performance of the receiving firms without the knowledge of the transferring firms (Vera-Cruz & Dutrénit, 2005). Technology spillover leads to production efficiency benefits (Abereijo & Ilori, 2012), and improved managerial skills and market range for the receiving firms. Also, knowledge created by one agent could be transmitted to other related agents by affecting their R&D or other economic performances (Kim & Kim, 2005). Technology spillover is synonymous to knowledge spillover. Knowledge spillover is the process of learning from research outcomes of other researchers to increase research productivity without fully compensating the owners for the value of such learning (Branstetter, 2006).

There are differences in the level of technology across economies and developing countries have been working in meeting up to the level of technology of developed economies via technology transfers, spillovers and diffusion (Wang & Mu, 2012).

(ii) Channels of technology upgrading

Technology spillover effect is a driving force in economic growth and diffuses across industries of the host country through different channels. The channel of spillover implies "learning by watching effect" (Blomström *et al.*, 1999), trade, foreign direct investment (FDI) and technology development alliance. The differences in the level of technology in economies are bridged via different channels of technology upgrading so as to attract foreign capital that are both financial and non-financial.

Channels of technology upgrading involve trade and economic activities, technology development alliance(s) and organizational capital of local firms with multinational firms (Abereijo & Ilori, 2012). Technology spillover via human capital is related to continuous improvement of personnel by MNCs through the movement of these personnel toward

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domestic firms. Technology spillover for the host firm has been an important route of the outsourcing of knowledge embodied in FDI brought in by the MNCs. Foreign direct investment drives technology development alliances. Technology development alliance is as a result of domestic firms having alliances with other domestic or multinational companies for R&D activities. Technology development alliance is a collective process in which emerging firms access advanced technology and further localize it in their production system (OECD, 2015). Emerging economies' firms having access to foreign technology through FDI is like establishing R&D centers in developed economies, and competitive pressure among a number of home and host firms drive technology development alliances through FDI (OECD, 2015). Alliance partners share information, jointly develop products or services (Mueller *et al.,* 2010) and such results in competitive advantage due to cost sharing among the partners. There are three different dimensions and components of technology upgrading.

The three dimensions of technology upgrading are intensity of technology upgrading by types, interaction with the global economy and breadth of technology upgrading (Radosevic & Yoruk, 2015). Each of these dimensions have three components. One, the intensity of technology upgrading by types entails production capability, technology capability, R&D and knowledge capability. Two, the interaction with the global economy entails technology (embodied) imports, knowledge imports and knowledge cooperation. Three, breadth of technology upgrading entails infrastructure (human, physical and organizational), structural change and firms' structure. The dimensions of technology upgrading implies improvement in the embodied and disembodied technologies of the firms.

Technology upgrading depends on organizational learning and such is an instigator for innovativeness (Giniūnienė & Jurksiene, 2015). The embodied technologies are product and process innovation. This is because improvement in the product (diversification and functionality) may be new to the firm, their industry, the economy or to the world. In the 90s, Schumpeter (1934) defined innovation as new products, new processes, new sources of supply, new market and new organization activities. Innovation is the basis for unavoidable changes in an enterprise (Baregheh *et al.,* 2012) which could be inform of technology upgrading; creating new brand of products, new management system, new services, and new economic activities and new business models (Giniuniene & Jurksiene, 2015).

The selected technology for upgrading might be a function of internal factors, external factors or both such as windows of opportunities, that requires immediate upgrading of technology. By implication, transitions stem from improving the technology upgrading of the firms either via its embodied technology or disembodied technology and the resultant effect of that will lead to improved financial performance. Danneels (2002) considered product innovation as an operational routine and based his argument on five high-tech firms studied. Danneels, came up with the conclusion that new product development was associated with the development and regeneration of firm-level capabilities. Zahra and George (2002) argued that absorptive capacity thus affects the firm's ability to produce and deploy technology required to build other capabilities.

