TECHNOLOGY-RELATED FACTORS AS DETERMINANTS OF EXPORT POTENTIAL OF NIGERIAN MANUFACTURING FIRMS

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ABSTRACT

Though economic growth has improved in recent years in Nigeria, there has been no evidence of significant manufacturing exports. A critical input that enables capacity for export is investment in technology especially at the firm-level. This study investigates investment in technology by firms in Southwest Nigeria and how technology investment related factors affect the export potential of firms. Data was obtained from a survey of Nigerian firms in 2008. Results demonstrate that investments in technology are dominated by imported technologies, investment in ICTs are becoming widespread though not deep in manufacturing related functions, and technology investments are not directly targeted at improving the export potential of firms. The results also showed that firm size has a strong positive relationship with export potential, and it is the most important factor that affects the export potential of firms. The coefficient of firm size is the only parameter estimate that is consistently statistically significant at 1% level for all four export models estimated. Other technology investment related factors that impact positively on export potential include skills intensity, investment in skills upgrading, cost efficiency, and investment in quality management.

Keywords: technology investment, export, manufacturing, firms, Nigeria

1. Introduction

The important role of technology in economic development has long been established. With the widely acknowledged fact that the Solow residual, later described as total factor productivity, is essentially a measure of technology input into the production process, investment in technology became an issue of strategic focus in economic development. This is celebrated in the new growth theory, which deviates from the neoclassical treatment of technology as exogenous and an upward shift in the production function. The new growth theory explains growth by treating technology as endogenous and a factor of production in its own right (Solow, 1957; Romer, 1990; Barro and Sala-i-Martin, 1995). The contribution of technology to macroeconomic performances explained by growth accounting is however rooted in investments in technology at the firm level. It is the microeconomic impact of investment in technology at the firm level that translates into the improvement in the aggregate economy explained by the endogenous growth theory. Several authors have shown that the economic miracles experienced especially among the East Asian economies in the last half century tremendously benefited from policies that actively promoted firm level investments in technology. (Mathew and Cho, 2000; Lall and Urata, 2003; Amsden and Chu, 2004). Investment in technology was a major tool of achieving the objectives of the strategy of export orientation as an economic policy. While most countries in sub-Saharan Africa did not go for export orientation early enough, it has now been widely accepted that export of manufactures is an important means of economic diversification and subsequently a major contributor to long term sustainable growth and poverty reduction. In Nigeria, the current economic reform espoused by NEEDS (National Economic Empowerment and Development Strategy) and the Seven-Point Agenda (SPA), emphasizes the importance of growing the private sector of the economy to make it internationally competitive. (NPC, 2004; FGN, 2008). The Nigerian manufacturing sector is a major part of this private sector, and to be internationally competitive, there should be a clear understanding of the current state of investment in technology that can stimulate or promote export performance of the manufacturing firms. The study reported in this paper therefore investigates the nature of firm level investments in technology among manufacturing firms in Southwest Nigeria and how technology investment related factors affect the export potential of firms. The specific objectives are to:

i) identify the type of investments in technology being made by manufacturing firms in Southwest Nigeria;
ii) identify the constraints on and opportunities for investments in technology by manufacturing firms; and
iii) examine the impact of technology investment related factors on export potential of firms.

The rest of the paper is organized as follows: section two discusses the evolution of the Nigerian industrial policy and export promotion, section three presents a conceptual framework for the analysis of technology related factors as determinants of export potential of firms, section four describes the research methodology, section five discusses the research findings, while the final section presents the conclusions and policy implications of the findings.

2. The Nigerian Industrial Policy and Export Promotion

Industrialization became a major development objective in Nigeria with the enactment of Aid to Pioneer Industries Ordinance of 1952 (Ekundare, 1973). Thereafter several policy initiatives and industrialization programmes have been targeted towards achieving significant structural transformation of the economy. The post independence Nigeria adopted the import-substitution industrialisation strategy (ISI). Helmsing and Kolstee (1993) observed that the Nigerian import-substituting industries were generally of a factory mass-production type, though the scale was much smaller than in Europe or North America. These industries were largely monopolist or oligopolist producers (multinational enterprises or affiliates), either under foreign or expatriate ownership, and/or with considerable expatriate technical and managerial domination. Until the mid-1980s, the Nigerian government assumed a control-oriented policy involving administrative measures, foreign exchange allocation, investment regulation, and the like; the peak of which was the 'indigenisation of ownership' schemes in the 1970s. These control measures were supposed to stimulate an active participation of the indigenous business community, and thereby enhance the entrepreneurship and technical capabilities of the Nigerian partners of foreign firms (Biersteker, 1987; Forrest, 1994).

Apart from the traumatic experience of the civil war between 1967 and 1970, the post-independence industrial policies nevertheless witnessed considerable economic development based on ISI. The economy was particularly improved by the discovery of crude oil in commercial quantities in the 1960s, and subsequently by the 'oil boom' of the early 1970s. The cost of the apparent inefficiency of the ISI policies was paid for by the unprecedented large oil revenues. However, the crash of the crude oil price on international market in the early 1980s, poor economic management, and the high dependence on imported inputs by the import-substituting industries, combined together to bring about a drastic economic down-turn in the early 1980s. This had profound impact on the Nigerian manufacturing industry. The industry was highly import dependent for manufacturing inputs. Foreign exchange to purchase machinery & equipment and critical intermediate products became scarce, and hence, there was drastic decline in capacity utilisation. Attempts to revamp the economy and put it on the path of sustainable growth brought about the introduction of the World Bank/IMF-led economic structural adjustment programme (SAP) in July 1986 (Moser *et al*, 1997; Mkandawire and Soludo, 1998). As rightly observed by Ogunkola (2002), under SAP, there was an overbearing reliance on the role of the market in ‘getting the price right’. Government interventionist approaches were jettisoned for exchange rate and trade liberalisation. Ogunkola’s analysis demonstrated that the response of the manufacturing sector to the SAP reform was far below expectation. Specific case studies also revealed that many large scale public manufacturing firms failed in spite of SAP. Oyeyinka et al (1997) provided illustrations of this for the fertiliser and iron and steel plants, while Adubifa (1990) presents the account of the auto industry. Understandably, SAP recognised that through the revitalisation of the country’s industries, a viable productive base that could serve as a nerve-centre of the nation’s economic stability and growth would be created. However, SAP did not succeed in this respect, and the decade of the 1980s was a period of industrial decline. (Jalilian et al, 2000).

From the foregoing, it is apparent that the focus of industrial policy in Nigeria has metamorphosed from pre-independence emphasis on cottage and craft industries, through to the import substitution strategies of the 1960s and 1970s, and the reform era attempts to promote export orientation. In all stages Nigeria has remained an open economy and effective protection has always been limited. Prior to 1980, industrial policy was subsumed in the policy thrusts and strategies for the national development plans and budget proposals. The first industrial policy was articulated by the Federal Ministry of Industry in 1980. It was subsequently revised in 1989. The policy document gave particular attention to development of Small and Medium Enterprises (SMEs).[1] The latest revision of the industrial policy was done in 2003, and it was aimed at bringing the industrialization vision to be in unison with the objectives of Nigeria's current economic reform agenda. The main thrust of the industrial policy is to increase the pace of industrial development by radically increasing value-addition at every stage of the value chain. It is expected that Nigeria's resources will no longer, in the main, be traded in the primary state. Emphasis is to be placed on total factor productivity by encouraging knowledge and skills-intensive production activities. The target is to stimulate the emergence of 100% export-oriented production units in selected areas, and also to encourage technological upgrading in the informal sector (FGN, 2003).

The specific objectives of the new industrial policy are to:

i) place Nigeria among the ranks of industrially developed countries;
ii) encourage the private sector to play a pivotal role in the industrial development of the country;
iii) increase industrial output and linkages for both domestic and export markets;
iv) increase value addition by creating a few niches of competitive advantage;
v) increase capacities for entrepreneurship and technical skills in order to create more direct and indirect employment opportunities;
vi) increase competitiveness of Nigerian manufactures;
vii) facilitate inflow of foreign capital and technologies; and
viii) encourage geographical dispersal of industries.

