

Analysis of the national system of innovation in Nigeria: context and emerging trends

John O. Adeoti, Foluso Adeyinka and Kolade Odekunle
Nigerian Institute of Social and Economic Research (NISER), Ibadan, Nigeria

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Lead Research Institution:

Human Sciences Research Council
Private Bag X9182
Cape Town 8001
South Africa

Research Team:

Glenda Kruss, Jo Lorentzen, Il-haam Pattersen (HSRC)
Dani Nabudere, Babuuzibwa Luutu, Edgar Tabaro, Dani Mayanja (MGPARI)
John Adeoti, Kolade Odekunle, Foluso Adeyinka (NISER)

Contact Information of Research Team Members:

South Africa: gkruss@hsrc.ac.za
Uganda: nabudere@gmail.com
Nigeria: adeotij@yahoo.com

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ABSTRACT

This paper examines the features of the national system of innovation (NSI) in Nigeria in order to set the technological and economic development context for the analysis of university-firm interactions in Nigeria. The extent to which previous economic and social development experiences have constrained or enabled the technological development trajectory is reviewed. While Nigeria has made diverse and widespread attempts to develop science and technology (S&T), it is shown that until 2007 the development planning process in Nigeria failed to appreciate the central role of science, technology and innovation (STI) in economic and social development. S&T development focused on the supply of scientific knowledge without due consideration for the relevance of knowledge generated to the expected user. The existing apparatus for achieving the objective of scientific development and technological innovation is highly disjointed in establishment, management and operation. It is however demonstrated that policy concerns are beginning to address the challenge of a relatively weak NSI characterized by poor linkages between universities, R&D institutions and manufacturing firms.

Keywords:

National system of innovation, science and technology, firms, university, R&D, Nigeria

INTRODUCTION

The national system of innovation (NSI) framework has been used severally to analyse the linkages and interactions among the agents involved in the generation and use of innovation in a national economy. This has been done narrowly to limit the NSI to only a system of public research and development institutions and their interactions with firms in the private sector; or sectoral systems of innovations that focus on the analysis of specific sectors and the interactions among agents responsible for the innovative activities in the sector. In a broad sense, the NSI encompasses the conceptualization of the economic and social agents in a nation state as working in an intricate system that has a focus on generation and use of innovation to achieve economic and social development objectives. This can be further broadened into regional systems depending on the political and cultural linkages of the stakeholders involved (Freeman, 1987, 1995; Lundvall, 1992; Nelson, 1993; Malerba, 2002).

The NSI framework was originally applied to analyse developed country systems. Over the years, its application for analysis of developing countries has continued to grow in depth and scope. Kim (1997) applied it to analyse the Korea innovation system in the semi-conductor industry; Adeoti (2002), Oyeyinka and Barclay (2003) and Muchie et al (2003) have used it to analyse the systems of innovation in some African economies. This paper aims to present the features of the NSI in Nigeria to set the technological and economic development context for the analysis of university-firm interactions in Nigeria within the broad study of university-firm interactions in sub-Saharan Africa, and later, in global perspective among countries in the three regional studies. The study will characterize the NSI in Nigeria and capture the existing conditions for technological learning and upgrading, in general, and in industrial development in particular. It will also identify the extent to which previous economic and social development experiences have constrained or enabled the current and anticipated technological development trajectories.

The African regional study team has adopted a 'double-diamond' framework (presented in Figure 1) for the analysis of the NSI in the countries involved in the African regional study (Nigeria, South Africa and Uganda). The 'double-diamond' framework is an adaptation of Von Tunzelmann's (2007) model, which he used to analyse an 'industrial innovation system'. The model attempts to integrate the NSI models of Lundvall and Nelson with Michael Porter's famous diamond of competitiveness, which provides explanation for the determinants of the competitive advantage of nations (Lundvall, 1992; Nelson, 1993; Porter, 1990). As amply demonstrated by Kim (1997), the firm (and by implication, industry) is the core of the NSI as the principal agent of technological learning and innovation in any economy. Thus, 'firm and industry structure' is placed at the centre of the 'double-diamond' framework to signify the crucial role of firms and industry in the innovative activities that determine the extent and scope of economic structural transformation. While interactions among agents in the NSI are far more complex than shown in the schematic diagram, we propose that the framework suggests a convenient starting point for the analysis of an intricately linked constellation of factors that deter or promote the generation and use of technological innovation in the African context of largely under-developed economies. In fact, some authors (e.g. Lall and Pietrobelli, 2003) have suggested that there is no NSI in the sub-Saharan African context. In their study of technology development systems in sub-Saharan Africa they

discovered that, in general, S&T institutions are poorly funded, poorly resourced, de-linked from industry, and operate with little government support. From their findings, the NSI in such a context does not produce or use innovation in the sense of creating and using new knowledge that suggests advancing technology at the frontiers. Rather, what exists is a national technology system (NTS) that adopts, adapts and diffuses technologies that are already in use elsewhere. In this study we agree that this notion has a lot of merit and substantial empirical evidence. However, it is difficult to accept that generation and use of innovation at technological frontiers is foreclosed or not even already happening in the sub-Saharan African context. Besides, the NTS can be viewed as a constrained NSI which can be helped to evolve into a robust NSI given the right policy incentives. This is instructive because the NSI framework stresses the crucial role of policy intervention as taking precedence over the market in the achievement of a successful NSI.

