Technology Acquisition and Productivity among Nigerian Firms

Adekemi J. Oluwadare
Science Policy Research and Innovation Studies
National Centre for Technology Management,
Ile-Ife, Nigeria
adekemijessica@gmail.com (corresponding e-mail)

Olufemi Obembe and David O. Olayungbo
Department of Economics
Obafemi Awolowo University,
Ile-Ife, Nigeria.
f_obembe@yahoo.com, doolayungbo@oauife.edu.ng

Abstract – **This study examines the statistical relationship between technology acquisition and productivity in Nigerian firms. The role of technology in firm operations has been well explored in developed economies, but little evidence exists in the developing country context, especially in Nigeria. Technology acquisition, broadly described as a process in which firms obtain technology from both internal and external sources, is measured in this study as the sum of expenditure on R&D, royalty payments and technical/license fees. The Cobb-Douglas production function is modeled with acquired technology as an input into the production process. Output, capital and labour included in the productivity equation are measured by turnover, fixed assets and labour cost, respectively. Data was obtained from the published annual reports and accounts of selected manufacturing firms listed on the Nigerian Stock Exchange between 2001 and 2013. The firms are distributed across approximately eight sectors and the dominant ones are firms in the consumer goods, industrial goods and healthcare sectors. The data obtained was analysed using the Arellano and Bond Generalized Method of Moments (GMM) technique which is known to address problems of endogeneity. The GMM estimates obtained indicate a negative and insignificant relationship between technology acquisition and productivity in Nigerian firms. This was against the apriori expectation. This provides evidence that foreign-sourced technology negatively impacts on economic development in the country and might indicate that the technology acquisition/transfer processes in the country do not incorporate the development of internal absorptive capacity. Policy recommendations provided in this study include designing industrial policies in Nigeria to ensure effective technology acquisition/transfer processes and to develop and promote the use of indigenous technology in the private sector.**

Keywords–Technology Acquisition; Productivity; Firms; Nigeria; GMM

I. INTRODUCTION

In today's knowledge-driven society, technology plays a central role in real economic growth and development. Technology constitutes the totality of the use and application of knowledge, skills, tools, and materials for the well-being of man. The application of science and technology to manufacturing activities led to the scientific and industrial revolutions in the 17th and 18th century, respectively. Technology has since been driving industrial activities and technological innovation is right at the centre of economic growth. Much of modern growth theory was developed at a time when economists began "to stress savings, investment, and capital accumulation as key drivers of gross national product levels and growth" [1]. Early economic contributions such as [2], illustrate how long-run economic growth depends on technical change. Scholarly contributions to the endogenous growth theory reveal that a consistent increase in economic growth is made possible by consistent investments in the creation of new technologies [3]. There is evidence that growth in traditional factors of production such as capital and labour explain less than half of productivity growth in countries [4]; the 'residual' is ascribed to technical change. According to [5], technology adoption and adaptation is fundamental to increasing productivity in developing countries. Technical change has the benefit of increasing firm efficiency, improving the quality of goods and services, increasing consumer demand as well as reducing costs of production [4]. Companies hence seek to introduce technology into their production process, and this can be done by either developing the technology internally or by buying new technologies from external sources. Firm-level technical change is driven by increases in the firm's knowledge base through successive knowledge-enhancing investments by the company [6].

Technology acquisition, broadly described as a process in which firms buy technology from external sources, provides a host of benefits to companies, ranging from the development of new products, to gaining entrance into new markets. Acquiring knowledge and technology involves adopting and adapting knowledge externally (e.g. through an open trading regime, foreign investment, and licensing agreements), as well as creating knowledge internally through research and development [7]. Three major means of acquiring technology include research and development (R&D), technology transfer and technology adoption [8]. The exploitation of technology in production and firm operations is motivated by different factors which include satisfying consumer needs, improving export potential, gaining competitive edge in the market and entering into new markets. To do this, firms in Nigeria, like in many other developing countries, rely on existing technology in the developed economies which is acquired through direct purchase of technological equipment, technical support agreement and technology licensing [9]. There are however, many underlying factors to ensure that firms effectively exploit foreign technology, and the factor most importantly identified in the literature is the absorptive capacity of the

firms, which is further strengthened by the capacity to conduct R&D. This has motivated a lot of recent studies examining the local absorptive capacities of Nigerian firms.