These policy objectives are again currently undergoing review to enable Nigeria realize the vision of becoming one of the largest 20 economies by the year 2020.[2]

As shown in table 1, the period from 1960 to 1979 generally witnessed rapid industrial growth largely due to the inefficient ISI aided by the oil economy. The growth rate of manufacturing value added soared in the 1960s and 1970s. The decade of the 1980s was a period of industrial decline. The manufacturing value added growth which was 46.9% in 1979 declined to -3.9% in 1986 indicative of de-industrialisation phenomenon which was widespread in Sub-Saharan Africa (Jalilian et al, 2000). The following decade of the 1990s shows that the decline might have been halted, but possible improvement appears

[1] To date SMEs predominate and account for about 87% of business activities in Nigeria, but only accounts for about 10% of total manufacturing output (MAN, 2004).
[2] The current Nigerian government is currently articulating a 'Vision 20-2020' which is regarded an economic policy document aimed at making Nigeria one of the largest 20 economies by year 2020.

to be only marginal. By 1999 growth rate of the manufacturing value added improved to 2.1%. It is also important to point out that structural transformation of the economy remains a major challenge. The manufacturing sector is relatively small, and as shown in table 2, contributes less than 4% to GDP. Besides, there has been no significant improvement in the share of manufacturing in the GDP.

Table 1. Nigeria: key economic performance indicators

Key economic performance indicator	1960	1966	1970	1979	1986	1999	2006
GDP in current US$ (billion)	4.2	6.37	12.5	47.3	20.2	34.8	115.34
GDP growth rate	n.a	-4.3	25.0	6.8	2.5	1.1	5.2
GDP per Capita in const. 2000 US$	314	326	382	454	342	380	440
Share of manufactures in total merchandise exports (%)	n.a	1.27	0.72	0.46	0.02	0.60	2.07*
Share of manufactures in total merchandise imports (%)	n.a	83.0	83.1	77.4	79.6	66.6	66.3*
Manufacturing, value added (% of GDP growth)	3.81	5.3	3.7	8.8	8.7	4.9	4.0*
Manufacturing, value added (annual % growth)	n.a	70.6	27.9	46.9	-3.9	2.1	6.2*
Agric., value added (% of GDP)	63.9	54.9	41.3	28.7	38.7	36.6	23.4**
Agric., value added (annual % growth)	n.a	-7.0	17.5	-3.0	9.2	5.2	8.2**
Services, value added (% of GDP)	28.5	32.7	45.0	33.5	35.3	28.2	19.9
Services, value added (annual % growth)	n.a.	-4.6	20.8	2.4	7.3	0.7	8.0

*data is for 2003; ** data is for 2005

Data source: World Bank (2008). World Development Indicators, CD ROM

Table 2. Nigeria: Scetoral contribution to GDP, 1999-2005

Sector	Percent contribution to GDP						
	1999	2000	2001	2002	2003	2004	2005
Agriculture	43.45	42.65	42.3	42.14	41.01	40.98	41.21
Petroleum	24.45	25.91	26.04	23.46	26.53	25.72	24.33
Solid Minerals	0.25	0.25	0.25	0.26	0.25	0.26	0.27
Telecommunications	0.45	0.46	0.55	0.78	0.99	1.2	1.45
Manufacturing	3.49	3.44	3.52	3.7	3.57	3.68	3.79

Financial Institutions	4.05	4.03	4.02	4.97	4.12	3.96	3.82
Wholesale and Retail Trade	13.46	13.04	12.76	12.99	12.54	12.9	13.64
Others	10.25	10.1	10.42	11.54	10.87	11.18	11.36
Total	99.85	99.88	99.86	99.84	99.88	99.88	99.87

Source: NPC (2007, p.34) based on data from various issues of Statistical Bulletin of the Central Bank of Nigeria, Abuja

Export performance of Nigerian firms has been relatively small especially since the early 1970s when crude oil became the major source of export earnings. As explained by Thoburn (2000) and Afangideh and Obiora (2004), the share of manufactured export in total export increased in the 1960s, and began to decline in the 1970s (especially after the first oil shock in 1973) through to the 1990s. Though the decline has apparently been halted, it has nevertheless remained relatively low. Presently, there is no indication that the recovery process has actually attained significant proportions. Moreover, the manufacturing sector in Nigeria still depends heavily on import of machinery/equipments indicative of the relatively under-developed state of the engineering subsector. Critical raw materials are also largely sourced through imports. Table 1 shows that while share of manufactures in total merchandise imports is very high (66% in 2006), the share of manufactures in total merchandise exports is very low (2% in 2006) but much lower in previous years. Thus, the manufacturing sector apparently lacks international competitiveness.

3. Technology and Export Potential of Firms: a Conceptual Framework

It is well known that the conventional theory of comparative advantage was originated during an era when international trade was largely separate from industrial production and undertaken by merchant organizations that operated independently from the actual producers. Most of the goods traded were primary commodities and semi-manufactured goods and international specialization clearly reflected the factor endowments of countries. The structure of the international economy then afforded the relative factor cost approach to international trade a substantial degree of explanatory power. (Soedersten and Reed, 1994; Wangwe, 1995). However the unprecedented growth in productivity increases in the second half of the last century and the tremendous economic progress made in some developing countries, especially in East Asia, have not only altered the pattern and structure of the international trade but also introduced new elements into factors that determine global competition. From the accounts of Porter (1990) in his famous treatise on competitive advantage of nations some of these new elements include the emergence of large-scale transnational corporations that engage in foreign direct investment in diverse productive endeavours, breakthroughs in technologies that have facilitated great improvements in transport and communication infrastructure, increased application of scientific principles and new technologies to manufacturing processes. International trade, both in terms of value and tonnage, has

experienced a growing trend in the global economy. With increasing trade, many countries (both developed and developing) have realized the neo-liberal expectations (gains of trade) of increased competition, economies of scale, specialization, lower prices, and interdependencies.

The gains of trade are largely realized through firms' active participation in the global economy. The instrument of this participation is exports. Export of manufactures has particularly been an instrument of rapid structural change in the newly industrializing economies. Several factors can determine a firm's potential for export. As indicated in section one, technology investment related factors are important contributors to building capacity for exporting. Lall (2001) provide theoretical links between investment in technology and export performance in his analysis of the role of technology in international competitiveness. However, empirical findings on relationship between export performance and investment in technology have been mixed. While Cotsomitis *et al* (1991) and Kumar (1990) indicated that the technology variable has no role to play in export performance, more recent studies (e.g. Kumar and Siddharthan, 1994; Basile, 2001) however demonstrated that technology variable measured in terms of R&D expenditure is an important determinant of export performance. The earlier studies measured technology in terms of technology stock (Cotsomitis *et al*, 1991) and R&D intensity (Kumar, 1990). In a study of e-business and export performance of small and medium-sized industries (SMIs) in India Lal (2002) also reported that the adoption of e-business technologies is an important factor in explaining the export performance of Indian SMIs. It thus appears from more recent empirical findings that technology investment related factors are important in explaining export performance of firms. We accordingly propose in this study that export performance derive its substance from the export potential or capability of the firm, and hence factors that explain export performance will *a priori* provide explanation for the level of the export potential. We therefore hypothesise that technology investment related factors would provide substantial explanation for export potential of firms. As demonstrated by Wakelin (1998) and Soderbom and Teal (2002), other factors determining export may be largely captured by the firm size and cost/technical efficiency of the firm. Drawing on previous theoretical and empirical evidence on the links between investments in technology, export performance and industrial competitiveness the following specific hypotheses are proposed for the study.

i) Investment in ICT (E-business facilities)