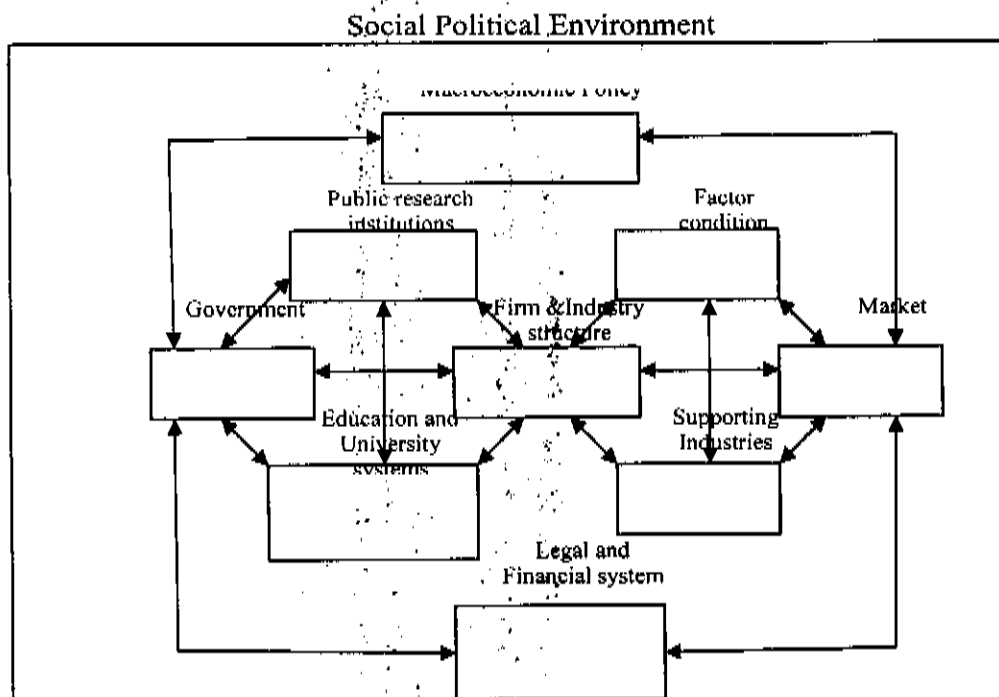


Figure 1. A framework for the analysis of a national system of innovation (adapted from a proposal for analyzing NSI by Von Tunzelmann (2007) drawing on Vanichseni)

This study attempts to ascertain how the activities at the firm and industry levels are affected by the policy initiatives and related institutional changes represented by the elements shown in the 'double-diamond' framework, taking a historical perspective where necessary. The education and university system is isolated by this study as playing very important roles in driving the evolution of the NSI when significant interactions exist between universities and firms. The analysis of the NSI provides background to testing this hypothesis empirically through a survey of manufacturing firms in Southwest Nigeria and case studies of university-industry linkages (UIL) in specific sectors. For Nigeria, the sector of interest for the UIL case studies is agro-food processing.

The rest of the paper is organized as follows: the next section discusses the trends in the macroeconomic policy context; the third section discusses the evolution of the public research institutions and the related policy regimes; the fourth section analyses the education and university system; the fifth section discusses the structural change and innovation capability; and the final section concludes the paper with suggestions for forging an effective transition into a NSI in Nigeria.

TRENDS IN THE MACROECONOMIC POLICY CONTEXT

The macroeconomic policy context that underpins the NSI in Nigeria can be divided into five distinct periods marked by significant shifts in economic policy management. These periods are:

- immediate post-independence period starting from independence in 1960 to the advent of the first military regime in 1966;
- post civil war oil economy starting from the end of the 30-month civil war in 1970 to the handover of government by the military to civilians in 1979;
- transition to an austere economy that emerged from the second republic and resulted in the adoption of the World Bank/IMF led economic structural adjustment programme (SAP) in 1986;
- the era of SAP and guided economic liberalization, starting from 1986 to the advent of the new democratic dispensation in 1999; and
- the regime of further economic liberalization starting from 1999 and resulting in the emergent macroeconomic stability in recent years.

Table 1 presents key economic performance indicators at the beginning and end of these periods. The macroeconomic policy context in Nigeria has not put the evolution of the NSI in focus as a strategic objective of economic policy. For the most part, in the policy process the importance of technological innovation as the engine of growth was neglected. The performance of key economic indicators has been rather poor. From 1960 to 2005 real GDP has increased, only approximately, by five fold from US\$12.8 billion to US\$60.4 billion; while real GDP per capita improved marginally from US\$314 in 1960 to US\$459 in 2005. Value addition in agriculture as per cent of GDP declined over the years from about 64% in 1960 to 23% in 2005. Manufacturing value-added as per cent of GDP remained considerably low at less than 10% over the years, while the share of services has been considerably high (between 19.9% and 45%) in the selected years. The relatively consistently high share of the services sector can be explained by the large informal sector in the Nigerian economy. Most economic activities of the informal sector are known to be in the domain of services. Furthermore, the share of manufacturing in total merchandise exports has been very low with the lowest of 0.2% in 1986, and an improvement of 2.07% in 2003. Moreover, Table 2 shows that the growth rates of the economy have been unimpressive. In particular, the decade of the 1980s was a period of manifest de-industrialization indicated by the negative average growth rate of industry. Much of the growth in earlier decades (1960s and 1970s) was not associated with structural change but was rather concentrated in the consumer goods sector, service industries, and assembly-type operations. The highest industrial incentives were reserved for import-substituting consumer industries with low value added and assembly plants based on imported raw materials. It was noted that the use of local raw materials by industries was discriminated against and incentive to develop exports was practically non-existent. The fastest pseudo-growth occurred in textiles,

vehicle assembly, soap and detergent, soft drinks, pharmaceuticals, beer, paints, and building materials.

Table 1. Nigeria: key economic performance indicators

Key economic performance indicator	1960	1966	1970	1979	1986	1999	2005
GDP in current US\$ (billion)	4.2	6.37	12.5	47.3	20.2	34.8	99.0
GDP in const. 2000 US\$ (billion)	12.8	15.3	19.8	30.2	27.6	43.6	60.4
GDP growth rate	n.a.	-4.3	25.0	6.8	2.5	1.1	6.9
GDP per Capita in const. 2000 US\$	314	326	382	454	342	380	459
GDP per Capita growth rate	n.a.	-6.5	22.0	3.6	-0.3	-1.3	4.7
No. of tractors per 100 ha of arable land cultivated	n.a.	0.48	1.09	2.99	6.94	10.64	n.a.
Manufacturing value-added (as % of GDP)	3.8	5.4	3.7	8.8	8.7	4.9	n.a.
Share of manufactures in total merch. 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 (annual % growth)	n.a.	70.6	27.9	46.9	-3.9	2.1	n.a.
Agriculture, value added (% of GDP)	63.9	54.9	41.3	28.7	38.7	36.6	n.a.
Agriculture, 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	n.a.
Services, value added (annual % growth)	n.a.	-4.6	20.8	2.4	7.3	0.7	7.1

Source: Compiled from World Development Indicators 2007, CD ROM

Notes: * latest available data for 2003; n.a = not available

Table 2. Growth rates of the Nigerian economy

Sector	Average Annual Growth Rate (%)				
	1960-70	1970-80	1980 - 90	1990 - 99	2000-04
Agriculture VA	-0.4	-0.1	3.3	2.9	5.3
Industry* VA	14.7	7.3	-1.1	1.7	5.1
Manufacturing VA	9.1	5.2	-1.0	n.a.	8.8
Services VA	2.3	9.6	3.7	3.1	6.1
Total Product (GDP)	3.1	4.6	1.6	2.4	5.4

Source: World Development Report (2002-05), World Development Indicators (2001-06).

