

FACTORS INFLUENCING TECHNOLOGICAL CAPABILITY OF ALUMINIUM FABRICATING FIRMS IN NIGERIA

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ABSTRACT

The technological capability (TC) of aluminium fabricating firms in Southwestern Nigeria was assessed in this study. This was with a view to establishing the factors influencing the accumulation of technological capability in aluminium fabricating firms in the study area. A questionnaire was administered on 300 randomly selected firms out of which 172 responses were found useful for analysis. The results showed a significant relationship between technological capabilities and various technological learning options such as learning-by-searching, learning-by-doing, learning-by-interaction and learning-by-training. The study concluded that there is a considerable amount of investment, production and innovation capabilities among aluminium fabricating firms in Nigeria as a result of various technological learning opportunities available in the country.

Keywords: Technological capability; Learning-by-searching; Learning-by-doing, Learning-by-interaction; Learning-by-training; Aluminium.

1. Introduction

Technological capability is crucial in the implementation of strategy for competitiveness and value creation in any environment (Garcia-Muina and Navas-Lopez, 2007). Technological capability is embedded in those efforts geared towards assimilation, adaptation and improvement of the existing technologies as well as creation of new technologies. Aderemi, Ilori, Aderemi and Akinbami (2009) describe technological capability along three broadlines, which include the input side of economic activities, the output side, and both input and output sides of economic activities. Furthermore, Girvan (1981) and Enos (1991) describe technological capability as a complex mix of three components. These components comprise people whose background and training are scientific in nature with knowledge relevant to a particular area of concern; possession of a considerable amount of operational experience; and existence of organisation housing these skills from where they can be harnessed and deployed effectively and efficiently. Lall (1994) defines technological capability as assets comprising human and organisational capital employed by the firm for the efficient running of machinery and equipment.

Technological capability influences firms' innovation (Lee, 1995), and therefore can be the basis for competitive advantage. In addition, Sobanke (2012) classifies technological capability into basic and key skills that firms require to function in any business environment. In his submission, basic technological capabilities are the skills and knowledge firms require in starting a new business or for upgrading an existing business. These are important for the management of the effect of technological change in any industry or sector. Furthermore, technological

capability can create technological change in any industry thereby discontinuing established systems and creating a new one. This study provides evidence on the importance of technological learning activities in building the technological capability of aluminium fabricating firms in Nigeria.

2. Literature review

2.1. Indicators for measuring technological capability

There are many identified indicators used for measuring the level or extent of technological capabilities at the firm-level (Sobanke, 2012). Some of these indicators are based on complexity and functionality of the four main categories of technological capabilities identified in the literature (Lall, 1992; Biggs *et al.*, 1995; Oluwale, Ilori and Oyebisi, 2013), and these include investment, production, innovation and linkage capabilities.

Investment Capability

Investment capability encompasses the skills and information that are required for identifying feasible investment projects. They also include the process of preparing, locating and purchasing technologies; staffing, designing and managing the construction as well as commissioning and starting-up. Undertaking this process in-house has been suggested as a strategic ability for firms (Pierre *et al.*, 1992). However, this capability is observed to be considerably low in African enterprises when compared to firms in industrialized and newly industrialized nations (Biggs *et al.*, 1995; Sobanke, 2012).

Production capability

Production capability comprises the skills and knowledge required for the smooth operation of production facilities. Functions such as process engineering, product engineering and industrial engineering (Lall, 1999; Biggs *et al.*, 1995) were identified as criteria for achieving production capability. The functions ensure efficient and effective operation, and maintenance of new production facilities. Further, these activities foster effective adaptation, improvement, quality and inventory control systems as well as robust work flow, scheduling, and monitoring process of newly commissioned production facilities (Biggs *et al.*, 1995; Lall, 1999; Egbetokun, 2012).