Investment in ICT is an important factor that has enabled the competitiveness of many successful economies in recent decades. However while Nigerian firms still lag behind in the use of ICT in the production process, Nigerian firms are beginning to employ ICT for operations management and other e-business activities (Adeoti, 2005). Lal (2002) defines e-business to encompass the application of ICTs in all business processes such as office automation, production processes, coordination with other plants, customer relation management, supply chain management, and management of distribution networks. This study adopts this definition of e-business, and will examine the influence of investment in ICTs that enable e-business activities on a firm's potential for export. Following Lal (2002) we consider a discrete measure for investment in ICT, and identify three

categories of ICTs that can enable e-business. These are offline, online, and portal-based technologies. The first is the electronic messaging system (E-mail). This is relatively less effective than other e-business tools. The second is online website enabled transactions. The company's website must be dynamic and should have online transaction facilities such as Active Server Pages (ASPs) that allow online transactions. The third is portal-based and is the most effective way of carrying out e-business. In addition to hyperlinks to other URLs, portals fulfill an important role of aggregating contents, services, and information on the net. For example, the portal of a company can search, extract, and display information about a particular product from a large product profile. We hypothesize that the presence of one or more of the e-business facilities will increase firm's export potential.

ii) Skills intensity ratio

Skills intensity ratio has been defined as the ratio of professional staff employed by a firm to the total workforce (Adeoti, 2001; Lal, 2002). Professional staff in this context includes members of the workforce with degrees or higher diploma in scientific, engineering and management skills required for efficient production activities. Skills intensity ratio is a modest indicator of human capital level. Theoretical models presented by Lucas Jr (1988) and Drazen (1990) demonstrated that export performance can be driven by human capital. Though Kumar and Siddharthan (1994) did not find any impact of skill on exports in several industries in India, they did find that skill was an important factor in the export performance of food processing and transport equipment sub-sectors. Moreover, several other studies (e.g. Lal, 1996; Bernard and Wagner, 2001) indicated that firms with high skills intensity are more likely to export. Based on these theoretical and empirical considerations we hypothesise that skills intensity ratio will have a positive impact on firms' potential for export.

iii) Investment in skills upgrading

For the purpose of this study we conceive investment in skills upgrading to entail investment in training activities that enable better and efficient operation of machines and equipment. However skills upgrading is generally reckoned as the outcome of learning mechanisms that enable firms improve their technological capability endowment. Learning mechanisms includes in-house and external training programmes; learning-by-doing; strong networking between various units of the firm; and strong linkages with local suppliers, clients, other firms, industry networks, research institutes, governments, universities, financial institutions, local or foreign consultants (Biggs *et al*, 1988; Madanmohan *et al*, 2003). Among all these factors, investment in training is less difficult to capture in a developing country firm, and hence we adopt it as a proxy for skills upgrading. Boddy and Buchanan (1986) observed that skills upgrading fosters cross-fertilisation of knowledge, and thus enhances technological innovation. Besides, as earlier mentioned, several other studies (e.g. Lal, 1996; Bernard and Wagner, 2001) indicated that firms with high skills are more likely to export. We therefore hypothesise that investment in skills upgrading will be positively related to firms' potential for export.

iv) Investment in technology hardware

This variable represents firm's implementation of a programme of reengineering that brings in new production equipment/machines or reengineering that improve existing production equipment/machines. We have assigned only a discrete measure (1 for investing; 0 for not investing) to this variable because it is difficult to ascertain the impact of the level of investment in technology hardware on the potential for export. Many Nigerian firms (especially SMIs) are known to use second hand machines/equipment due to capital constraints, and some even use production equipment that are obsolete (NISER, 2004). It is assumed that an immediate challenge that faces firms that have interest in exporting would be the necessity to embark on a reengineering programme that would replace obsolete or inefficient machines/equipment in order to significantly improve production performance. Even if the rationale for reengineering is not to embark on export drive, the action would improve the chances of making an export drive. For this study, we therefore hypothesise that investing in technology hardware would have a positive impact on a firm's potential for export.

v) Technological collaboration with foreign firm(s)

Lal (2002) observed that technological collaboration between local and foreign firms can have positive impact on export performance of firms. Technological collaboration in this respect can be in the form of foreign direct investment in a subsidiary of a multinational firm or technology licensing, technical agreements, trademarks, etc. Following Lal (2002) we propose a binary variable for technological collaboration and hypothesise that this variable will positively affect firms' potential for export.

vi) Investment in quality management

Product quality is an important determinant of access to the export market (Lall, 2001). In the West African subregion, dumping of manufactured products from Asia has been a major problem. Improving the quality of Nigerian manufactured goods is thus a major challenge that is being tackled by firms not only to satisfy local demand, but also to succeed in export to neighbouring countries. For this study we hypothesise that investment in quality management will have positive impact on potential for export.

vii) Firm size

There is ample evidence that firm size is an important determinant of ability to venture into international market. Krugman (1979) demonstrated that a larger size of operation provides greater risk-bearing capacity, brand names, and price setting power. Several studies (e.g. Kumar and Siddharthan, 1994; Haddad *et al*, 1996; Wakelin, 1997, 1998) have found a positive relationship between firm size and export capability. Wakelin (1998) showed that large innovative firms are likely to export, and the more innovations they have had, the higher the probability that they will enter the export market. Aggrey and Richard (2007) demonstrated that firm size is a determinant of export propensity among Ugandan manufacturing firms. The result of the Nigerian manufacturing enterprise survey by Soderbom and Teal (2002) also indicated that decision to export is strongly related to firm size. We therefore accordingly hypothesize that firm size will have a positive relationship with potential for export. It is also necessary to point out that the scale effects provided by size is often non linear ((Kumar and Saqib, 1996). Thus, a

quadratic term of firm size would also be tested to ascertain the direction of influence of firm size on potential for export.

viii) Cost efficiency

Competitiveness at the firm or sectoral level means the ability to do better than comparable firms or sectors in sales, market share, or profitability (Fagerberg, 1996; Lall, 2001). In an investigation of African manufacturing enterprises Soderbom and Teal (2000) indicated that there is a positive association between technical efficiency and exporting.[3] A similar result had earlier been reported by Bigsten et al (2000) with an evidence that the direction of causation runs both ways. In a latter study of the Nigerian manufacturing firms, Soderbom and Teal (2002) also demonstrated that the decision to export is strongly related to the technical efficiency of firms. The firm's underlying technical efficiency would determine its costs. The firm's cost efficiency would subsequently determine its ability to compete locally and in the export market. We accordingly hypothesize that the cost efficiency of the firms would be positively related to export potential of firms.

4. Research Methodology

4.1. Scope of the study

It would have been good to make the sectoral coverage of this study to be identical to those of two important previous surveys of Nigerian firms by the RPED[4] (reported by Marchart *et al*, 2002) and CSAE[5] (reported by Sonderbom and Teal, 2002). This would have provided an opportunity to enrich the RPED and CSAE data and thus increase the analytical possibilities of the study. However, the RPED survey was carried out in March/April 2001 while the CSAE survey was done in July/August 2001. Locating the firms in these surveys would be extremely difficult and there would be problem of information recall by respondents who were interviewed more than seven years ago. We therefore surveyed the Nigerian manufacturing subsectors where exports are more highly represented. Table 3 presents the quantities and value of Nigeria's manufactured exports in 2003. The manufacturing sub-sectors in table 3 include six of the eight sub-sectors covered by the RPED and the CSAE surveys. These six subsectors are food and beverages; chemicals and pharmaceuticals; paper/printing/publishing; plastics and rubber products; textiles and garments; and furniture and wood products.[6] A careful examination of the data in table 3 showed that these six subsectors are well represented in the manufactured exports. It is also instructive that 27 out of the top 50 companies listed by the Central Bank of Nigeria as having made non-oil exports in 2006 (see CBN, 2007) were manufacturing firms in these six subsectors. We therefore select these six subsectors for the study.

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[3] The study is an RPED survey of African manufacturing enterprises in four countries (Cameroon, Ghana, Kenya and Zimbabwe).

[4] RPED is the World Bank Regional Programme on Enterprise Development.