Notes: + The figure for industry includes manufacturing; n.a. implies not available; VA = value added.

For an overview of the macroeconomic policy that underpinned these outcomes, it would be useful to briefly discuss the salient features of Nigeria's macroeconomic policy from immediate post independence to date, and highlight the innovation-deficit character of the macroeconomic policy regimes.

IMMEDIATE POST-INDEPENDENCE (1960-1966)¹

The immediate post independence economy was characterized by deterioration in the terms of trade and the rise of the oil economy. The spot prices of the Nigerian agricultural exports were declining though there was volume growth in exports in the early 1960s before stagnation in production set in around 1962. Price decline was no longer offset by volume growth. However, oil production which was only 17,000 barrels per day in 1960 rose to 415,000 barrels per day in 1966. The revenue from oil was thus timely in addressing the balance of payment problems. The contribution of the oil sector to total government revenue (mainly in royalties and rentals) rose to 17% in 1967, and its foreign exchange contribution amounted to about 20% of the total exports. Macroeconomic policy attempted to attract foreign investors with generous incentives that included import duty relief, accelerated depreciation allowances, and easy remission of profits. At independence Nigeria was regarded as a large and rapidly growing market. The merchant firms that dominated trading in imported manufactures during the colonial period suddenly found their positions threatened by new competitors. The outcome of this was that some of the trading firms switched to local manufacturing and lobbied successfully for protective tariffs. For example, the United African Company became involved in textiles, brewing, plywood and vehicle assembly. However, domestic value added in these industries was considerably low because their products had high import content.² It is also important to note that the main instrument of trade policy was the tariff, and Nigeria made very little use of quantitative restrictions. (Bevan et al, 1999).

Bevan et al (1999) reported that the economy grew rapidly from 1960 to 1966 at an average of about 5% per annum. While agricultural production began to decline, oil, public utilities, manufacturing, health, and education grew the most compared to other sectors. The first National Development Plan (1962-1968), which was Nigeria's first attempt at comprehensive and integrated planning, was launched.³ The plan set macroeconomic performance targets that included: an aggregate growth rate of 4% per annum; an increase in the rate of investment from 11 to 15% of GDP; and an increase in the "directly productive component" of government investment. As shown in Table 3, the plan allocated more than two-thirds (67.8%) of the budget⁴ to economic sectors; social sectors received about 24.4% out of which 10.3% was allocated to education; and political administration received 7.8%

¹ This section draws largely from the account of Bevan et al (1999).

² These are typical import-substituting industries, and Kilby (1969) observed that the major players are firms with prior interests in the Nigerian market.

³ Previous colonial plans are 'the ten year plan' of 1946, and the 1955-1960 Plan. These plans were regarded to be grossly deficient as development plans but rather akin to shopping lists of government departments.

⁴ The plan budgeted a public expenditure of N677million.

Table 3. Composition of planned public investments in the first national development plan, 1962-68.

Public investment	Percent of total
Economic sectors	
Primary production	13.6
Trade and industry	13.4
Electricity	15.1
Transport	21.3
Communication	4.4
Subtotal	67.8
Social sectors	
Water supply	3.6
Education	10.3
Health	2.5
Others	8.0
Subtotal	24.4
Administration	7.8
Total (N677million)	100.0

Source: Bevan et al (1999, p.30)

POST CIVIL WAR OIL ECONOMY (1970-1979)⁵

The military intervention in Nigeria's governance in 1966 subsequently culminated in a 30 month civil war from July 1967 to January 1970. The post war economy was dominated by the oil economy arising from the unprecedented increase in the price of crude oil in the international market. The oil boom enabled expansion in infrastructure and public sector investment in large scale manufacturing, most of which are aimed at achieving import substitution of foreign consumer goods and consumer durables. As shown in Table 4, oil exports as per cent of total exports rose from 58% in 1970 to 83% in 1973, and to about 90% or more in subsequent years. Similarly, oil revenue as per cent of total revenue rose from 26% in 1970 to 54% in 1972, and to 60% or more in subsequent years. The oil economy was characterized by the 'dutch disease' signified by the diversion of productive resources away from agriculture in particular, into commercial activities that thrived on trade in imported manufactures.⁶ The windfall in oil revenue affected the fiscal policy of government. Political pressures which would have improved the taxation of personal incomes, farm incomes, and property incomes were absent because everyone believed that oil revenue would always lead to surplus. Non-oil taxes were neglected and some taxes abolished. Added to this, rapid expansion of state expenditure took place without adequately reasoned sense of priority in the allocation of public expenditure.

The second development plan (1970-1974) and the third development plan (1975-1980) were launched, and the main thrust of macroeconomic policy in the two plans was to achieve growth by public sector led investment. Indigenization policy was implemented in 1973 and 1978 with the objectives of increasing the level of local managerial control, building local technological capability, and extending state ownership and control. Heavy

⁵ This section draws largely from Forrest (1993) and Biersteker (1987).

⁶ "Dutch disease" originally referred to the adverse effects on Dutch manufacturing of natural gas discoveries of the 1960s, which operated to raise the real exchange rate of the Dutch Guilder (Forrest, 1993). Similarly, the upsurge of foreign exchange earnings from oil in Nigeria led to the appreciation of the Nigerian Naira with adverse consequences on the export of agricultural produce and dependence of the economy on the fate of the oil industry.

subsidies were provided for public companies and corporations because they did not usually cover their running costs. In the 1970s only the communication (NITEL)⁷ and the power (NEPA)⁸ companies made consistent small operating surpluses (Biersteker, 1987; Forrest 1993). Education was given priority in the 1970s and public expenditure on education peaked in 1975 when the sector absorbed N1.05 billion, representing 19% of the federal government's current and capital expenditures. The federal government established the National Universities Commission, created seven new universities to increase the number to nineteen, and the number of university students rose from 14,000 in 1970 to 53,000 in 1978. Though the study of the sciences and engineering was particularly encouraged, the universities were all conventional universities not significantly different from the University of Ibadan, which is the only university established during the colonial era. The oil economy was largely dominated by foreign capital and provided the rent that serviced the domestic economy. Technological transfer was a major policy during this period, but there is no evidence that economic policy succeeded in stimulating knowledge transfer to build local technological capability in the oil industry. For example, Adubifa (1990) provided the case study of the failure of policy to achieve the desired technology transfer in Nigeria's petrochemical industry.