The rise of the knowledge-based economy is an indication that economies are now growing with respect to their exploitation of knowledge and technology rather than just possession of natural resources; it is important for Nigeria to follow this growth path. Furthermore, the private sector plays an important role in enhancing economic growth and development and a burgeoning private sector is hugely dependent on technological progress and innovations. Global competition and trade is now the case of industrialized economies striving to retain their technology and innovation lead; emerging economies seeking to catch up; and less developed economies initiating measures to promote industrialization and structural change [10]. In reality, the catching up process of developing economies will require a great deal of efforts as advanced economies continue to push knowledge frontiers forward. Given that the capability to set new knowledge frontiers by developing nations is low, most settle for the absorption and adaptation of already existing technologies. Technology is at the core of much of the activities of firms and it is a tool that forward-thinking governments employ in providing solutions to underdevelopment, unemployment and poverty. Acquiring technology from overseas plays an important role at early stages of economic development as much of the knowledge and technology required for innovative growth in developing countries will be foreign-sourced [11], [12]. Thus, "many developing countries largely benefit from importing readily available technologies from abroad to complement their technological capability" [13].

The primary objective of this study is to examine the impact of technology on productivity of Nigerian firms. The focus of this study is on non-financial firms in Nigeria which are listed on the Nigerian Stock Exchange (NSE) between 2001 and 2013. The study period was selected in order to allow for the use of more recent firm data; and listed firms were considered in order to ease the process of data collection. This study covers forty-two (42) firms and the data was extracted from the annual reports and accounts of the firms.

II. THE PROCESS OF TECHNOLOGY ACQUISITION

Firms engage in the process of technology acquisition by either adopting technology developed outside the firm, or engaging in internal R&D to develop own technology. With respect to the former, firms can adopt knowledge or technology embodied in purchased technologically sophisticated plant and equipment, intermediate and final goods imports, inward FDI, expatriate personnel, licensing and franchising [14]. R&D on the other hand, comprise "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" [15]. Thus, whether internal or external, R&D contributes significantly to firms' productivity growth as a source of new technologies and applications. However, for firms to maximize the benefits of sourcing technology externally, there must be a minimum level of absorptive capacity [8], which is the ability to learn and implement technologies and processes developed elsewhere [16]. For countries acquiring technology acquisition from abroad, there is further need for openness to trade, foreign direct investment and technology licensing. Therefore, improving the policy and business environments to create conditions favourable for international trade and to attract FDI has benefits for firms' technology acquisitions.

III. EVIDENCE FROM LITERATURE

This section presents evidence of the relationship between technology acquisition and productivity among firms. In examining what drives international and domestic technology transfer strategies of firms and the impact of these transfers on firms' productivity performance, [17] discovered that Flemish innovating firms engaging in international knowledge sourcing strategies record substantially and significantly higher productivity growth. Firms which combine foreign transfer strategies with local technology acquisition experience the largest impact. This suggests that "a diverse external technology strategy combining local technologies as well as know-how from abroad is most likely to improve firm performance". Reference [18] sought to determine the factors influencing total factor productivity (TFP) growth in Malaysia by analysing the TFP growth rate between 1971 and 2004. TFP grows when technological change is introduced or when existing technology and economic inputs are used more efficiently. For the test period, TFP growth in Malaysia was not encouraging due to negative contribution from technical efficiency. Growth in TFP attributable to innovative change only accounts for a small fraction of GDP per labour growth and so, growth may not be sustainable on a long-term basis. The author identified the needs of the Malaysian economy as including enhancement of productivity-based catching-up capability, increase in the number of skilled workers to operate sophisticated technology and the adoption of new technology.

In a study of high-tech Taiwan firms for the period 1994–2000, [19] provided evidence of a positive relationship between R&D expenditure and productivity growth. The results of the analyses revealed an estimate of R&D capital elasticity lying between 0.18 and 0.20, at the 1 percent significance level, showing that R&D has a significant impact on productivity growth in Taiwan manufacturing firms. Although the Schumpeterian hypothesis that the returns on R&D are an increasing function of firm size was tested, the study could not demonstrate that the impact of R&D on productivity growth is an increasing function of firm size. High-tech firms, by virtue of huge investments in R&D are able to create more value resulting from new product development. The effect of R&D investment on firm productivity is thus stronger in high-tech firms than in other industrial firms. In a panel study analysis of 16 OECD

countries, [20] provide evidence of the role of new technology in the improvement of the productivity of firms by estimating the contribution of technical change to productivity growth. The authors take into account, domestic business R&D, public R&D and foreign business R&D as major sources of new technology, and assess their impact on output growth. The results of their analysis reveal the importance of R&D investments on productivity and economic growth. Based on their study, the authors conclude that absorptive capacity is a basic requirement for benefiting from other countries' R&D. Overall, the study points to the importance of technology for economic growth, be it developed by business, by the public sector or coming from foreign sources.