[5] CSAE is the Centre for the Study of African Economies at the University of Oxford, United Kingom.

[6] The other two sub-sectors covered by the RPED and CSAE surveys are metals and non-metals.

Table 3. Nigeria's manufactured exports, 2003

No.	Commodity	Net Weight (kg)	Value (fob) (₦ '000)	% of total value
1.	Vegetable products	5.512,353	200,873	2.9
2.	Animal and vegetable fats and oil and other cleavage production	4.600,090	201,615	2.9
3.	Prepared food stuffs; beverages, spirits and vinegar; tobacco	8,322,257	393,655	5.7
4.	Products of the chemical and allied industries (paints, pharmaceuticals, soap & detergents, cosmetics, etc.)	1,338,714	1,110,656	16.2
5.	Plastic, Rubber and articles thereof	6,998,289	2,725,067	39.8
6.	Goat or kid skin leather, prepared after tanning	9,271	54,075	0.8
7.	Paper making materials, paper and paper board articles	2,181,695	100,422	1.5
8.	Textiles and textile articles (yarn and fabrics, wearing apparel/garments, etc.)	931,684	1,338,154	19.5
9.	Footwear, headgear, umbrellas, sunshades, whips, etc.	2,600,826	407,201	5.9
10.	Articles of stone, plaster, cement, asbestos, mica, ceramic	1,521,053	81,922	1.2
11.	Miscellaneous manufactured articles (Furniture, mattress, mattress support, cushion, etc.)	176,334	239,200	3.5
	Total	**24,080,123**	**6,852,840**	**100.0**

Source: NBS (2003). 'Nigeria Foreign Trade Summary', National Bureau of Statistics, Central Business Area, Garki, Abuja.

4.2. Sampling, data collection and sources

The survey of firms used the instrument of a semi-structured questionnaire.[7] Our previous survey of Nigerian industry reported in Adeoti (2002) provided important background information on the Nigerian manufacturing industry. Location of firms selected for the study was done with the aid of the list of manufacturing establishments obtained from the state offices of the National Bureau of Statistics (NBS). The availability of secondary data on Nigerian industry is known to be poor and relatively unreliable (Mosley, 1992; Thoburn, 2000; Soderbom and Teal, 2002). Thus, it was difficult to plan a stratified sampling for the research sample. Based on available secondary information in the NBS list of establishments, efforts were nevertheless made to obtain a fair geographical spread of firms, and to minimise bias in firm size distribution. The research sample includes

[7] The pre-test of the questionnaire was carried out in the month of May 2008. The responses were considerably good and only minor refinement was necessary before the full survey which was carried out in the months of June, July and August 2008.

firms employing 20 or more persons. This generally excludes the microenterprises that dominate the informal sector economy. We have excluded microenterprises because export barrier to microenterpises in developing countries is high. The vast majority of microenterprises are known to produce to satisfy local demands and they often lack technical capacity to manufacture products that can meet export standards (Helmsing and Kolstee, 1993). The size restriction to firms employing 20 or more persons also follows the RPED survey. With the NBS list of establishments as the starting point, and guided by the distribution of firms by size and subsectors in the RPED sampling frame (see Marchat et al, 2002), a sample of 200 firms was selected. For each subsector, firm selection was done in such a way as to include different scales of operation in order to ensure heterogeneity among the sampled firms as well as to allow for analysis across scales of operation.

With respect to the geographical distribution of the research sample, it is pertinent to note that manufacturing firms in Nigeria are essentially in three large clusters. These include the Lagos-Otta-Agbara-Ibadan industrial axis; Nnewi-Aba-Port Harcourt industrial axis; and Kano-Kaduna-Jos industrial axis. These clusters are geographically widely dispersed. However, it is generally acknowledged that most Nigerian manufacturing enterprises are located in Southwest Nigeria, which essentially includes the Lagos-Otta-Agbara-Ibadan industrial axis. Some estimate claim that Lagos State alone has 60-70% of Nigerian manufacturing enterprises (Lubeck, 1992, p.17; LASEPA, 1999). The fieldwork was accordingly restricted to cover only firms located in Southwest Nigeria. Besides making the data collection activities less cumbersome, this enhanced the chances of collecting good quality data since the research sample was drawn from firms less widely dispersed. The research questionnaires were delivered to the firms by trained enumerators who also personally retrieved them.

The target respondents were plant managers or operations managers assisted by personnel managers or heads of the accounting department. The respondents were particularly requested to provide information on the nature and type of investments in technology made by the firm in 2006/2007, the rationales for these investments, and whether or not the firms exported. For exporting firms, information on the quantities and destination of exports were requested. The respondents were also asked to provide information on the constraints on and opportunities for investment in technology. To enable the estimation of the cost efficiency levels of the firms, data on inputs and outputs of the firms were collected along with information on input and output prices.

4.3. Data analysis and the empirical model

Data analyses are carried out using descriptive statistics, correlation analysis, stochastic frontier analysis, and logistic regression analysis. Entry into the export market is not automatic. The challenge of local and international competition has made deliberate effort in building capacity for exporting an important objective of firms. As capacity for exporting is improved, the potential for exporting increases. Accordingly, the firm's probability of exporting also increases given that the export market is unsaturated. In this study we therefore reckon that the export potential of a firm mirrors its probability of

exporting. This approach enables us to apply the logistic regression analysis to investigate the links between technology investment-related factors and export potential of firms.

Determination of cost efficiency

Before the specification of the logit model as the export model in this study, we apply the stochastic cost frontier analysis to estimate the cost efficiency (CE) which is one of the main explanatory variables in the logistic regression.

Following Schmidt and Lovell (1979) we assume that the firm's production technology is characterized by a Cobb-Douglas function of the form:

$$Y = \alpha \prod_{i=1}^{n} X_i^{\alpha i} l^{\varepsilon} \qquad (1)$$

which linearly becomes:

$$Y_i = \alpha + \sum_{i=1}^{n} \alpha_i X_{ij} + \varepsilon_i \qquad \text{where } Y_i = In(Y_i),\ X_{ij} = In(X_{ij}),\ \alpha = In\alpha \qquad (2)$$

where Y_i is output, X_j are observable inputs, ε_i is an error term and α and α_i are parameters.

As exemplified by Kopp and Diewert (1982) and Bravo-Ureta and Rieger (1991) we assume that the production frontier is self-dual such that the corresponding cost frontier can be written in general form as:

$$C = h(P,Y) \qquad (3)$$

where C is the minimum cost associated with the production of output Y, and P is a vector of input prices. Following Aigner et al (1977) and Meeusen and Van den Broeck (1977), the error term takes the form:

$$e = V - U \qquad (4)$$

where V is assumed to be identically and independently distributed as N(0, σ_v^2). This permits random variation in output due to factors outside the control of the firm like government policy, social infrastructure, etc.; U is a non-positive disturbance that reflects the technical inefficiency. Rewriting equation 2 in the log-linear form, we have:

$$InY = \alpha + \sum_{i=1}^{n} \alpha_i InX_{ij} + (V - U) \qquad (5)$$

InY is bounded from above by the stochastic production frontier:

$$\alpha + \sum_{i=1}^{n} \alpha_i InX_{ij} + V \qquad (6)$$

with technical efficiency relative to the frontier given by *U* percent.

We assume that each firm may be both technically inefficient and allocatively inefficient by operating off its least cost expansion path. Allocative inefficiency is modeled by

permitting the cost minimizing conditions which defines the least cost expansion path in implicit form to fail to hold. Errors in choosing cost minimizing factors' proportions then correspond to disturbances from the exact satisfaction of the first-order conditions for cost minimization (Schmidt and Lovell, 1979). As proposed by Aigner *et al* (1977) the maximum likelihood estimation (MLE) method is applied for the analysis.

For this study, the output variable is represented by firm's sales turnover; while the input variables include:

- the cost of raw material inputs;
- total wages of all categories of workers;
- depreciation on machinery, equipment and building; and
- total expenditure on energy and other utilities (e.g. water bill/procurement and communication bill).