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Statement of the problem

Despite diverse literature on technology upgrading, there is dearth of information on the processes and channels of technology upgrading and the nature of technology upgrading in developing countries while data for Nigeria is missing. Yet these firms play a vital role in the development of Nigeria's economy. This study will contribute to the existing body of knowledge on technology upgrading by providing answers to the listed research questions below:

(i) What are the processes and channels of technology upgrading of the selected firms in Southwestern Nigeria?

(ii) What is the nature of technology upgrading of the firms?

The remaining part of the study is structured thus: literature review, methodology, results and discussion, conclusion, further studies and acknowledgement.

METHODOLOGY

The study was carried out in three selected states in Southwestern Nigeria, namely: Lagos, Oyo and Ogun states. The research draws insights and builds on the works by OECD (1996, 2004) and Smith (2005) on classification of knowledge-based industry, while adapting the framework to suit the local context in Nigeria. This includes high tech and medium high-tech firms as high-tech based firms, and medium low-tech and low-tech firms as low-tech The analysis of this study will be firm based; hence, this study adapted the four OECD classification of knowledge-based industry into two such as "low tech-based firms and high tech-based firms". A set of questionnaires was deployed in the data collection process. The one hundred (100) questionnaire administered to the selected KBF elicited information on the processes, channels and the nature of technology upgrading. Out of the 72% of questionnaires retrieved from the selected KBF, fifty (50) were low-tech based firms and twenty-two (22) were high-tech based firms in the three states. Variable measurements for processes of technology upgrading were technology transfer and spillover, while channels of technology upgrading were trading activities, foreign direct investment (FDI) and technology development alliance (TDA). The variables were measured with five points Likert scale of 0-20% as min. and 81-100% as max. The nature of the upgrading was captured with the type of products and process technology that were upgraded by the selected firms. The data obtained were analyzed with frequency, percentages, mean, cross tabulations and clustering analysis (dendrogram).

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RESULTS AND DISCUSSION

Processes and Channels of Technology Upgrading (Technology Absorption)

Table 1 shows that low-tech based firms (47.8%) in Southwestern Nigeria upgrade their technology through technology spillover than high-tech based firms (21.1%). This supports the report of Haddad and Harrison (1991) that large technology gap MNCs inhibit spillover effects. Also, this study supports Cantwell (1989)'s report that spillovers are most important in the industries where the technology gap is small. This implies that the technology gap in low-tech based firms is small unlike the high-tech based firms. The study buttressed the report of Findlay (1978) and Wand and Blomstrom (1992) that spillovers effect grows with the size of the technology gap in the industries.

Table 1 further shows that both high-tech based firms (52.4%) and low-tech based firms (47.8%) in Southwestern Nigeria upgrade their technology through technology transfer. The finding from this study corroborated with the Oyelaran-Oyeyinka's (2006) report that "some leaders in tech-based firms tend to share their knowledge of the market trends with the smaller players while some others rely on spying what the leader is currently stocking to determine what components to import". This is because technology-based trading activities need close market monitoring based on quickness in equipment outdated and emergence of new-streams of technologies.

The channels of technology upgrading are the transaction medium in which the selected KBF upgrade their technology. This economic medium of the selected firms is related to trading activities with partners (customers, suppliers, and competitors), foreign direct investment and technology development alliance (license procurement and joint R&D).

Table 1: Processes of technology upgrading

Characteristics	Q	Class of the Knowledge-based Firm		Total
		Low- Tech based	High- Tech based	
Technology upgrading through Technology Spillover	Very Low	-	3 (15.8%)	3 (4.6%)
	Low	1 (2.2%)	1 (5.3%)	2 (3.1%)
	Moderate	6 (13%)	9 (47.4%)	15 (23.1%)
	High	17 (37%)	2 (10.4%)	19 (29.2%)
	Very High	22 (47.8%)	4 (21.1%)	26 (40.0%)
Total		**46 (100.0%)**	**19 (100.0%)**	**65 (100.0%)**

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Technology upgrading through Technology transfer	Low	1 (2.1%)	-	1 (1.5%)
	Moderate	5 (10.6%)	3 (14.3%)	8 (11.8%)
	High	19 (40.4%)	7 (33.3%)	26 (38.2%)
	Very High	22 (46.8%)	11 (52.4%)	33 (48.5%)
Total		47 (100.0%)	21 (100.0%)	68 (100.0%)