Innovation capability

Innovation capability is regarded as the knowledge and skills required for developing significantly improved or completely new methods of conducting firms' activities. Some of the activities under innovation capability are investment, production, and marketing functions. Romijn and Albaladejo (2002) citing Lall (1992) described innovation capability as the skills and knowledge for effective absorption, mastery and improvement of existing technologies and as well for creating new ones.

Linkage capability

Linkage capability is a set of subsystems connected together, and used for transmitting and receiving supportive information at enterprise level, from other enterprises (intra-industry and inter-industry), and from R&D institutions (local and overseas), as well as universities (Olamade, 2001). Lall (1992) describes linkage capability as those skills required in order to transmit information, skills and technology to, and from material suppliers, customers, service firms and technology institutions.

2.2. Technological learning

Technological learning strengthens the technological capabilities with a view to generating and managing technical change (Oluwale *et al.*, 2012). According to Amara *et al.* (2008), technological learning are organisational assets that enable firms to transform and exploit available resources in order to develop product or process innovations. Types of learning that are necessary for developing innovation capability are learning by searching, learning by training, learning by using, learning by doing, and learning by interacting (Cohen, 1995; Freeman, 1995a; Lundvall, 1997a; Amara *et al.*, 2008).

Learning-by-searching

Learning by searching is related to internal R&D functions. This type of learning helps in the creation of new knowledge. Amara *et al.* (2008) suggest that investments in R&D activities help in creating the needed knowledge for developing innovations, particularly those of greater degree of innovativeness (Cohen and Levinthal, 1989; Romijn and Albaladejo, 2002; Caloghirou *et al.*, 2004; Rogers, 2004).

Learning-by-training

This type of learning requires firms to employ an adequate number of skilled manpower for developing various capabilities. It is generally believed that skilled manpower forms a critical pool of knowledge which is further improved through investments in staff training, using both formal and informal means (Subramaniam and Youndt, 2005; Goedhuys, 2007; Egbetokun, 2012).

Learning-by-using

Learning by using is generally associated with the use of significantly improved or new technologies (Gatignon and Xuereb, 1997). Amara *et al.* (2008), argue that such technologies comes with codified knowledge which further create new opportunities for experimentation and problem solving on the shop floor and as informal technological efforts in close contact with production. Furthermore, Wuyts *et al.* (2004) posit that the use and appropriation of advanced technologies accelerate both the process of innovation and the resolution of more radical problems, which then generate greater degree of novelty of innovation.

Learning-by-doing

Learning by doing is a form of learning which suggests that firms become more efficient as they get more practice at doing what they do. This is considered important because it involves both formal and informal technological efforts directed at problem solving, and experimentation for developing firms' technological capabilities and growth (Koberg *et al.*, 2003; Amara *et al.*, 2008).

Learning-by-interacting

This form of learning generally helps in providing additional complementary inputs into a firm's capabilities stock by giving access to external knowledge which the firm itself may not be able to provide during innovation development. This requires that firms engage in both formal and informal relationships with other firms together with different actors within the National Innovation System (NIS) such as customers, suppliers, industrial associations, research institutions, universities and government agencies (Albu, 1997; Meeus *et al.*, 1999a; Chipika and Wilson, 2006; Goedhuys, 2007; Egbetokun, 2012). Oyebisi *et al.* (1996) for instance observed the interactions existing between university and industry in Nigeria. Similarly, Abramo *et al.* (2009) concluded that university researchers who collaborate with the industrial sector had a

better overall personal research performance in both output and functional scientific strength than their colleagues who do not engage in similar cooperation. Collaborating firms on the other hand, stand the chance of being the first to utilise the result of such research.