Logistic regression

Following Soderbom and Teal (2000) we specify the logit model as the export model for the study. The logit model as applied for this study can therefore be formally stated as follows:

Let y be a dichotomous variable representing exporting ($y = 1$) or not exporting ($y = 0$). We express y as a linear function of vector, X_j:

$$y = b_o + \sum_{j=1}^{k} b_k X_j + \mu \qquad (7)$$

where

X_j is a vector (1 x j matrix) of factors determining exporting listed as explanatory variables in table 4;

b_o, b_k are the parameters to be estimated; and

μ is the error term.

Table 4. Explanatory variables and their measures

Variable name	Variable description	Measure
Ebuz	Investment in ICT (E-business facilities)	1 = invest 0 = not invest
SIR	Skills intensity ratio	Ratio of the no. of scientist and engineers to total workforce
ISU	Investment in skills upgrading	Investment in skills as proportion of sales turnover
HDW	Investment in technology hardware	1 = invest 0 = not invest
TCF	Technological collaboration with foreign firm(s)	1 = collaboration 0 = no collaboration

IQM	Investment in quality management	Investment in quality management as proportion of sales turnover
FZ	Firm size	No. of persons employed
CE	Cost efficiency	Percentage

Drawing on Maddala (1983; 1992, pp.327-328) and Liao (1994), exporting by a firm as defined in equation 7 could be equated to the *log-odds*[8] of the logit model. Thus,

$$log\ \frac{P}{1-P} = b_o + \sum_{j=1}^{k} b_k X_j \qquad (8)^9$$

where,

P is the probability of exporting given the vector of factors determining exporting, X_j .

The logit regression framework represented by equation 8 can be estimated to give the estimated parameters as the change in the log-odds that can be attributed to unit change in an independent variable. However, such estimation results may be relatively difficult to explain because the log-odds is itself an endogenous variable. To get round this problem, using matrix notations, equation 8 can be rewritten as shown in equation 9, and then transformed to give the probability of exporting as a non-linear function of X_j shown below as equation 10.

$$log\ \frac{P}{1-P} = b' X_j \qquad (9)$$

where

b' is the transpose of the matrix of parameters to be estimated.

Thus,

$$P = \frac{\exp(b' X_j)}{1+\exp(b' X_j)} = \frac{1}{1+\exp(-b' X_j)} \qquad (10)$$

Using maximum likelihood estimator, the estimation of the parameters in the logit model (equation 8) can therefore be carried out, and the conditional probability of exporting P, given the vector of independent variables X_j , can be obtained.

[8] As in Hamilton (1992) and Mukherjee *et al* (1998) we define *odds* with respect to this study as the ratio of the probability of exporting to the probability of not exporting of the product of a firm: *odds = P / (1-P).*

[9] For detailed proof on the derivation of this relationship of the logit model, see Maddala, (1992, pp.327-328).

5. Empirical Results

5.1. Investments in technology

The research sample

As indicated in section four, 200 questionnaires were administered to firms across the size distribution with the RPED sample frame as a guide. At the end of the survey, 109 questionnaires were retrieved. Thirteen of the retrieved questionnaires were not usable due to incomplete information or inadequate responses.[10] This resulted in a research sample of 96 firms distributed across the subsectors and firm sizes as shown in table 5. The mean firm size of the research sample according to number of persons employed is 205, median is 115, minimum is 20 and maximum is 1502. Following the examples of the RPED survey and previous studies by Lall et al (1994) and Adeoti (2001), we define firms employing 20-49 persons as small-sized, 50-199 persons as medium-sized, and 200 or more persons as large-sized. The research sample is almost evenly spread across the firm sizes with 30.2% in the small-sized industry (SSI) category, 37.5% in the medium-sized industry (MSI) category, and 32.3% in the large-sized industry (LSI) category. The food, beverages and tobacco (FBT) subsector dominates the sample with 31.3% of the sample size. This is expected because the FBT firms are known to be relatively more numerous, and contribute more than 25% of the manufacturing value-added (MVA) in most countries of sub-Saharan Africa (UNIDO, 1997). The distribution of other sub-sectors is fairly consistent with the RPED sample frame. 18.8% of the sample firms are in the plastics and plastics products, 15.6% are in the chemicals and pharmaceuticals, 12.5% are in furniture and wood products, 11.5% are in paper/printing and publishing, and 10.5% are in textiles and garments.

Table 5. Distribution of the research sample firms according to size

Subsector	Number of firms employing			Total
	20-49 persons	50-199 persons	200 or more persons	
Food, beverages & tobacco	7	10	13	30 (31.3%)
Chemicals & pharmaceuticals	3	5	7	15 (15.6%)
Paper/printing/publishing	4	5	2	11 (11.5%)
Plastics & rubber products	4	8	6	18 (18.8%)
Textiles & garments	5	3	2	10 (10.5%)
Furniture and wood products	6	5	1	12 (12.5%)
Total	**29 (30.2%)**	**36 (37.5%)**	**31 (32.3%)**	**96 (100.0%)**

Source: Analysis of survey data

[10] Six of the rejected questionnaires were out-rightly useless due to incoherence in the data supplied. The remaining seven were rejected largely because of the paucity of data on the input and output figures.

Type of investments in technology

Tables 6 and 7 respectively present the composition and origin of the main production machinery/equipment employed by the firms. 84.4% of the firms use either completely foreign technology equipment or equipment that are largely foreign technology. No firm employs completely locally fabricated production facility while only 15.6% of the firms use equipment that are largely locally fabricated equipment. The foreign components of the equipment are imported mostly from Europe, and to some extent also from Asia. These results are indication that Nigerian manufacturing is still dominated by the use of imported technology adapted to local conditions. This confirms the notion that the Nigerian engineering subsector that could fabricate manufacturing facilities is highly constrained and remains weak.

The mean age of the main production equipment is 8.65 years, median 7 years, mode 10 years, minimum 1 year, maximum 30 years. The relatively low mean and median ages suggest that most of the respondent firms carried out substantial re-engineering involving replacement or refurbishing of the main production equipment in recent years, arguably within the past ten years. Actually within the past three years, 51.7% of the firms claimed to have made significant changes in the production process, 57.6% have introduced new machinery/equipment, and 29.3% claimed to have added refurbished or second-hand machines to the production system. Moreover, 42.6% of the firms claimed to be involved in technology collaboration (with foreign firms) that could improve the physical capital stock. 37.7% of the firms mentioned the type of collaboration as mainly technical support agreement, 22.5% claimed technology licensing, 12.5% trademark licensing, and only 2.5% mentioned foreign direct investment (FDI). The type of collaboration is thus largely in the form of technical support agreement and technology licensing.

Table 6. Composition of the main production equipment/machine(s) used by firm

Composition	No. of firms	Percent
Completely locally fabricated equipment	0	0
Mostly local and some foreign equipment	15	15.6
Mostly foreign and some local equipment	44	45.9
Completely foreign technology equipment	37	38.5
Total	**96**	**100.0**

Source: Analysis of survey data

Table 7. Origin of foreign component of main production equipment

Origin	No. of firms	Percent
Europe	58	67.4
North America	5	5.8
Asia	22	25.6

Africa	1	1.2
Total	**86***	**100.0**

* Total does not add up to 96 because there are 10 missing cases that did not provide data
Source: Analysis of survey data

The type of ICT hardware investment by the respondent firms in the last three years is shown in table 8. Almost all the firms have made substantial investment in computers in the last three years. About one third (33.7%) have made investment in electronic inventory monitoring units, 30% have invested in computer aided manufacturing (CAM), 29.3% have invested in electronic sensors, while 25% have invested in digital cameras. In effect, each of the respondent firms has invested in information and communication technology (ICT) hardware in the past three years. Table 9 presents the type and perception of the importance of ICT application by the respondent firms. The application of ICT is most pronounced in production processes, customer relations management, and office automation as 68.1%, 65.9% and 59.3% respectively claimed deployment of ICT in these tasks. About 47% of the firms apply ICTs for managing product distribution networks, 45% deploy ICTs for supply chain management, while only 30% of the firms use ICTs for coordinating with other plants. The use of ICTs in coordinating with other plants is relatively low apparently because only the affiliates of multinational enterprises may require coordination with other plants. Virtually all the local firms in the research sample are single-plant manufacturing firms. It is also observed that 32.4% of the firms claimed ICT application in production processes the most important, 31% claimed ICT application in office automation most important, while 14.1% of respondents consider ICT application in customer relation management most important. Management of distribution networks, coordination with other plants, and supply chain management are considered most important areas of ICT application by only 12.7%, 7% and 2.8% of the respondents respectively. It thus appears that production processes and office automation are perceived as most important areas of ICT application by firms in our research sample. This may be an indication that firms are more conscious of the need to apply ICT in activities that have direct impact on the improvement of firm's in-house activities. Using ICTs in managing supply chain and distribution networks, and in coordinating with other plants are not perceived as most important by firms possibly because of the relatively poor ICT infrastructure in Nigeria. As the ICT infrastructure improves firms may have better appreciation of ICT applications in these areas.