Technological diversity no doubt exists among firms in Africa as proven by [21]. The productivity of firms across the five African nations (Ghana, Kenya, Nigeria, Tanzania, South Africa) studied by the authors differs significantly because of differences in returns to education and forms of technology employed. A major finding from their study is that the country location of a firm influences the technology adopted by such firm. This implies that African governments seeking to improve productivity in the private sector must provide the appropriate environment for firms to operate. In support of this, [22] shows that strengthening the manufacturing base of a country requires a certain level of education among the workforce. An investigation on the impact of technology investment on the export potential of firms in Southwest Nigeria by [9] shows that investments in technology are dominated by imported technologies, and are not directly targeted at improving the export potential of firms. Most of the firms make use of equipment that is largely foreign technology and no firm was observed to use a completely locally-fabricated production facility. It was also discovered that technology collaboration in the firms is largely in the form of technical support agreement and technology licensing. Export-motivated investments in technology only occurred in about 10% of the surveyed firms. Evidence is provided in the study by [23], that the adoption of Information and Communication Technology (ICT) in the Nigerian banking sector impacts positively on productivity, in terms of efficient operations, improved customer satisfaction, competitive advantage and records accuracy.

Economic growth theory in recent years, has witnessed a lot of research into the sources of productivity growth with scholars, policymakers, and the business press paying great attention to this subject [24]. Investment in factors of production such as labour and capital, together with the technical progress in industries has been identified as key contributors to productivity. Accelerating technical change has, in particular, been identified as the main source of permanent increases in productivity [25], whereas low levels of technology serves as an obstacle to productivity [26]. Hence, it is expected that as firms invest in the acquisition of knowledge and technology, they experience increase in productivity.

IV. DESCRIPTION OF DATA AND VARIABLES

The data used in this study has panel/longitudinal characteristics. Panel data is widely used in estimating dynamic econometric models, and "its advantages over aggregate time series data is that panel data offers to investigate heterogeneity in adjustment dynamics between different types of individuals or firms, whereas time series data has the possibility that underlying microeconomic dynamics may be obscured by aggregation biases," [27]. The firms included in this study were limited to those in the manufacturing sectors. As a result, firms listed on the Nigerian Stock Exchange (NSE) as service and financial service firms are not included in the data. Publicly quoted firms on the NSE are used in this study in order to aid accessibility to their financial reports and other information. At the time of data collection (March 2015), there were 112 manufacturing firms listed on the NSE and 42 (37.5%) were selected, cutting across the consumer goods, industrial goods, pharmaceutical, oil and gas, construction/real estate and agricultural sectors. The data for each variable used in this study was extracted from the annual reports and accounts of the selected firms; therefore, the accessibility to annual reports for the years 2001 to 2013 determined which firm would be included in the study. Distribution of the sampled firms according to sector of activity is presented in Table I.

Technology acquisition is measured as the sum of firms' expenditure on R&D, royalty payments and technical/license fees. R&D expenditure is the amount spent on research projects in a given year; royalties are paid for access to the use of patents, trademarks/brands and inventions; technical/license fees are paid for the provision of technological, scientific and professional assistance for product manufacture. Output, Labour and Capital in the Cobb-Douglas production function (1) are measured, respectively, by firm turnover, wages and fixed assets.

V. MODEL SPECIFICATION

The model specification for this study examines the effect of technology acquisition on productivity, and is adapted from [28]. The first equation in the model is the standard Cobb-Douglas production function which is given as follows:

$$Y_{it} = L_{it}^{\beta L} K_{it}^{\beta K} A_{it} \quad (1)$$

Where:

Y_{it} is output

L_{it} is labour

TABLE I. SECTORIAL DISTRIBUTION OF FIRMS

Sector	Number of Firms	Percentage of Total
Consumer Goods	13	31
Industrial Goods	9	21
Health Care	7	17
Oil & Gas	5	12
Others*	8	19
Total	**42**	**100**

*Construction/Real Estate, Conglomerates, Agriculture, Natural Resources

K_{it} is capital

A_{it} is a measure of total factor productivity,

Subscript *it* indicates values for firm *i* in year *t*.

Equation (1) describes the relationship between a firm's output, and its capital stock, labour stock and the productivity of the technique employed. This equation is further transformed into a regression equation by taking logs of the variables and by introducing lagged values of the dependent variable with a weight denoted by λ, firm-specific effects (α_i) to allow for unobserved firm heterogeneity, and ε_{it} which is the error term and is assumed to be serially uncorrelated over time.