Table 4. Trend in Nigeria's oil export earnings

Year	Oil export as % of total exports	Oil revenue, as % of total revenue
1970	58	28
1971	74	44
1972	82	54
1973	83	60
1974	93	82
1975	93	77
1976	94	79
1977	93	76
1978	89	62
1979	93	81
1980	96	81
1981	97	70
1982	99	66
1983	96	69
1984	97	74
1985	97	75
1986	94	66
1987	93	76
1988	91	77
1989	95	82

Source: Extracted from Table 7.1 on Nigeria's oil sector statistics, 1970-1989 in Forrest (1993)

⁷ NITEL is the Nigerian Telecommunication company which had the monopoly of the telecom services for many years until 2001 when the Global System for Mobile communication debut in Nigeria.

⁸ NEPA is the National Electric Power Authority which had the monopoly of electric power generation, transmission and distribution in Nigeria for many years until 2005 when the government enacted a new Electric Sector Reform Act providing opportunities for private sector participation in the electricity industry.

TRANSITION INTO AN AUSTERE ECONOMY (1979-1986)⁹

The advent of the second republic in 1979 was accompanied by rising oil revenues, which further accentuated the tendency of macroeconomic policy to foster an over-valued Naira and consequently unbridled penchant for imports. The build up of surpluses in the external and internal accounts instigated the expansion of state expenditures and the liberalization of imports. However, by the end of 1981 oil revenue had sharply declined and the result was a policy of very high deficit financing which drained the external reserve and resulted in an unprecedented increase in the foreign debt profile. The loss of reserves and accelerating inflation prompted emergency stabilization measures in 1982. These measures included advance deposits for imports, increases in import duties, review of import licenses, 40% across the board cut in public expenditures without any priority, and upward review of excise duties, interest rates, and prices of petroleum products.

These policies brought a lot of stress on the productive sector of the economy. In the agricultural sector, produce exports became highly constrained by the over-valued Naira and production thus declined. The production of labor intensive export crops (e.g. cocoa, palm oil, palm kernels, rubber, groundnuts, cotton), which had earlier been limited by high labor costs and high opportunity costs of non-farm employment, was then constrained by increasingly unfavorable export prices. The decline in output was probably more apparent in the manufacturing sector with dramatic loss of production capacity resulting in gross losses in output and employment. This demonstrated the high vulnerability of the high cost, import-dependent nature of the Nigerian industrialization that had been encouraged by the pattern of incentives prevailing in the 1970s. The decline in the aggregate index of manufacturing was observed to have begun in 1982. Plant closures were apparent in consumer goods sectors, especially in the textiles sector where protection proved inadequate to address the challenges of smuggling. It was reported that the aggregate index of manufacturing fell by 26% in 1983, with declines ranging from 13% in paints to 54% in the electronics assembly. The economic outlook presented by Fashoyin et al (1994) showed that average capacity utilization in industry declined from 73.3% in 1981 to 38.2% in 1986. The stabilization measures achieved some reduction in the volume of imports. However, the inability to effectively control the allocation of import licenses and foreign exchange were perceived to have largely aggravated the pace of industrial decline between 1979 and 1986.

SAP AND GUIDED ECONOMIC LIBERALIZATION (1986-1999)

The introduction of the economic structural adjustment programme (SAP)¹⁰ in July 1986 was widely acknowledged as a profound economic reform aimed at addressing the inherent weaknesses of the economy. SAP was World Bank/IMF packaged and its adoption by the Nigerian government generated unprecedented debate on economic policy and strategy for economic recovery and sustainable growth. The debate was essentially drawn between the proponents of a liberalized economy, characterized by a more private enterprise, market-oriented strategy for growth; and advocates of state-led

⁹ This section draws largely from Forrest (1993).

¹⁰ SAP was actually a type of 'one size fits all' policy packaged for developing countries battling with recession in the 1980s. For a detailed description of the background to SAP, see Adeoti (1993).

development characterized by government playing critical roles in enterprise management and distribution of rewards to factors of production.

SAP can be viewed as medium-term strategic policy programmes aimed at revamping an economy under persistent recession and set it on the path of sustainable growth. It is generally understood that such an economy is unable to positively respond to short-term economic revival measures or has literally defied such attempts. SAP consisted of the stabilization policies of the IMF and the structural adjustment policies of the World Bank. The main objective of the former is to reduce short-term disequilibrium such as budget deficits, balance of payment deficits and inflation; whereas the latter aims at reorientation of the structures of the economy towards greater efficiency in the medium term. In practice the World Bank hardly institutes a programme without having an IMF programme already in place. The IMF programmes were usually regarded as conditionalities to be met by the concerned developing country before obtaining the IMF economic stabilisation loan, and subsequently the participation of the World Bank by granting her SAP loans which were more developmental oriented. The World Bank SAP loans and the IMF programmes have market-economy orientation as the basic philosophical undertones and values for economic development (Hansohm, 1993; Ihonvbere, 1993). The salient features of SAP included:

- major currency devaluations;
- major real cuts and reorientation towards agriculture in the government budget;
- reorientation of public expenditures in the productive sectors towards rehabilitation and maintenance;
- increased taxes on consumer goods;
- holding nominal wages fixed and/or raising them by significantly less than required to make up the effects of inflation;
- liberalization of the import regime;
- substantially raising nominal producer prices for agricultural cash crops so as to at least limit real declines;
- reduced price controls;
- increased competition and flexibility in agricultural marketing; and
- privatization of government-owned assets and concentrated efforts to raise efficiency in remaining government institutions.

A close look at these core elements of SAP reveals that SAP was not a development objective in itself, like meeting the basic needs of the populace or reducing unemployment, but rather a selection of strategically co-ordinated policy instruments aimed at healing an ailing economy and thereby putting it on the path of sustainable growth. All these policy instruments were applied in the implementation of SAP, especially between 1986 and 1993. In a review of the application of SAP in Nigeria, Jega (1993) summarized these critical elements of SAP into four major groups as follows:

- i) Introduction of price reforms, by removing existing control mechanisms and incentives;
- ii) Introduction of trade liberalization, by removing barriers, giving export incentives, and deregulating exchange rates;
- iii) Reduction of public sector involvement in the economy, by disinvesting through commercialization and/or privatization; and
- iv) Attempts to 'roll back the State', by cuts in public expenditure on social services.