3. Methodology

The global demand and consumption of aluminium is expected to increase from thirty-two (32) million tonnes in 2005 to approximately fifty-seven (57) million tonnes in 2020. More than 40% of the world's bauxite production is produced by the BRICS economies (Brazil, Russia, India, China and South Africa). Also, alumina output has shifted towards bauxite-rich countries (Guinea, Australia, Vietnam, Brazil, India and South Africa) and away from industrialized economies (World Bank, 2009). In Nigeria, aluminium industry is comprised largely of a number of finished aluminium goods producers (World Bank, 2009; Nextier, 2013). Aluminium is fast replacing heavier steel used in the automotive industry, and the more expensive copper in electrical engineering. According to projections, the demand for aluminium is expected to exceed eighty (80) million tonnes by 2023 (Goutam *et al.*, 2016).

This study covered aluminium fabricating firms operating in Southwestern part of Nigeria. Although, there are six (6) states in Southwestern Nigeria which comprised Lagos, Ogun, Oyo, Ondo, Osun, and Ekiti states, three (3) states were however purposively selected as a representative sample of aluminium fabrication firms in Southwestern geopolitical zone of Nigeria. The selected states are Lagos, Oyo and Ogun. These states were selected due to high industrial and commercial activities. Data for the study were sourced from both primary and secondary sources. Two hundred copies of questionnaire were administered on fabricating firms in the study area, and out of which 172 copies were retrieved and found useful for analysis. Descriptive and inferential statistics were used in analysing the data. In identifying the technological capability of aluminium fabricating firms, the four indicators of technological capability were measured using a 3-point Likert scale (graded as None, Basic or Advanced). On the technological learning activities that are influencing the accumulation of technological capability in these firms, five (5) indicators were considered: learning-by-searching measured by R&D related activities; learning-by-doing measured by production capacity, target market and customer type; learning-by-using measured by types, sources and nature of technologies adopted; learning-by-training measured by training and related activities; and learning-by-interaction measured by linkages with universities/polytechnics, government research institutes, international research institutes, suppliers, financial inputs, customers and competitors.

4. Results and Discussion

4.1. Characteristics of firms

Table 1 presents the area of business activities and size of firms in our study. Almost all the firms engaged in the fabrication of aluminium products. The table also shows that some firms are involved in forming (4.1%) and extrusion (1.2%) activities while few combine colour coating and coiling with their business.

4.2. Firms' technological capability

The result of the technological capability of firms in the areas of investment, product, process and industrial engineering; process and product innovations; and linkage functions is presented in Table 2. The mean score for each of the functions shows the performance of firms in each of the capability areas. Scores were achieved by normalizing weighted average between 0 and 1. Firms have better capability in the area of searching and purchasing of materials (0.76), and equipment (0.75) needed for work.

Table 1: Firms' Characteristics

Business Activities	Frequency	Percentage
Fabrication	152	88.4
Roll Formers	7	4.1
Colour Coating	1	0.6
Aluminium Coils	1	0.6
Aluminium Extrusions	2	1.2
All Category	9	5.2
<i>Total</i>	<i>172</i>	<i>100</i>
Firm size		
Micro < 10	38	22.1
Small ≥ 10 and ≤ 49	123	71.5
Medium ≥ 50 and ≤ 199	7	4.1
Large ≥ 200	4	2.3
<i>Total</i>	<i>172</i>	<i>100</i>

Source: Field survey, 2017

Firms showed high capability in changing equipment parts (0.71) as well as in conducting quality control (0.71) and modifying existing production method (0.70) and product (0.71).

4.3. Technological learning and firms' investment capability

Table 3 presents the correlation between measures of investment capability and firms' technological learning. The result shows that the dependent variable (Y_1) had a significant but weak relationship with the three items of learning-by-searching ($r_1 = 0.159$; $r_2 = 0.188$) all at 0.05 significance level. Investment capability also had a significant relationship with learning-by-doing ($r_3 = -0.240$; $r_4 = 0.391$; $r_7 = -0.237$) at 0.01 level of significance. The result also shows a strong significant relationship with some items of learning-by-training ($r_8 = 0.316$; $r_9 = -0.210$; $r_{10} = -0.259$) at 0.01 level of significance, and ($r_{13} = -0.160$) at 0.05 level of significance and lastly, a weak and negative significant relationship with learning-by-interacting ($r_{14} = -0.218$; $r_{15} = -0.353$) at 0.01 and 0.05 levels of significance respectively. This suggests that there is a strong evidence to show that firms' efforts geared towards the training of their employees (X_9) actually paid-off by increasing firms' investment capability.