Table 8. Type of ICT hardware investment in the last three years

Type ICT hardware	Percent of respondents*
Computers	95.7
Electronic inventory monitoring units	33.7
Computer aided manufacturing (CAM)	30.0
Electronic sensors	29.3
Digital cameras	25.0

*Sum of column is more than 100% because of multiple responses
Source: Analysis of survey data

Table 9. Application of ICTs

Type of ICT application	Percent of respondents	Percent of respondents that consider ICT application most important
Office automation	59.3	31.0
Production processes	68.1	32.4
Coordination with other plants	30.8	7.0
Customer relation management	65.9	14.1
Supply chain management	45.1	2.8
Management of distribution networks	46.7	12.7
Total		**100.0**

Source: Analysis of survey data

Table 10 presents the motives for technology acquisition as perceived by the respondents. More than half of the respondents claimed "improvement in product quality", "improvement of existing production process", and "introduction of new product" as the motive for technology acquisition. About half (49.5%) of the respondents mentioned introduction of a new production process as motive for technology acquisition. The rating according to "most important" motive follow a similar pattern except that "to improve export capacity" has the fourth position while "introduction of a new production process" has the fifth position. For the rating according to '2nd most important" motive, "improvement of existing production process" has the first position. In the context of this study, these results suggest that the primary motives for firms' investment in technology are to improve products and production processes without deliberate target of exporting. Only about 10% of the respondents consider improvement of export capacity most important motive for technology acquisition.

Table 10. Motives for technology acquisition by firm in the last three years

Motive for technology acquisition	% of respondents that consider motive		
	important	*most important*	*2nd most important*
improvement of product quality	82.4	39.8	19.3
introduction of a new product	53.8	15.9	16.9
improvement of existing production process	74.7	22.7	32.5
introduction of a new production process	49.5	6.8	18.1
to improve export capacity	17.6	10.2	3.6

Response to government policy incentives to renew industrial facilities	12.2	2.3	1.2
Emission reduction to enable compliance with environmental regulation	12.1	2.3	0
to adhere to parent company's production standards	14.3	0	8.4
Total		**100.0**	**100.0**

Source: Analysis of survey data

5.2. Constraints on and opportunities for technology investments

Table 11 presents the respondent firms' perception of factors that have discouraged or limited firms' investment in technology. These factors are apparent constraints on firms' capability to invest in technology. Most notable among these factors are high cost of technology, poor industrial policy and poor export promotion incentives which are considered by 76.9%, 75.6% and 45.1% of the respondents respectively as factors that have constrained investment in technology. The rating of the factors that discourages technology investments also revealed that these three factors are the most important deterrent to firms' technology investments. For example, 38.4% of the respondents claimed high cost of technology as the most important factor that discouraged technology investments, 25.9% claimed poor industrial policy, while 12.3% mentioned poor export promotion incentives. Factors such as "lack of competition", "lack of manpower to operate relevant technology", and "lack of information on relevant technology" are not considered by most of the firms as deterrent to investments in technology. It appears from these results that technological information and skills that could result in technology upgrading exists among the research sample firms, but there is lack of policy incentives and financial resources to implement firms' desirable technology investments. It is particularly noteworthy that as much as 45% of the respondents consider the extant export promotion incentives as incapable of stimulating investment in technology.

Table 12 presents the perception of the respondent firms on factors that have favoured investment in technology. Product quality requirement, competition among local firms and production process requirement were mentioned by 58.7%, 57.6% and 43.5% of the respondents respectively as factors that have favoured investment in technology. The rating of the most important factor that have favoured investment in technology almost followed the same order. 36.1%, 25.8% and 11.2% of the respondents respectively claimed "competition among local firms", product quality requirement" and "production process requirement" as the most important factor that favoured investment in technology. These three factors were also more frequently mentioned as the second most important factors. The three factors that were least commonly mentioned include "national policy on IT", "parent company operation standards" and the "challenge of access to export market" which were mentioned respectively by only 10.9%, 13.0% and 13.2% of the respondents as factors that favoured investment in technology. Moreover, no firm mentioned the "challenge of access to export market" as most important factor and only 2.2% each mentioned "parent company operation standards" and "science and technology policy" as most important factor. From these results it may be inferred that

the three major factors that present opportunities for investment in technology as perceived by the respondent firms include (in order of importance[11]): product quality requirement; competition among local firms; and production process requirement. The factors considered least important as presenting opportunities for investment in technology include (in order of importance[12]): national policy on IT; parent company operation standards; challenge of access to the export market; and science and technology policy. Thus, on one hand, improvement in products quality and production processes coupled with the challenge of competition among local firms are perceived as the driver of investments in technology. On the other hand, the Nigerian industrial, science and technology policies are considered incapable of promoting opportunities for investment in technology. The challenge of gaining entrance into export market is also not viewed as crucial for technology investments suggesting that firms in the research sample are yet to develop keen interest in the export market.

Table 11. Perception of factors that discouraged or limited investment in technology by firm

Constraint on technology investment	% of respondents consider constraint		
	important	*most important*	*2nd most important*
Poor industrial policy	75.6	25.9	22.6
Poor science & technology policy	30.8	4.9	3.6
Poor policy on IT	34.1	6.2	11.9
Poor export promotion incentives	45.1	12.3	14.3
Lack of competition	4.4	0	0
Lack of manpower to operate relevant technology	20.9	0	6.0
High cost of technology	76.9	38.4	26.2
Lack of information on relevant technology	25.3	3.7	8.3
Technical limitations in adapting foreign technology	28.6	8.6	7.1
Total		**100.0**	**100.0**

Source: Analysis of survey data

[11] To obtain the relative importance of the factors the score for the three columns were added.
[12] To obtain the relative importance of the factors the score for the three columns were added.

Table 12. Perception of factors that favour investment in technology by firms

Factor that favour technology investment	% of respondents consider factor		
	important	*most important*	*2nd most important*
Industrial policy	28.3	7.9	9.7
Science & technology policy	15.4	2.2	6.1
National policy on IT	10.9	3.4	1.2
Export promotion incentives	20.7	5.6	6.1
Competition among local firms	57.6	36.1	15.9
Challenge of access to export market	13.2	0	6.1
Production process requirement	43.5	11.2	17.1
Product quality requirement	58.7	25.8	23.2
Parent company operation standards	13.0	2.2	3.6
Need for flexibility in product mix	23.9	5.6	11.0
Total		**100.0**	**100.0**

Source: Analysis of survey data

5.3. Factors affecting export potential of firms

In the analytical framework in section four we specified the logit model as the export model, and hypothesized on factors determining the export potential of firms. In this section, the export model would be estimated. As a prelude to this, we will discuss the key features and structure of exporting by the research sample firms, explain the MLE estimates of the cost function and the distribution of the cost efficiency levels.