The implementation of SAP had controversial economic and social consequences. While the painful effects of the IMF conditionalities were immediate, especially as evidenced by sharp deterioration in living standards, the developmental impacts of SAP were slow. With the introduction of the second-tier foreign exchange market (SFEM) in September 1986, the devaluation of the Naira was put on course, and demand management became an important feature of the monetary and fiscal policy. In order to avoid a mutually reinforcing currency depreciation and inflation, SAP reduced liquidity in the economy and compressed consumer incomes through a wage freeze and a significant cut in public expenditure. The result of the liquidity squeeze was to cushion the inflationary effects of SAP. The impact of SAP on the productive sectors of the economy was mixed. Industry had to devise strategies to cope with the various aspects of the new regime as well as a slump in effective demand. Tariff reduction cut duties on finished goods more than on intermediate inputs and raw materials thereby reducing effective rates of protection and increasing competition with foreign producers. However, industries that were less dependent on imports and had a steady demand (e.g. textiles) were less adversely affected. Besides, there were indications of new investments in industries that relied on local raw materials like palm kernel, cotton seed, and maize milling; rubber and vegetable oil processing; tanning of hides and skins; sorghum malting; and soya milk processing. There was also evidence of a deliberate shift to local raw material sourcing by industry. It was reported that increase in the cost of imports and pressure by government had resulted in the rise of local raw material sourcing by industry from 38% in 1985 to 50% in 1988. An interesting example of local substitution of foreign raw material is the substitution of imported barley malt for malted sorghum in the Nigerian brewing industry in the late 1980s after the government banned the importation of barley in 1988. Added to this, the beer industry, flour mills, textiles firms, and soft drink companies were all known to have invested in agro-industrial enterprises to secure supply of raw materials from local sources. While the ban on imported wheat in 1987 led to the closure of several bakeries, it also stimulated the conversion of some flour mills to processors of local grains.

The impact of SAP on the export of agricultural produce was also remarkable. Cocoa exports rose significantly as the producer prices soared from N3,000 per metric ton at the inception of SAP to over N15,000 in the 1988-1989 season, especially as exports became an avenue for capital flight into hard currencies. The tanning industry in Kano received new export-oriented investment, and the export of rubber also increased. There were also small exports of textiles, beer, tiles, plastics, carpets, wood products, perfumes, and tyres were recorded.

As the pains of SAP deepened with no evidence of reversal of the economic recession, the government adopted a policy of guided deregulation in the decade of the 1990s. Under this programme, attempt was made to limit the liberalization under SAP. A dual exchange rate emerged (one official, which is used for government essential transactions and another which serves as the intermarket exchange rate); and privatization and commercialization of public sector companies, which was intensely debated under SAP proceeded with a measured pace.

FURTHER LIBERALIZATION AND EMERGENT MACROECONOMIC STABILITY (1999 TO DATE).

The decade of the 1990s was mostly a period of economic and political crisis in Nigeria largely due to authoritarian military rule. The economic policy of guarded deregulation was largely dictated by the tendency of the military rulers to intervene in the market operations in order to service their cronies. However, the return to democratic governance in 1999 introduced a new opportunity for political and economic freedom, which enabled economic debate and planning for growth and poverty reduction. By 2003, the macroeconomic policy regime had shown a clear pattern of an accentuation of the economic liberalization and ardent commitment to private enterprise led development. The economic development policy was packaged under the tag, 'National Economic Empowerment and Development Strategy (NEEDS)'. The key features of the macroeconomic policy encapsulated by NEEDS¹¹ are:

- sustain a rapid, broad-based GDP growth rate, outside of the oil sector, that is consistent with poverty reduction, employment generation, and a sustainable environment;
- diversify the production structure away from oil and mineral resources;
- make the productive sector internationally competitive;
- systematically reduce the role of government in the direct production of goods, and strengthen its facilitating and regulatory functions;
- adopt policies that are consistent with raising domestic savings and increasing private investments;
- promote exports and diversify exports away from oil;
- gradually liberalize imports, harmonize tariffs with ECOWAS' common external tariffs, and use import levies and import prohibitions to protect local industries;
- maintain a competitive but stable exchange rate regime by establishing a market-determined nominal exchange rate regime, and avoid overvaluation of the real exchange rate; and
- maintain low real lending interest rates.

From 2003 to date these policies were being vigorously pursued and institutional frameworks for their implementation were strengthened or established where necessary. Some of the existing institutions that were considerably strengthened are:

- The Central Bank of Nigeria (CBN), which is now relatively more autonomous and empowered for monetary policy implementation and supervision of the financial sector – A major achievement of the CBN is the consolidation of the Nigerian banking institutions which reduced the number of banks from 89 to 25 by the end of 2005. The 25 banks are considerably stronger and able to provide better financial services;
- The Customs and Excise Department has improved infrastructure, especially in the area of information and communication technology, which has enabled better tariff collections and tracking of smuggling activities;
- The Bureau of Public Enterprises, which has increased the pace of privatization of publicly owned enterprises;

¹¹ NPC (2004), National Economic Empowerment and Development Strategy, published by the National Planning Commission (NPC), Abuja, Nigeria.

- The National Communication Commission, which has successfully liberalized the telecommunications sector, resulting in Nigeria being one of the fastest growing telecommunications markets in the world;
- Nigerian Agency for Food and Drug Administration (NAFDAC), which has succeeded in making Nigeria's food and drug products of acceptable quality;
- Standard Organisation of Nigeria (SON), which has improved standardization of industrial products; and
- Nigerian Export Promotion Council, which has improved the awareness and implementation of export incentives for Nigerian manufactures.

Some of the new institutions which have contributed to policy implementation include:

- Bank of Industry (BOI) formed through the merger of the former Nigerian Industrial Development Bank and the Nigerian Bank for Commerce and Industry;
- Nigerian Agricultural Cooperative and Rural Development Bank formed through the merger of the former Nigerian Agricultural and Cooperative Bank and the Peoples Bank;
- Small and Medium Enterprises Development Agency;
- Small and Medium Enterprises Equity Investment Scheme;
- Nigerian Information Development Agency (NITDA); and
- The Economic and Financial Crime Commission (EFCC).