Keys
Level of commitment: very Low =0-20%; Low = 21-40%, Moderate = 41-60%, High = 61-80%, very high = 81-100%
Q = = Commitment level;

Low- tech based = Low tech firms and Medium low-tech firms;
High- tech based = Medium high tech and high-tech firms

Table 2 shows that high-tech based firms (81%) in Southwestern Nigeria upgrade their technology than low-tech based firms (46%) through trading activities with customers, suppliers and competitors. This complements Lundvall (2016) that innovation is interactive and not linear i.e innovation stems from the users, competitors and business environment and not only from the producers. In addition to Lundvall's (2016) report about the interactive nature of innovation, this study shows that high-tech based firms are more interactive with their customers than low-tech based firms through different trading activities with customers, suppliers of embodied technologies and competitors. In addition, the table further shows that high-tech based firms upgrade their technologies than low-tech based firms through foreign direct investment such as importation of advanced machineries and equipment, and subcontracting to other firms. This study affirms the proposition of Barbosa and Eiriz (2009) that "firms do not benefit equally from the presence of MNCs.

In addition, high-tech based firms (59.2%) upgrade their technology more than low-tech based firms (47.9%) to some extent through technology development alliance. This complement OECD (2015) report that foreign direct investment drives technology development alliance of firms. This technology development alliance is a result of domestic firms having alliances with other domestic or multinational companies for R&D activities. Technology development alliance is a cumulative process through which emerging firms gain access to advanced technology and further localize it with their technological capabilities (OECD, 2015).

By implication, the high-tech based firms upgrade their technology more than low-tech based firms through the channels of technology upgrading, this is because of the short life cycle of high- tech based products and the dynamic nature of their business environment.

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Table 2 Channels of technology upgrading

Characteristics	Q	Class of the knowledge-based firm		Total
		Low-tech based	High- tech based	
Firms upgrade technology through trading partners (customers, suppliers and competitors)	Low	2 (4%)	-	2 (2.8%)
	Moderate	4 (8%)	-	4 (5.6%)
	High	21 (42%)	4 (19%)	25 (35.2%)
	Very High	23 (46%)	17 (81%)	40 (56.3%)
Total		**50 (100.0%)**	**21 (100.0%)**	**71 (100.0%)**
Firm upgrade technology through Foreign direct investment (importation of advanced machineries and equipment, and sub-contracting to bigger technology firms).	Moderate	9 (18.8%)	-	9 (12.9%)
	High	16 (33.3%)	1 (4.5%)	17 (24.3%)
	Very High	23 (47.9%)	21 (95.5%)	44 (62.9%)
Total		**48 (100.0%)**	**22 (100.0%)**	**70 (100.0%)**
Firm upgrade technology through technology development alliance (license procurement and joint R&D)	Low	1 (2.8%)	3 (13.6%)	4 (6.0%)
	Moderate	6 (11.1%)	3 (13.6%)	9 (13.4%)
	High	21 (47.2%)	13 (59.2%)	34 (50.7%)
	Very	17 (38.9%)	3 (13.6%)	20 (29.9%)
Total		**45 (100.0%)**	**22 (100.0%)**	**67 (100.0%)**

This study supports previous studies on how firms upgrade their technology. Based on that, firms upgrade their knowledge through different innovation activities such as R&D, acquisition of embodied and disembodied, technology transfers, patents, buying capital goods with new embodied technologies such as change in the production processes, products, commercialization or organizational forms, buying of computer hardware and software, spending on machineries and equipment, paying for materials and labor related to innovation activities carried out in the firms (Bustos, 2005; Scarso & Bolisani, 2010). Also, firms upgrade disembodied technology by training and re-training personnel to effectively and efficiently use acquired embodied technology (Khan, 2007).