Features and structure of exporting

38 (i.e. 39.6%) of the research sample firms claimed to have engaged in some exporting. While all firms sell to domestic units or consumers, about 11.1% of the firms in our research sample export through distributors while 33.3% engage in direct exports. The mean age in exporting is about 9 years, while the median age of exporting is 7 years. The firm with the minimum experience in exporting has only exported for one year while the firm with maximum experience has engaged in exporting for 28 years. As shown in table 13, more than two-thirds (68.6%) of exporting firms in the research sample have engaged in export for not more than 10 years. It thus appears that there is an increasing tendency to export among these firms in the last ten years. This could be explained as an impact of the ongoing economic reforms.

As shown in table 14, about two-fifth (42.8%) of the firms exported not more than 5% of their output in 2007. It is however also noteworthy that at least one-third (34.2%) of the firms exported more than 20% of their outputs in 2007. The proportion of the export that

went to West African sub-region was 77.9%; 15.9% was exported to Europe; 5.5% was exported to other African regions; 0.4% was exported to North America; and 0.3% was exported to Asia.

Table 13. Distribution of age in exporting

Age in exporting (yrs)	Frequency	Percent
1 – 5	14	40.0
6 – 10	10	28.6
11 – 15	4	11.4
16 – 20	2	5.7
21 – 25	4	11.4
26 -30	1	2.9
Total	**35***	**100.0**

* there are three cases of exporting firms that did not indicate age in exporting, hence total of 35 firms.
Source: Analysis of survey data

Table 14. Distribution of the proportion of output exported in 2007

Proportion of output exported	Frequency	Percent
Less than 1%	4	11.4
1-5%	11	31.4
6-10%	5	14.3
11-15%	1	2.9
16-20%	2	5.7
21-25%	6	17.1
More than 25%	6	17.1
Total	**35***	**100.0**

* there are three cases of exporting firms that did not indicate level of exporting, hence total of 35 firms.
Source: Analysis of survey data

Cost efficiency of firms

The parameter estimates for the Cobb-Douglas stochastic frontier cost function for the sample firms is presented in table 15. With the exception of the coefficient of the cost of depreciation, all the other cost determinants of output in the empirical model have positive sign. Besides, while the other cost determinants have coefficients that are statistically significant, the coefficient of the cost of depreciation is not statistically significant. There is thus a clear indication that increases in the cost of raw materials,

wages, and utilities have a tendency to yield increase in output. The total variance of the parameter estimates is very large (0.983) and significant at 1% level. This represents the relative magnitude of the variance associated with the cost frontier model, and thus indicates that the estimated model is quite significant. Though all the four cost inputs have inelastic relationship with respect to output levels, the coefficient of the cost of raw materials is relatively high and significant at 1% level, while the coefficients of salary & wages and cost of utilities are also significant at 1% level. This suggests that cost of raw materials may be more important than any of the other three cost factors as determinant of output levels. One percent change in cost of raw materials, depreciation, salary & wages, and cost of utilities would change output levels by 0.687 percent, 0.359 percent, 0.370 percent, and 0.124 percent respectively.

Table 15. MLE estimates of parameters of Cobb-Douglas stochastic frontier cost function

Variable	Parameter	Coefficient	Standard error
Intercept	β_0	0.387**	0.181
Ln (cost of raw materials)	β_1	0.687***	0.065
Ln (cost of depreciation of machines/equipment/building)	β_2	-0.036	0.045
Ln (salary and wages)	β_3	0.370***	0.066
Ln (cost of utilities-electricity/water/telephone)	β_4	0.124***	0.050
Variance ratio: gamma	γ	0.983***	0.024
Total variance: sigma squared	c^2	0.704***	0.140
Log likelihood function		-61.708	

* and ** represent 10% and 5% levels of significance respectively.
Source: Analysis of survey data

Generally speaking, the cost efficiency levels are low. The mean cost efficiency is 0.22; median is 0.17; minimum is 0.11; and maximum is 0.78. About 65% of the firms in the research sample have cost efficiency below 0.20, 34.3% have cost efficiency of between 0.20 and 0.59, while only 3.1% have cost efficiency of at least 0.70. This is an indication that there may be a cost efficiency crisis in some of the firms in the research sample. For example, the median cost efficiency clearly suggests that the cost efficiency of half of the firms is not more than 17%.

Results of the estimation of the export model

Table 16 presents the results of the logistic regression for the determinants of export potential of firms. The first model (model 1) includes all the variables hypothesized as

determinants of export potential in subsection 4.3. All the parameter estimates have the expected positive sign. However, only four out of the eight variables have coefficients that are statistically significant. The Nagelkerke R^2 is 0.609, the Hosmer and Lemeshow test result is significant at 70% level,[13] and the percent of cases the model classified as either exporting or non-exporting is 78.9%. To improve the fit of the model, we dropped Ebuz from model 1 because its coefficient is the least statistically significant. In the resulting model 2, five out of the seven coefficients are statistically significant various levels; the Nagelkerke R^2 improved to 0.621, the Hosmer and Lemershow test is significant at 38.7% level, and the percent of cases that the model classified correctly improved to 79.1%. Further attempt to improve the model's fit resulted in model 3 where we have dropped HDW because it is the least statistically significant in model 2. Only five of the coefficients remain statistically significant with the significance of the coefficient of investment in skills upgrading (ISU) improving slightly from 10% level to 5% level. The percent of cases that the model correctly classified remained unchanged at 79.1%, and the Hosmer and Lemershow test is significant at 45.4% level. However, the Nagelkerke R^2 declined slightly to 0.613. In all the three models, the coefficient of firm size (FZ) is consistently statistically significant at 1% level. Since the firm size distribution of the research sample has a wide span, minimum firm size is 20 while maximum firm size is 1502, we replaced firm size with the log of firm size (LnFZ) to obtain model 4. Consequently, some of the previously significant coefficients become less statistically significant, LnFZ is significant at only 5% level, the Nagelkerke R^2 declines further to 0.560, and the percent of cases correctly classified reduced to 77.9%. From these results, it is apparent that models 2 and 3 are better fits for the data than either models 1 and 4. Models 2 and 3 have the same number of coefficients that are statistically significant. Model 2 is however preferred as the model that best fits the data because it has the higher Nagelkerke R^2. Model 2 would therefore be used to discuss the impact of technology investment related factors on export potential of firms. In table 17 we present the exact levels of significance of each of the parameter estimates of the explanatory variables in model 2.

[13] The Nagelkerke R^2 is a coefficient of determination similar in intent to the R^2 in OLS. It is a measure of the percent of total variation in the probability of exporting that is explained by the model's explanatory variables. Hosmer and Lemeshow test is a model calibration goodness of fit test. It shows how closely the observed and predicted probabilities match, which is an indication of how reasonably the model fits the data. Normally, the Chi-square level of significance should be more than 10%. In which case, the null hypothesis that there is no difference between the observed and predicted probabilities is not rejected. (Hosmer and Lemeshow, 1989; Norusis, 1999).

Table 16. Summary of the logistic regression for the determinants of export potential

Dependent variable: firm exporting = 1, firm not exporting = 0

Variable	Model 1	Model 2	Model 3	Model 4
Cost efficiency (CE)	0.154* (0.090)	0.159* (0.090)	0.162* (0.088)	0.141* (0.086)
Foreign tech. collaboration (TCF)	0.826 (0.667)	0.852 (0.664)	0.770 (0.652)	0.877 (0.621)
Invest in E-business (Ebuz)	0.234 (0.758)			
Firm size (FZ)	0.009*** (0.003)	0.009*** (0.003)	0.009*** (0.003)	
Log of firm size (LnFZ)				1.041** (0.406)
Invest in tech. hardware (HDW)	0.757 (0.970)	0.857 (0.952)		
Invest in skills upgrading (ISU)	2.138* (1.196)	2.060* (1.155)	2.269** (1.142)	1.892* (1.081)
Skills intensity ratio (SIR)	5.968** (2.734)	5.867** (2.701)	6.038** (2.670)	4.956* (2.635)
Invest in quality mgt. (IQM)	0.396 (0.262)	0.416* (0.257)	0.418* (0.256)	0.456* (0.245)
Intercept	-5.947*** (1.463)	-5.999*** (1.427)	-5.376*** (1.183)	-8.529*** (2.162)
Nagelkerke R^2	0.609	0.621	0.613	0.560
-2 Log Likelihood	62.99	63.23	64.10	70.14
Hosmer and Lemeshow test	0.700	0.387	0.454	0.993
Number of firms, *N*	83	86	86	86
% correctly classified	78.3	79.1	79.1	77.9

* , ** , *** represent 10%, 5%, and 1% levels of significance respectively.