Equation (2) below is thus generated:

$$y_{it} = \lambda y_{(i,t-1)} + (1-\lambda)\beta_L l_{it} + (1-\lambda)\beta_K k_{it} + (1-\lambda)a_{it} + \alpha_i + \varepsilon_{it} \quad (2)$$

Where:

y_{it}, l_{it}, k_{it} and a_{it} denote logs of Y_{it}, L_{it}, K_{it} and A_{it}, respectively.

Taking first differences eliminates the firm fixed effect α_i and (2) becomes:

$$\Delta y_{it} = \lambda \Delta y_{(i,t-1)} + (1-\lambda)\beta_L \Delta l_{it} + (1-\lambda)\beta_K \Delta k_{it} + \Delta a_{it} + \Delta \varepsilon_{it} \quad (3)$$

The sources of productivity are specified by using the level of technology acquisition in year t-1 (p_{it-1}). Competition in year t-1 ($c_{i,t-1}$) is also included in the model as a source of productivity. This is in support of the work done by [29], which documents that competition has a positive and significant impact on productivity growth of Nigerian firms.

$$\Delta a_{it} = \beta_1 p_{(i,t-1)} + \beta_2 c_{(i,t-1)} + \gamma_1 g_{(i,t-1)} \quad (4)$$

g_{it-1} represents the lagged values of corporate governance, introduced as a control variable. Equations 3 and 4 represent the productivity growth model. This model also corresponds to the productivity growth model in [30].

VI. METHOD OF ESTIMATION AND RESULTS

A regression analysis is carried out to define the statistical relationship between technology and productivity. The [31] Generalized Method of Moments (GMM) technique, known to address problems of endogeneity, is used in this study. Endogeneity is a major challenge in econometric analysis in much of social science studies, and can be caused by omitted variables, measurement error or simultaneity [32]. The problem of endogeneity is implied by the correlation of explanatory variable(s) with the error term, leading to biased estimates. Consistent estimates can however be obtained using the GMM technique which allows for valid instruments to be obtained in a dynamic panel data model [27], [33]. The use of instrumental variables helps to control for unobserved heterogeneity in the model. A good instrument is determined by its correlation with the key independent variable, and absence of correlation with the dependent variable [32]. Valid instruments are also expected to satisfy the condition of no correlation with the error term. To effectively estimate the model parameters, it is important to validate the instruments of the model by verifying the absence of serial correlation in the error term. This is because an "estimator that uses lags as instruments under the assumption of white noise errors would lose its consistency if in fact the errors were serially correlated" [31]. The Arellano-Bond test of autocorrelation and Sargan test of over-identifying restrictions are used to achieve this and are reported in the table below.

Table II shows the GMM estimates of the relationship between technology acquisition and productivity in the firms. Concerning the relationship between technology and productivity, the GMM estimates in the table do not support the apriori expectation of a positive relationship. The coefficient of expenditure on technology acquisition indicates a negative relationship with productivity. The model coefficient is negative (-0.051) and not significant at 0.05 or 0.10 levels. The result implies that a 1 percent increase in the level of technology acquisition decreases productivity by 5.1 percent. The results of the specification tests reveal the absence of serial correlation in the residuals and the validity of the instruments. The null hypothesis at the first-order serial correlation is rejected as Prob = 0.0301 < 0.05 while the null hypothesis is accepted at the second order given that Prob = 0.1694 > 0.05. The Sargan test of over-identifying restrictions shows the validity of the instruments with a probability value of 1.0000 > 0.05.

TABLE II. THE IMPACT OF TECHNOLOGY ACQUISITION ON PRODUCTIVITY

SystemGMM Dynamic Panel – two-step results			
Dependent Variable - Output Δy_{it}			
Independent Variables	Coefficients	Standard Error	P-Value
Lagged Dependent Variable ($\Delta y_{i,t-1}$)	-0.222	0.111	0.045*
Log of Labour (Δl_{it})	0.097	0.048	0.043*
Log of Capital (Δk_{it})	0.014	0.036	0.697
Corporate Governance ($g_{i,t-1}$)	0.298	1.434	0.835
Log of Expenditure on Technology ($p_{i,t-1}$)	-0.051	0.044	0.241
Competition ($c_{i,t-1}$)	0.088	0.248	0.723
Constant Term	0.521	0.808	0.519
Number of Observations:		308	
Number of Instruments:		137	
Specification Tests			
Arellano-Bond test for AR(1) in first differences [H0: There is no first-order serial correlation in residuals]		z = -2.1687 Prob > z = 0.0301	
Arellano-Bond test for AR(2) in first differences [H0: There is no second-order serial correlation in residuals]		z = -1.3742 Prob > z = 0.1694	
Sargan test of over-identifying restrictions [H0: Over-identifying restrictions are valid]		chi2(129) = 23.18872 Prob>chi2 = 1.0000	