Table 2: Aluminium Firms' Technological Capability

Technological Capability	None	Basic	Advanced	Score
Investment Functions				
Carry out feasibility studies on this work	7(4.1)	114(66.3)	51(29.7)	0.63
Search and purchase materials needed for this work	-	84(48.8)	88(51.2)	0.76
Search and purchase equipment needed for this work		85(49.4)	87(50.6)	0.75
Produce detailed engineering drawing on this work	6(3.5)	114(66.3)	52(30.2)	0.63
Prepare and set-up a modern workshop on this work	10(5.8)	107(62.2)	55(32.0)	0.63
Product Engineering Functions				
Reproduce fixed specifications and designs	-	135(78.5)	37(21.5)	0.61
Process accreditation/certification of product quality	122(70.9)	43(25.0)	7(4.1)	0.17
Design & introducing new products in-house	10(5.8)	125(72.7)	37(21.5)	0.58
Process Engineering Functions				
Debugging & calibration of new equipment	39(22.7)	120(69.8)	13(7.6)	0.42
Do routine maintenance operation	7(4.1)	124(72.1)	41(23.8)	0.60
Replacing original equipment parts	8(4.7)	84(48.8)	80(46.5)	0.71
Perform quality control	5(2.9)	91(52.9)	76(44.2)	0.71
Industrial Engineering Functions				
Operating inventory control system	32(18.6)	133(77.3)	7(4.1)	0.43
Carry out scheduling production	41(23.8)	124(72.1)	7(4.1)	0.40
Monitoring of productivity	2(1.2)	129(75.0)	41(23.8)	0.61
Process Innovation Functions				
Develop new production method	123(71.5)	45(26.2)	4(2.3)	0.15
Introduce new production method	6(3.5)	131(76.2)	35(20.3)	0.58
Carry out modification to existing production method	2(1.2)	99(57.6)	71(41.3)	0.70
Product Innovation Functions				
Develop new product(s)	122(70.9)	47(27.3)	3(1.7)	0.15
Copy/imitation of imported product(s)	7(4.1)	132(76.7)	33(19.2)	0.58
Carry out modification to existing product(s)		104(60.5)	68(39.5)	0.70
Linkage Functions				
Sell internally developed technologies to third parties	107(62.2)	61(35.5)	4(2.3)	0.20
Design processes and products in partnership with scientific and technology institutions	68(39.5)	75(43.6)	29(16.9)	0.39
Obtain goods and services from local firms and exchange information with suppliers	39(22.7)	105(61.0)	28(16.3)	0.47

Source: Field survey, 2017

Note: Figures in parentheses are row percentages

Table 3: Relationship between Investment Capability and Firms’ Technological Learning