Standard errors are given in the parenthesis.

Source: Analysis of survey data

Table 17. Details of the final export model (model 2)

Dependent variable: firm exporting = 1, firm not exporting = 0

Variable	Parameter estimate (B)	Significance level	Exp (B)
Cost efficiency (CE)	0.159* (0.090)	0.076	1.173
Foreign tech. collaboration (TCF)	0.852 (0.664)	0.199	2.345
Firm size (FZ)	0.009*** (0.003)	0.003	1.009
Invest in tech. hardware (HDW)	0.857 (0.952)	0.368	2.355
Invest in skills upgrading (ISU)	2.060* (1.155)	0.075	7.845
Skills intensity ratio (SIR)	5.867** (2.701)	0.030	353.172
Invest in quality mgt. (IQM)	0.416* (0.257)	0.104	1.516
Intercept	-5.999*** (1.427)	0.000	0.002
Nagelkerke R^2	0.621		
-2 Log Likelihood	63.23		
Hosmer and Lemeshow test	0.387		
Number of firms, *N*	86		
% correctly classified	79.1		

* , ** , *** represent 10%, 5%, and 1% levels of significance respectively.
Standard errors are given in the parenthesis.
Source: Analysis of survey data

Impact of technology investment related factors on export potential

The *a priori* expectation of a positive impact of technology investment related factors on export potential of firms was supported by the survey data. All the estimated coefficients have positive sign. However, three of the eight factors hypothesized have coefficients that are not statistically significant. We therefore reject the null hypothesis that the coefficients of the factors are statistically different from zero. These factors include technology collaboration with foreign firms; investment in e-business facilities; and investment in physical equipment and machines. Technology collaboration with foreign firms may not be important for export because as earlier mentioned in section 4.2 the type

of collaboration is mainly technical service agreement and technology licensing aimed essentially at producing to satisfy the local demand. Foreign direct investment (FDI) that may be aimed at producing high quality goods for the global market has been experienced by only 2.5% of the respondents. E-business transactions have not made significant impact on export potential possibly because the type of e-business identified among the sample firms are mainly the simple e-mail type transactions. Most of the firms in our research sample are yet to be involved in online website enabled and portal based transactions that can help them tap into the export market. Investment in equipment and machines have not been so important for export because such investment might have been perceived by the respondents as not essentially aimed at stimulating export or improving export performance.

Based on the results in table 17, firm size has a strong positive relationship with export potential, and it appears that firm size is the most important factor that affects the export potential of firms. The coefficient of firm size is the only parameter estimate that is statistically significant at 1% level. Besides, the coefficient of firm size is consistently statistically significant at 1% level for all the four models in table 16. This finding confirms the results of several studies (e.g. Krugman, 1979; Kumar and Siddharthan, 1994; Wakelin, 1998; Soderbom and Teal, 2002; Richard (2007) which have demonstrated a positive relationship between firm size and export capability. Other technology investment related factors that impact positively on export potential include (in order of the level of statistical significance of their parameter estimates): skills intensity ratio, investment in skills upgrading, cost efficiency of firms, and investment in quality management.

The skills intensity ratio is an indication of the level of skills employed by the firm in terms of the proportion of engineers and scientists in the total workforce. The result thus suggests that the use of high level skills in manufacturing activities has a positive impact on potential for export. Similarly, investment in skills upgrading activities such as staff training that enables better and efficient operation of machines and equipment is also positively associated with improvement in export potential. These results corroborate the findings of earlier studies by Lal (1996) and Bernard and Wagner (2001) which indicated that firms with high skills are more likely to export.

The data also support the hypothesis that cost efficiency has positive impact on export potential in cognizance of the fact that only efficient firms are most likely to succeed in the export market. This finding may serve as a complement to the finding of Soderbom and Teal (2002) which demonstrated that exporting by Nigerian manufacturing firms is strongly related to the firms' technical efficiency. The firm's underlying technical efficiency determines its costs, and hence both technical and cost efficiencies should plausibly impact on exports in the same direction. Investment in quality management has a positive relationship with export potential apparently because only high quality products can make significant debut into the export market.

6. Conclusions

The findings of the study generally indicate that investments in technology among the research sample firms are dominated by imported technologies, investment in ICTs are becoming widespread though not evidently deep in manufacturing related functions, and investments in technology are not directly targeted at improving the export potential of firms. Only about 10% of the respondents consider improvement of export capacity most important motive for technology acquisition. Most notable among factors that are perceived as apparent constraints on firms' capability to invest in technology are high cost of technology, poor industrial policy and poor export promotion incentives. The three major factors that present opportunities for investment in technology as perceived by the respondent firms include (in order of importance): product quality requirement; competition among local firms; and production process requirement. The factors considered least important as presenting opportunities for investment in technology include (in order of importance): national policy on IT; parent company operation standards; challenge of access to the export market; and science and technology policy. Thus, on one hand, improvement in products quality and production processes coupled with the challenge of competition among local firms are perceived as the driver of investments in technology. On the other hand, the Nigerian industrial, science and technology policies are considered incapable of promoting opportunities for investment in technology. Though firms' perception of the quality of industrial and export policies may be subjective, these results suggest that there should be deliberate intervention aimed at motivating firms to build capacity for export.

The *a priori* expectation of a positive impact of technology investment related factors on export potential of firms was supported by the survey data. All the estimated coefficients have positive sign. However, three of the eight factors hypothesized have coefficients that are not statistically significant. These factors include technology collaboration with foreign firms; investment in e-business facilities; and investment in physical equipment and machines. Firm size has a strong positive relationship with export potential, and it appears that it is the most important factor that affects the export potential of firms. The coefficient of firm size is the only parameter estimate that is consistently statistically significant at 1% level for all the four export models estimated. Other technology investment related factors that impact positively on export potential include (in order of the level of statistical significance of their parameter estimates): skills intensity ratio, investment in skills upgrading, cost efficiency of firms, and investment in quality management.

Flowing from the key findings of this study, the following suggestions for policy can help improve firms' capacity to carry out technological innovations aimed at improving export potential.

i) It should be a major concern that most firms are not keen on exports. This can be a problem arising from poor export policy incentives or perverse implementation of export policy. It would be useful to review the existing export policy regime and its implementation. Firms should be actively involved in the policy review process to

ensure that their views are taken into consideration in addressing the export challenges. An immediate focus of policy review should aim at reducing the cost of firms' investment in technology, improve incentives for export, and ensure effective implementation of export promotion incentives.

ii) The science and technology policy and the National policy on Information Technology are considered incapable of stimulating investment in technology by most firms. A wide consultation should be done to confirm this perception of firms. In fact, it would be good to launch a technology foresight programme that will articulate Nigeria's priorities in science and technology investments. The results of the technology foresight would serve as basis for an effective S&T policy and would also provide direction on areas that firms can be encouraged to divert their investments in technology.

iii) The results demonstrated that larger firms are more likely to export. While not neglecting large firms in export promotion, this suggests that policies on export promotion should pay particular attention to removing disincentives for exports among small and medium-sized firms.

iv) The results also demonstrated that technology investment related factors such as the use of high level skills in manufacturing activities, staff training that enables better and efficient operation of machines and equipment, cost efficiency, and investment in quality management are to be deliberately promoted in order to improve the export potential of manufacturing firms.

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