The outcome is an emerging economy with a relatively stable exchange rate, fairly predictable macroeconomic environment, and good prospects for growth. The GDP growth rate, which was only 1.1% in 1999, recorded an average growth of 5.4% between 2000 and 2004, and rose to 6.9% in 2005. Value added in agriculture, manufacturing and services grew at an average of 5.3%, 8.8% and 6.1% between 2000 and 2004. (See Tables 1 and 2.) However, this seemingly good performance notwithstanding, there are strong indications that the micro impact of the macroeconomic reform measures is limited.

A review of the performance of NEEDS showed that its implementation had remarkable achievements by meeting most of the targets set. GDP growth rate, which was 3.3% in 1999, was an average of 6.0% in the period 2004-2007 with 0% and 8.3% in the oil and non-oil sectors respectively; the external reserves rose from US\$4 billion in 1999 to US\$43 billion in 2007 while exiting external debt to the tune of US\$34 billion; and an average inflation rate of 9.5%. Furthermore, noticeable achievements were recorded in the consolidation of banks and liberalization of the telecommunications industry. The Nigerian banking and telecommunications industries became some of the fastest growing in the world. The privatization of publicly owned enterprises also progressed appreciably with about 110 privatization transactions effected between 2000 and 2006 (NPC, 2007).

INNOVATION-DEFICIT CHARACTER OF THE MACROECONOMIC POLICY REGIMES

From the foregoing, it is apparent that the macroeconomic policy regime and management in Nigeria is deficient in identifying and harnessing technological innovation as an engine of economic growth and development. Investment in knowledge development has been limited. Ekundare (1973) reported that a main feature of economic development policy after independence was the establishment of three new universities to boost the production of local manpower mainly for bureaucratic management, and to some extent, participation in the private sector economy. The oil

boom era also witnessed the deepening and expansion of production of knowledge for development in Nigerian universities. However, macroeconomic policy management was then rudimentary and could not articulate a role for innovation policy. STI were considered exogenous to Nigeria's economic development and could only be acquired from outside by means of technology transfer. The mechanisms for technology transfer were also designed mostly by outside agents that claimed to understand the technological requirements of often isolated pilot cases.

The economic recession of the post oil boom made further investment in building knowledge and technological resources difficult. Besides, there was no period when reference was made to building a national system of innovation as an objective of macroeconomic policy. This is in contrast to newly industrializing countries where building capacity for STI capabilities were important features of economic development policy in their defining periods of growth. As demonstrated by Oyeyinka (2006) in his analysis of the role of STI capacity in making Nigeria competitive, Nigeria's current economic lag behind newly industrializing countries of Southeast Asia that were at relatively similar levels of per capita income with Nigeria in the early 1960s is strongly related to Nigeria's failure at building STI capabilities.

An important determinant of building STI is the ability to put in place mechanisms to ensure that indigenous technologies become integrated with modern technologies to boost productivity in the industrial sector. Two major perspectives have emerged in the literature in an attempt to provide a conceptual definition for indigenous technology. The first alludes to indigenous technology as homegrown and traditional technologies, while the second perspective observes the improvement of traditional technologies to fit within the requirements of a modern industrial sector. The latter perspective follows a framework that uses the 'old' and the 'new' in a complementary manner and regards the resulting nexus as innovation that is taking place within the national system of innovation (Okigbo, 1996; Maduemezia, 1996). The importance of indigenous technologies in any country cannot be over-emphasized as it is a necessary precondition for building technological capabilities and for sustaining domestic efforts aimed at effectively adapting and utilizing imported technology. Furthermore, successful industrial development lies in the ability to utilize available technologies, equipment and facilities effectively and efficiently. It involves improvement in productivity over time and the ability to diversify and increase capacity, as well as build more efficient capabilities.

At a meeting¹² of experts held in Nigeria on the promotion of indigenous technology for development in Africa, a working definition for indigenous technology emerged as follows:

Indigenous Technologies consists of all the skills, techniques or know-how that are traditional/homegrown or generated in any given location, community, country or region. It may be regarded as a component of the indigenous culture or tradition, and belief in a particular locality. Most indigenous or traditional technologies were generated, invented, or evolved by trial and error or intuition over long periods of time.

Specific examples of indigenous technologies on which modern industries could be based in Nigeria exist in agriculture, medicine and capital goods sectors of the economy. For example, indigenous techniques for brewing alcoholic beverages such as whiskey

¹² Meeting of OAU/STRC Inter-African Committee on Science and Technology for Development held at IITA, 26-30 August 1996.

and gin still provide the baseline for the numerous improvements that science and technology now provide for increase in quality and quantum of output. The brewery industry in Nigeria was successful in the utilization of local input resources (raw materials, technology, equipment and labor), to boost production activities in the late 1980s. Sorghum malt, a local and indigenous raw material, was used as an alternative to barley wheat, which was being imported. Subsequently, the machinery and equipment had to be adjusted to use the local input materials. The macroeconomic policy context in Nigeria did not provide for the sustainability of this integration of indigenous knowledge into modern technology. Consequently, by the late 1990s, the liberal economic atmosphere facilitated policy reversal resulting in the return to the use of imported barley wheat in many brewing plants.

In spite of the failure to make innovation policy an important aspect of the macroeconomic policy, there have been attempts by an array of institutions to promote technological upgrading and the integration of indigenous and foreign technologies. These institutions include publicly owned research and development institutes, science and engineering faculties in universities, specialised universities of agriculture and technology, polytechnics, the Raw Materials Research and Development Council (RMRDC), National Biotechnology Development Agency (NABDA), and the National Agency for Science and Engineering Infrastructure (NASENI).

RESEARCH AND DEVELOPMENT AND THE EVOLUTION OF SCIENCE AND TECHNOLOGY POLICY

RESEARCH AND DEVELOPMENT ACTIVITIES

Research and Development activities in Nigeria began during the colonial period with the establishment of the Nigerian Agricultural Research Institutes in Ibadan, Zaria and Umudike in the Western, Northern and Eastern regions of Nigeria respectively. Some other sub-regional research institutions were also set up with their headquarters in Nigeria about the same period. These included the West African Institute for Oil Palm Research (near Benin), the West African Cocoa Research Institute in Ibadan, the West African Institute for Trypanosomiasis Research in Kaduna and the West African Council for Medical Research in Yaba, Lagos. During this period, Nigeria belonged to sub-regional research bodies, such as the West African Road Research Institute, West African Rice Research Station and the West African Timber Research Unit. The bodies were coordinated from the West African Research office located in the then Gold Coast (now Ghana). When Ghana became independent in 1957, it withdrew from the sub-regional bodies, and the agencies located in Nigeria became national institutions (Oyeyinka et al, 1995).