	Y ₁	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	
Y ₁	1.000																		
X ₁	.159*	1.000																	
X ₂	.188*	.942**	1.000																
X ₃	-.240**	.646**	.626**	1.000															
X ₄	.391**	-.338**	-.312**	-.669**	1.000														
X ₅	-.121	.101	.068	-.101	-.523**	1.000													
X ₆	.118	-.702**	-.711**	-.429**	.254**	-.269**	1.000												
X ₇	-.237**	-.301**	-.360**	.135	-.336**	-.171*	.571**	1.000											
X ₈	.316**	.067	.038	.103	-.466**	.401**	.175*	.393**	1.000										
X ₉	-.210**	-.516**	-.502**	-.450**	.606**	-.410**	.258**	-.114	-.644**	1.000									
X ₁₀	-.259**	-.315**	-.391**	-.491**	-.071	.731**	-.060	-.214**	.135	.153*	1.000								
X ₁₁	-.034	-.767**	-.786**	-.853**	.469**	.188*	.559**	-.053	-.137	.590**	.636**	1.000							
X ₁₂	.067	-.669**	-.702**	-.479**	.338**	-.356**	.818**	.619**	.247**	.268**	-.060	.469**	1.000						
X ₁₃	-.160*	-.274**	-.346**	-.049	-.529**	.452**	.475**	.678**	.672**	-.433**	.292**	.189*	.385**	1.000					
X ₁₄	-.218**	-.359**	-.323**	-.005	.338**	-.817**	.491**	.433**	-.395**	.580**	-.545**	.062	.551**	-.192*	1.000				
X ₁₅	-.353**	-.510**	-.514**	-.425**	.559**	-.422**	.237**	-.147	-.733**	.925**	.134	.552**	.276**	-.435**	.619**	1.000			
X ₁₆	-.039	-.329**	-.277**	-.054	.378**	-.778**	.581**	.359**	-.381**	.519**	-.591**	.084	.512**	-.180*	.943**	.557**	1.000		
X ₁₇	-.085	-.321**	-.286**	-.044	.355**	-.772**	.562**	.374**	-.401**	.511**	-.592**	.086	.520**	-.163*	.954**	.575**	.988**	1.000	

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Y₁: Linkage Capability; **X₁**: Sales reinvested R&D; **X₂**: Worker in R&D Department; **X₃**: Sales from Local Market; **X₄**: Sales from National Market; **X₅**: Sales from International Market; **X₆**: Production Capacity; **X₇**: Customer Type; **X₈**: Production Workers with Training; **X₉**: Increase in Production; **X₁₀**: Increase in Market Share; **X₁₁**: Enter International Market; **X₁₂**: Reduce Production Costs; **X₁₃**: Acquire Advanced Technologies; **X₁₄**: Customers; **X₁₅**: Suppliers; **X₁₆**: Education Institution; **X₁₇**: Research Institute

4.4. Technological learning and firms’ production capability

For production capability (Y₁) whose result is presented in Table 4, there exists a weak but positive significant relationship with learning-by-searching (r₁= 0.156; p<0.05) represented by percentage of firms’ sales reinvested in research and development activities. Furthermore, production capability showed a significant positive (r₄= 0.455) and negative (r₅= -0.188; r₆= -0.433; r₇= -0.496) relationship with learning-by-doing at both 0.05 and 0.01 significant levels. The dependent variable also showed a fairly strong positive (r₉= 0.354) as well as negative (r₈= -0.518; r₁₂= -0.315; r₁₃= -0.689) relationship with learning-by-training all at 0.01 significant level. Some items of learning-by-interaction also showed positive (r₁₅= 0.281) and negative (r₁₆= -0.192; r₁₇= -0.204) relationships with production capability at 0.01 and 0.05 levels of significance. Generally, under production capability, the percentage of firms’ sales reinvested in R&D, percentage of firms’ sales from the national market, need to increase production and firms’ interaction with suppliers were some activities of the aluminium fabricating firms that increased their production capability.

Table 4: Relationship between Production Capability and Firms’ Technological Learning