* 0.05 level of significance

VII. DISCUSSION OF FINDINGS

The results reveal a negative relationship between technology acquisitions and productivity among Nigerian firms. A possible justification for this result could be that two components of technology acquisition (technical fees and royalty payments) by the firms are mostly foreign-sourced and may therefore not be tailor-made to the needs of the Nigerian economy. It was observed during the data collection process that expenditure on technology acquisition mostly comprises payments of fees to the parent companies of the firms. It can thus be inferred that the true nature of technology acquisition in Nigerian quoted firms may indeed be a source through which multinational firms transfer funds out of the country and not necessarily as a result of a demand to introduce innovative products. This study shows that imported technology negatively impacts on economic development in the country and also signifies the importance of indigenous technology in economic development. By implication, knowledge produced at the world technology frontier is not readily absorbable by the Nigerian economy, and thus necessitates modifications. Inferring from [34], trading with a country on the world technology frontier may show only a slightly positive effect on TFP growth, while leaving rates of innovation unaffected in developing economies. References [13], [5] and [12] posit that increasing productivity in developing countries via the adoption of foreign technologies requires the pre-condition that there is an internal ability to adapt the technologies to local conditions and that they are complementary to the technological capabilities of local firms; meanwhile, a study by [35], revealed that firms in Nigeria have low-level absorptive capacity. The lack of persistency in R&D can induce low productivity [36], while TFP growth can be stunted in spite of technological change when there is no 'productivity-based catching-up' capability in the acquiring country [18]. This study thus provides another instance where foreign acquired technology does not translate into increased productivity.

It can further be inferred from the findings in this study that firm productivity in Nigeria will be hindered by inappropriate technology investments. Knowledge acquisition in the sampled firms is largely embedded in patents and trademarks owned by foreign multinationals and there is no evidence of modifications to suit domestic needs. This means that the indigenous technological and knowledge base needs to be strengthened, as also affirmed by [37] in order to improve productivity growth. Free-riding on rich countries' technologies, in the presence of weak intellectual property regulations have the potential to limit radical R&D that can lead to innovative products and services, thereby limiting sustained productivity growth [38], [39]. Being a late developer in the technology game can give firms, industries and whole economies advantages, only if they understand how to capitalise on them [40]. For developing countries to successfully ride on the wings of developed countries on their path to development, [41] posit that they must transit from learning from FDI as an initial channel, to licensing and then to indigenous R&D.

VIII. CONCLUSION

The main aim of this study is to identify the nature of relationship between the acquisition of technology and productivity in Nigeria using data from firms listed on the Nigerian Stock Exchange. The contribution of this study is vital because not many studies have examined the impact of technology on firm performance in Nigeria. The GMM approach, known to effectively address problems of endogeneity in models, was used in the data analysis and the estimates showed a negative relationship between technology acquisition and productivity among Nigerian firms. This is contrary to many findings in the literature on the impact of technology on firm performance and has been explained to mean that the capacity to absorb the acquired technology may be low or non-existent in Nigerian firms. The results of this

study indicate a need for further investigation into the channels of technology acquisition in Nigeria.

A better understanding of the relationship between technology and productivity will further aid in framing the right policies for the private sector in Nigeria. This study provides evidence for policy makers that transfer of technology into the country needs to be deliberate and properly regulated. This implies that firms' technology acquisition processes will not produce desired national results if they are not tailored towards the unique needs of the economy. Also, if the investment and business climate in the country is not conducive, especially with respect to intellectual property (IP) rights protection, multinational firms will be forced to restrict R&D activities to their home country. This is because the effectiveness of the process of technology acquisition and development is guaranteed under an effective system of IP protection. Industrial policies should thus be designed to ensure effective technology acquisition and research and development activities in Nigerian firms. In particular, policies should be put in place to encourage firms to develop technological and innovative solutions which are specific to the Nigerian economy, and also to stimulate the growth of indigenous firms with significant local content in their production inputs, ensuring the exploitation of the nation's resources. Therefore, attention should be paid to the development of indigenous knowledge and domestic solutions in the economy, and also to the development of the absorptive capacity of Nigerian firms.

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