Table 3 shows the process and product upgrading in the selected firms. About 77.3% of high-tech based firms and 60.9% of low-tech based firms claim that there was an improvement in

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their product technology. Also, 89.2% of low-tech based firms and 72.7% high-tech based firms indicate improvements in their process technology. The improvements in their process technology are found in their delivery techniques, software and equipment deployment. These processes and products upgrading does not happen in aloof, rather through the innovation drivers such as customer driven, supplier driven, organizational/institutional or speculation driven, government policy driven, technology driven and competitors driven among others as the case may be. The nature and need of technology upgrading as reflected in Figures 1 and 2 complements the drivers of technology upgrading through technology push and market pull innovation. This nature and needs of technology upgrading corroborate previous studies on the drivers of innovations. These drivers are from regulatory, demand and supply sides (Frondel et al., 2007; Horbach, 2008; Kesidou and Demirel, 2012; Guoyou et al., 2013). These innovation drivers are within firms (technology push) and outside firms (market push innovation).

Table 3: Improvement in product and process technology (2014 to 2016)

	Class of the knowledge-based firm		Total
Product technology	**Low-Tech based**	**High-Tech based**	
There was an improvement	28 (60.9%)	17 (77.3%)	45 (66.2%)
Process technology			
There was an improvement	43 (89.2%)	16 (72.7%)	59 (81.9%)

Keys

(a) Product technology (Technical specification, user friendliness and other functional characteristics of the firms)

(b) Process technology (delivery techniques, software and equipment deployed)

The nature of technology upgrading (KBF's perspectives)

The selected knowledge-based firms qualitatively identify the nature of technology upgrading that occur in their organizations. The clustering analysis using dendrogram as shown in Figure 1 reveals the picture-graphic nature of technology upgrading of the selected firms. The picture-graphic nature of technology upgrading is the content analysis of the primary data of the selected KBF. The nature of technology upgrading that occurs in high-tech based firms as shown in their categories are information and communications technology which entails reduction in latency rate, an improved uploading and downloading speed, improved uptime and introduction of new state of the art telco equipment that improve bandwidth and network coverage such as new LTE modems, multi user WIFI capable modems with telephone ports among others. Pharmaceuticals have introduced inhaled corticosteroid ('long-acting muscarinic antagonist and long-acting beta2 agonist bronchodilator'). There are new-stat-of-the-art products such as Throttle Acordeon C100, supermag suspension, among others.