	Y ₁	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	
Y ₁	1.000																		
X ₁	.156*	1.000																	
X ₂	.087	.942**	1.000																
X ₃	-.071	.646**	.626**	1.000															
X ₄	.455**	-.338**	-.312**	-.669**	1.000														
X ₅	-.188*	.101	.068	-.101	-.523**	1.000													
X ₆	-.433**	-.702**	-.711**	-.429**	.254**	-.269**	1.000												
X ₇	-.496**	-.301**	-.360**	.135	-.336**	-.171*	.571**	1.000											
X ₈	-.518**	.067	.038	.103	-.466**	.401**	.175*	.393**	1.000										
X ₉	.354**	-.516**	-.502**	-.450**	.606**	-.410**	.258**	-.114	-.644**	1.000									
X ₁₀	.056	-.315**	-.391**	-.491**	-.071	.731**	-.060	-.214**	.135	.153*	1.000								
X ₁₁	-.016	-.767**	-.786**	-.853**	.469**	.188*	.559**	-.053	-.137	.590**	.636**	1.000							
X ₁₂	-.315**	-.669**	-.702**	-.479**	.338**	-.356**	.818**	.619**	.247**	.268**	-.060	.469**	1.000						
X ₁₃	-.689**	-.274**	-.346**	-.049	-.529**	.452**	.475**	.678**	.672**	-.433**	.292**	.189*	.385**	1.000					
X ₁₄	-.135	-.359**	-.323**	-.005	.338**	-.817**	.491**	.433**	-.395**	.580**	-.545**	.062	.551**	-.192*	1.000				
X ₁₅	.281**	-.510**	-.514**	-.425**	.559**	-.422**	.237**	-.147	-.733**	.925**	.134	.552**	.276**	-.435**	.619**	1.000			
X ₁₆	-.192*	-.329**	-.277**	-.054	.378**	-.778**	.581**	.359**	-.381**	.519**	-.591**	.084	.512**	-.180*	.943**	.557**	1.000		
X ₁₇	-.204**	-.321**	-.286**	-.044	.355**	-.772**	.562**	.374**	-.401**	.511**	-.592**	.086	.520**	-.163*	.954**	.575**	.988**	1.000	

** . Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Y₁: Linkage Capability; X₁: Sales reinvested R&D; X₂: Worker in R&D Department; X₃: Sales from Local Market; X₄: Sales from National Market; X₅: Sales from International Market; X₆: Production Capacity; X₇: Customer Type; X₈: Production Workers with Training; X₉: Increase in Production; X₁₀: Increase in Market Share; X₁₁: Enter International Market; X₁₂: Reduce Production Costs; X₁₃: Acquire Advanced Technologies; X₁₄: Customers; X₁₅: Suppliers; X₁₆: Education Institution; X₁₇: Research Institute

4.5. Technological Learning and firms' Innovation Capability

Table 5 shows the relationship between firms' technological learning activities and their innovation capability. The result shows that innovation capability had a strong and positive significant ($r_1= 0.711$; $r_2= 0.656$) relationships with learning-by-searching at 0.01 level of significance. There were positive ($r_3= 0.346$; $r_5= 0.244$) and negative ($r_6= -0.752$; $r_7= -0.512$) significant relationships with learning-by-doing at 0.01 level of significance. All the items under learning-by-training had negative and significant ($r_9= -0.340$; $r_{11}= -0.486$; $r_{12}= -0.709$; $r_{13}= -0.414$) relationships at 0.01 level of significance with innovation capability of firms. Furthermore, firms' innovation capability had strong and negative significant relationship ($r_{14}= -0.611$; $r_{15}= -0.422$; $r_{16}= -0.602$; $r_{17}= -0.608$) with all the items of learning-by-interacting. The result of the relationship between firms' innovation capability and firms' technological learning indicates that only the percentage of firms' sales reinvested in R&D activities of the firm, percentage of workforce in the R&D department as well as the percentage of firms' sales from local and international markets are helpful in the development of firms' innovation capability.