In 1964, the Agricultural Research Institute Act was passed to coordinate the research activities in the country. The emphasis on R&D efforts in Nigeria until this time remained on agricultural activities. An international conference on the organization of Research and Training in Africa held shortly after the Act of 1964 however contributed to sharpening the awareness of policy makers on the need for a National Council for Scientific and Industrial Research (NCSIR). Subsequently, in December 1966, the Federal Military Government promulgated Decree No. 83 establishing the Nigeria Council for Scientific and Industrial Research. The NCSIR was replaced within three

years with the repeal of the NCSIR Decree, and the establishment of the Nigeria Council of Science and Technology (NCST) Decree of 1970.

The actualization of research activities in other sectors of the Nigerian economy started with NCST powers and mandate now covering agricultural sciences, experimental sciences, engineering and technology, medical sciences, environmental and social sciences. Specifically NCST had to oversee and manage research and development activities across ministerial lines, with four sectoral councils comprising:

- The Agricultural Research Council of Nigeria (ARCN), established in 1971;
- The Medical Research Council of Nigeria (MRCN), established in 1972;
- The Industrial Research Council of Nigeria (IRCN), established in 1972; and
- The Natural Sciences Research Council of Nigeria (NSRCN), established in 1973.

The primary function of each of this council was to fund and coordinate R&D efforts in the respective sectors. In 1977, the NCST and its sectoral councils were abolished and replaced with the National Science and Technology Development Agency (NSTDA). The NSTDA functioned until 1979 when it was dissolved and replaced with a Federal Ministry of Science and Technology (FMST). In 1984, the FMST was merged with the Ministry of Education. The name and character of this apex structure was later changed resulting in the re-establishment of the FMST in the late 1980s. Most of the public research and development institutes in Nigeria are clustered as parastatals under the FMST.¹³ Appendix 1 presents the list, year of establishment and the specific functions of some of Nigeria's R&D institutes. In very broad terms, the mandate and activities of these institutions can be summarized as follows:

- i) To conduct research in order to promote the utilization of natural resources appropriate to the economic conditions, environment, health and welfare of the people.
- ii) To improve productivity by propagating the results of research to benefit the country in sectors such as agriculture, industry and commerce, and health.
- iii) To train and upgrade the skills of researchers in these institutions.

In the last 25 years, institutional instability, declining funding, emigration of highly skilled researchers, and general uncertainty have characterized R&D activities in Nigeria (Idachaba, 2006a). After a few years of growth in the early 1970s, total spending for R&D activities fell by two-thirds starting from the mid-1970s. R&D institutions in Nigeria have therefore performed below expectation in terms of the degree of expected support to industry or initiation of new production outfits (Igwe & Okpala 1981; Bamiro, 1994). Some of the reasons given by Bamiro (1994) for the dismal performance of R&D institutions include poor infrastructure; inadequate or low funding; shortage of human resources; inadequate database; poor extension liaison services, poor linkages between institutions, as well as end-users; lack of continuity in some government policies; and the non-commercialization of research results.

¹³ As at 2004, Nigeria had over 66 public research institutes.

EVOLUTION OF SCIENCE AND TECHNOLOGY POLICY

Prior to Nigeria's independence in 1960, existing technology-related policies and programmes were primarily geared towards ensuring production of raw materials (predominantly agricultural), which were then exported to Europe and North America. The post-independent years subsequently followed with a technology drive based on import-substitution, and the promotion of private light consumer goods industries through foreign direct investment and joint ventures; promotion of large scale public owned core projects; promotion of private small and medium scale enterprises employing considerable labor; importation of foreign technologies, materials and personnel; and a heavy dependence on external R&D efforts.

The first coherent S&T policy of Nigeria was launched in 1986, and it emphasized the transfer of foreign technology to local firms via the licensing and registration of patents, trademarks, technical assistance arrangements, R&D, training and operations. The policy was distilled out of the contributions by the S&T community, made up of academics, industrialists, and policy makers, through consultations at numerous national conferences and specialized committee meetings. The objectives of the policy are as follows:

- i) To increase public awareness in S&T and their vital role in national development and well-being.
- ii) To direct S&T efforts along identified national goals.
- iii) To promote the translation of S&T results into actual goods and services.
- iv) To create, increase and motivate output in the S&T community.

To facilitate the achievement of the "self-reliance" aspect of the S&T policy, the Raw Materials Research and Development Council (RMRDC), was established by Decree No 39 in 1987. The Standards Organisation of Nigeria (SON) was also established for the purpose of ensuring standardization and adequate quality control in industrial production.

In 1990, the need to link the science, engineering and technology sectors to fit within industrial and economic development endeavors became one of the key issues of consideration by the S&T community. The absence of this key element was observed in the existing S&T policy. The S&T policy document was thus updated in 1992. The broad objective of the updated S&T policy is to vigorously prosecute a S&T infrastructure development programme aimed at catalyzing the emergence of an endogenous capacity. The specific objectives of the S&T policy include:

- i) Establishment of NASENI as an institution responsible for science and engineering infrastructure development.
- ii) Creation of implementation mechanisms for the rapid development and utilization of endogenous capacity in S&T.
- iii) Provision of suitable manpower with the appropriate multi-disciplinary spread and skills.
- iv) Ensure availability and convenient access to accurate up-to-date information on all aspects of S&T development.
- v) Ensure the provision of attractive investment incentives, particularly for private sector participation in S&T development.