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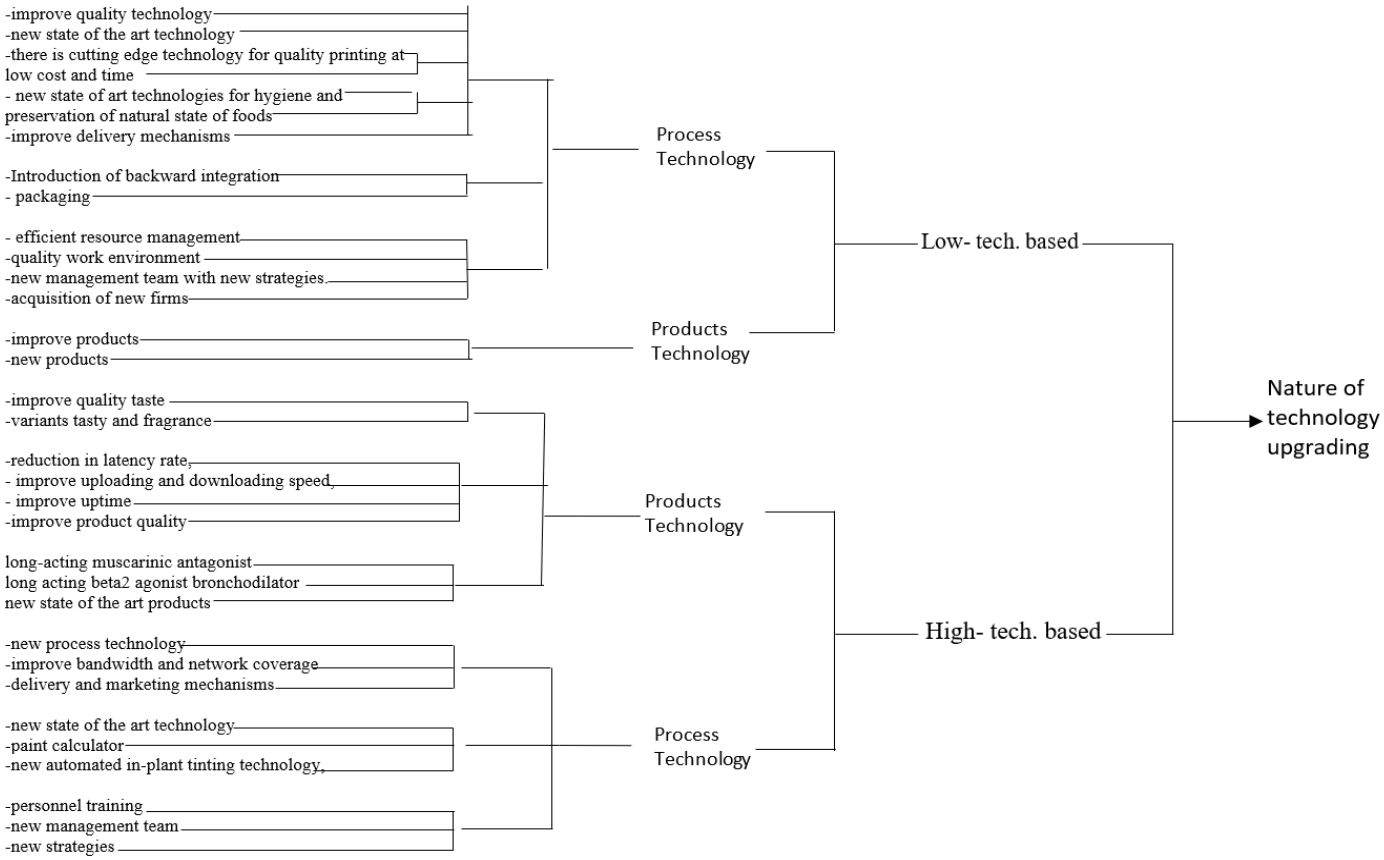

Figure 1: Clustering analysis using dendrogram for the nature of technology upgrading (KBFs' perspectives)

Also, there is new process technology such as personnel training and a new management team leading to new strategies. (iii) Chemical firms improve in the product quality, delivery and marketing mechanisms, their personnel management, introduction of new state of art technology to meet customers' need such as paint calculator to ease quantity combination of color, and new automated in-plant tinting technology, there is new products introduced with flexible management strategies and have adopted EU's cosmetics directive for quality improvement.

The nature of technology upgrading for low-tech based firms include improved quality technology and products, knowledge efficient resource management, and quality working environment, new state of art technology for production process such as husky injection molding machines and piovan dryers among others. New products such as milk candy, biscuit and cake bread among others. New or improvement in process of technology due to acquisition of new firms and new management team with new strategies. Introduction of backward integration (mechanize farming) to avoid being out of stock of input materials. There is cutting edge technology specifically designed to aid quality printing processes with delivery low cost and time among others relative to the traditional printing method. There is also an improvement in the quality, taste and packaging of new food and beverage products such as chinchin, multi-purpose flour, sweet rolls that come in variants tasty and fragrance among others. The new

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state of art technologies adopted enhances hygiene, retain the natural state of foods and delivery mechanisms for customer satisfaction.

CONCLUSION

The study concluded that, KBF do upgrade their technologies through different processes, channels and the nature of the upgrading is both products and processes which are customers' need driven.

RECOMMENDATION

The study recommends based on the findings from the study that knowledge-based firms should upgrade their technology based on demand and market driven and also create a feedback or interactive channel(s) with the users of its products.

FURTHER STUDIES

This study considered technology upgrading of knowledge-based firms in Southwestern Nigeria; further studies may consider Nigeria as a whole. This study considered knowledge-based firms across the sectors; further studies may focus on KBF on a single sector.

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