Table 5: Relationship between Innovation Capability and Firms' Technological Learning

	Y ₁	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇
Y ₁	1.000																	
X ₁	.711**	1.000																
X ₂	.656**	.942**	1.000															
X ₃	.346**	.646**	.626**	1.000														
X ₄	-.125	-.338**	-.312**	-.669**	1.000													
X ₅	.244**	.101	.068	-.101	-.523**	1.000												
X ₆	-.752**	-.702**	-.711**	-.429**	.254**	-.269**	1.000											
X ₇	-.512**	-.301**	-.360**	.135	-.336**	-.171*	.571**	1.000										
X ₈	-.031	.067	.038	.103	-.466**	.401**	.175*	.393**	1.000									
X ₉	-.340**	-.516**	-.502**	-.450**	.606**	-.410**	.258**	-.114	-.644**	1.000								
X ₁₀	-.026	-.315**	-.391**	-.491**	-.071	.731**	-.060	-.214**	.135	.153*	1.000							
X ₁₁	-.486**	-.767**	-.786**	-.853**	.469**	.188*	.559**	-.053	-.137	.590**	.636**	1.000						
X ₁₂	-.709**	-.669**	-.702**	-.479**	.338**	-.356**	.818**	.619**	.247**	.268**	-.060	.469**	1.000					
X ₁₃	-.414**	-.274**	-.346**	-.049	-.529**	.452**	.475**	.678**	.672**	-.433**	.292**	.189*	.385**	1.000				
X ₁₄	-.611**	-.359**	-.323**	-.005	.338**	-.817**	.491**	.433**	-.395**	.580**	-.545**	.062	.551**	-.192*	1.000			
X ₁₅	-.422**	-.510**	-.514**	-.425**	.559**	-.422**	.237**	-.147	-.733**	.925**	.134	.552**	.276**	-.435**	.619**	1.000		
X ₁₆	-.602**	-.329**	-.277**	-.054	.378**	-.778**	.581**	.359**	-.381**	.519**	-.591**	.084	.512**	-.180*	.943**	.557**	1.000	
X ₁₇	-.608**	-.321**	-.286**	-.044	.355**	-.772**	.562**	.374**	-.401**	.511**	-.592**	.086	.520**	-.163*	.954**	.575**	.988**	1.000

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Y₁: Linkage Capability; **X₁**: Sales reinvested R&D; **X₂**: Worker in R&D Department; **X₃**: Sales from Local Market; **X₄**: Sales from National Market; **X₅**: Sales from International Market; **X₆**: Production Capacity; **X₇**: Customer Type; **X₈**: Production Workers with Training; **X₉**: Increase in Production; **X₁₀**: Increase in Market Share; **X₁₁**: Enter International Market; **X₁₂**: Reduce Production Costs; **X₁₃**: Acquire Advanced Technologies; **X₁₄**: Customers; **X₁₅**: Suppliers; **X₁₆**: Education Institution; **X₁₇**: Research Institute

4.6. Technological learning and firms’ linkage capability

Lastly, the result of the correlation analysis of firms’ linkage capability and firms’ technological learning is presented in Table 6. The result in the table shows that firms’ technological capability is positively correlated with firms’ sales reinvested in R&D ($r_1= 0.270$; $p<0.01$) and workforce in R&D department ($r_2= 0.253$; $p<0.01$). Also, linkage capability had a strong and positive ($r_5= 0.515$), as well as weak and negative significant ($r_4= -0.229$; $r_6= -0.539$; $r_7= -0.464$) relationships with items of learning-by-doing at 0.01 significant level. The result also shows a positive ($r_{10}= 0.394$) and negative ($r_9= -0.258$; $r_{11}= -0.445$) significant relationships at 0.01 level of significance between linkage capability and items under learning-by-training. Linkage capability and learning-by-interaction result from Table 6 shows that all the significant items ($r_{14}= -0.612$; $r_{15}= -0.250$; $r_{16}= -0.659$; $r_{17}= -0.645$) are negatively correlated at 0.01 level of significance.

Table 6: Relationship between Linkages Capability and Firms’ Technological Learning

	Y ₁	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	
Y ₁	1.000																		
X ₁	.270**	1.000																	
X ₂	.253**	.942**	1.000																
X ₃	.096	.646**	.626**	1.000															
X ₄	-.229**	-.338**	-.312**	-.669**	1.000														
X ₅	.515**	.101	.068	-.101	-.523**	1.000													
X ₆	-.539**	-.702**	-.711**	-.429**	.254**	-.269**	1.000												
X ₇	-.464**	-.301**	-.360**	.135	-.336**	-.171*	.571**	1.000											
X ₈	.137	.067	.038	.103	-.466**	.401**	.175*	.393**	1.000										
X ₉	-.258**	-.516**	-.502**	-.450**	.606**	-.410**	.258**	-.114	-.644**	1.000									
X ₁₀	.394**	-.315**	-.391**	-.491**	-.071	.731**	-.060	-.214**	.135	.153*	1.000								
X ₁₁	-.077	-.767**	-.786**	-.853**	.469**	.188*	.559**	-.053	-.137	.590**	.636**	1.000							
X ₁₂	-.445**	-.669**	-.702**	-.479**	.338**	-.356**	.818**	.619**	.247**	.268**	-.060	.469**	1.000						
X ₁₃	-.074	-.274**	-.346**	-.049	-.529**	.452**	.475**	.678**	.672**	-.433**	.292**	.189*	.385**	1.000					
X ₁₄	-.612**	-.359**	-.323**	-.005	.338**	-.817**	.491**	.433**	-.395**	.580**	-.545**	.062	.551**	-.192*	1.000				
X ₁₅	-.250**	-.510**	-.514**	-.425**	.559**	-.422**	.237**	-.147	-.733**	.925**	.134	.552**	.276**	-.435**	.619**	1.000			
X ₁₆	-.659**	-.329**	-.277**	-.054	.378**	-.778**	.581**	.359**	-.381**	.519**	-.591**	.084	.512**	-.180*	.943**	.557**	1.000		
X ₁₇	-.645**	-.321**	-.286**	-.044	.355**	-.772**	.562**	.374**	-.401**	.511**	-.592**	.086	.520**	-.163*	.954**	.575**	.988**	1.000	

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Y₁: Linkage Capability; **X₁**: Sales reinvested R&D; **X₂**: Worker in R&D Department; **X₃**: Sales from Local Market; **X₄**: Sales from National Market; **X₅**: Sales from International Market; **X₆**: Production Capacity; **X₇**: Customer Type; **X₈**: Production Workers with Training; **X₉**: Increase in Production; **X₁₀**: Increase in Market Share; **X₁₁**: Enter International Market; **X₁₂**: Reduce Production Costs; **X₁₃**: Acquire Advanced Technologies; **X₁₄**: Customers; **X₁₅**: Suppliers; **X₁₆**: Education Institution; **X₁₇**: Research Institute;

5. Conclusion

The study provided information on the technological capabilities of the aluminium fabricating firms in Nigeria by examining those factors that contributed to their accumulation with a view to providing information on those factors that enhance their ability to innovate. The study revealed a significant but weak relationship between investment capability and learning-by-searching, learning-by-doing, and learning-by-training. There were also significant relationships between production capability and learning-by-searching, learning-by-doing, learning-by-training, and learning-by-interaction. Innovation capability showed a significant relationship with learning-by-searching, and learning-by-doing. The study also revealed significant relationships between linkage capability and learning-by-searching, and learning-by-training. Hence, the study suggests operation standardization of all aluminium fabricating firms across Nigeria, thereby establishing a minimum practicing code for all operators in the sector. This will ensure that there is uniform level of technological capabilities in the sector across the country. Also, periodic surveys with a view to researching into best practices and challenges in the sector as well as documentation of same for the purpose of reducing the learning curve for new firms in the sector should be encouraged. Furthermore, stakeholders in the sector should encourage more investment in cooperative or joint training in area of R&D with a view to improving on the productivity of individual firms particularly and the sector in general. Similarly, joint research between firms in the sector and the educational and public research institutions is urgently needed in order to stimulate robust interactions among the agents of the aluminium fabricating innovation system.

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