The fields of information technologies (IT) and biotechnologies have been amply shown to present new windows of opportunities for catch-up in technological and economic development (Perez and Soete, 1988). The recognition of the pivotal role of IT in economic development led to the formulation and approval of the National Information Technology Policy (IT policy) in March 2001. The formulation of the IT policy was a consultative process that brought together major IT stakeholders¹⁴. The National Information Technology Development Agency (NITDA) was subsequently established in 2001 to implement the contents of the Nigerian IT policy. This marked an important milestone of technology development in Nigeria. While the importance of IT facilities is acknowledged as necessary tools of integration with the global world, the present state of these facilities in Nigeria - for example, communication facilities and the information technology infrastructure - limits the effective performance of global partnerships and investments in the country. It is however noteworthy that while the technology and industrial policy regimes had in the past been marked by indiscriminate import of technology in which transfer agreements contained very unfair conditions¹⁵, the IT policy presents opportunities for technological learning and accumulation of technological capabilities. The idea is to utilize IT as a key to achieving economic growth, global partnerships and sustainable development in the economy, while ascribing significant roles to SMEs.

In the area of biotechnology, the National Biotechnology Policy was launched in 2001. The major policy challenge is to promote the use of biotechnology techniques and also to ensure that Nigeria becomes an international leader in this area of development. The important role of collaboration and linkages among relevant stakeholders is reflected through the entire contents of the biotechnology policy. The need to complement local R&D with technology transfer efforts is given appropriate mention considering the present level of development of expertise of the country in this area. The National Center for Genetic Resources and Biotechnology (NACGRAB) in Ibadan, and the National Biotechnology Development Agency (NABDA) in Abuja are the two major institutions involved in the implementation of the biotechnology policy. NABDA has a mandate to empower the nation to become self-reliant in the development and application of biotechnology-based products and services, while NACGRAB undertakes developmental research, data gathering and dissemination of technological information on matters relating to genetic resources utilization, genetic engineering and biotechnology. So far NABDA has established six regional centres that are aimed at promoting the use of bio-resources. Presently most of NABDA's activities involve sensitization of stakeholders and building in-house capacity to implement the biotechnology policy. In this respect, NABDA has a working relationship with the Sheda Science and Technology Complex (SHESTCO) in Abuja, especially in the area of capacity building. While there are pockets of biotechnology research in universities (e.g. the case of the University of Ibadan reported in Adeoti and Adeoti (2003)), there is presently no evidence of functional links between NABDA and any of the existing universities.

¹⁴ These included the Computer Association of Nigeria (COAN), now known as Nigeria Computer Society (NCS), National Information Technology Professional Associations (NITPA), Association of Licensed Telecommunication Companies in Nigeria (ALTCON), as well as all Nigerians in Diaspora

¹⁵ These unfair conditions include monopoly pricing; restrictive business practices; export restrictions; high royalty rates; tie-in clauses with equipment, raw materials, components, etc; little training and management succession programmes; and poor/weak local R&D activities.

INTERACTIONS BETWEEN UNIVERSITIES AND RESEARCH INSTITUTES

There is presently very little interaction between universities and research institutes in Nigeria. The most visible area of interaction is in the effort to upgrade the training and educational level of researchers. Bamiro (1994) observed that areas of potential for interaction between universities and public research institutes in Nigeria include:

- Crops (development of high yielding varieties of commonly grown crops);
- Livestock (development of vaccine and balanced feed formulae);
- Food Processing (development of local foods and processing technologies);
- Food Storage (development of grain silos and other storage systems);
- Machinery and Parts (development of prototype machines and parts to meet local needs);
- Health (development of vaccines and drugs from local resources, adaptation of some medical equipment and control of diseases);
- Physical & Mathematical Sciences (knowledge-oriented research);
- Mineralogical Exploration (oil, gas, tin, tar sands, etc.);
- Energy (renewable sources, such as solar, biomass and biogas, and non-renewable sources); and
- Chemical Sciences (synthesis of new organometallics, local herbs, reaction mechanisms, spectroscopic problems, etc.).

International interactions in the form of educational linkages between universities and public research institutes have also existed in some of the internationally affiliated research centres. The International Centre for Theoretical Physics (ICTP), founded in 1964 with the cooperation of the Italian Government and the International Atomic Energy Agency (IAEA), has provided the forum for Nigerian scientists to break their intellectual solitude through participation in workshops, visits to Italian Laboratories and use of library facilities of the Centre. It was observed by Bamiro (1994) that quite a number of departments (more than 20) in the S & T faculties of Nigerian universities are affiliated with the Centre, while some individuals also enjoyed the associateship programme that enabled them to carry out research on their own with the Centre fully responsible for travels and maintenance. Since its inception, the Centre has received more than 700 visitors from Nigeria. It is worthy of mention that the establishment of the National Mathematical Centre in Nigeria is an offshoot of the gains of the association of Nigerian scientists with the ICTP.

Another form of interaction and linkage that exist between universities and public research institutes in Nigeria can be traced to the concept of Centres of excellence (COEs). Characteristic of a COE is the existence of seasoned researchers and facilities of superior grade such that the researchers are at the cutting-edge in the research area for which the institution is so recognised. In the late 1990s, eight such COEs were created by the Nigerian government. These included two nuclear research centres; two solar energy research centres; and a research centre specialising in neuroscience, oncology, immunology and parasitic diseases, and cardiovascular diseases.

The Sheda Science and Technology Complex (SHESTCO) in Abuja is a COE established by the Federal Government and was commissioned in 1995. Its mandate is to embark on advanced R&D activities, especially in biotechnology, chemistry, physics, and nuclear science. SHESTCO collaborates with universities mainly in providing opportunities for university researchers to carry out experiments requiring high technology equipment that is not available in their universities. SHESTCO services are

rendered free of charge to researchers from local universities, except that the researchers pay for reagents and other consumables (Adeoti and Adeoti, 2003).

Bearing in mind that the focus of the present study encapsulates agro-food processing and biotechnology in the Nigerian context, it is important to point out that Oyeyinka and Sampath (2006) observed that the food industry in Nigeria has made significant progress in inventions in traditional fermentation processes. Nevertheless many of these inventions, which would have significantly improved process efficiency and raised the industrial scale at which products are produced, are yet to be commercialized. For example, commercial enzyme¹⁶ production is an important output of the use of biotechnology techniques in the agro-food processing industry, but so far very little has been achieved, due in part to the fact that there are no firms involved in large-scale enzyme production in Nigeria. The RMRDC, in cooperation with a Nigerian brewery (the Ilesha Brewery Plc) had, in the past, attempted to produce the amylase enzyme, while FIRO¹⁷ had conducted experiments into the papain from carica papaya as a substitute for imported papain used in dehairing leather. However, these projects did not progress beyond the laboratory stage. It is documented that these enzymes could find use in a great variety of ways in hospitals and pharmaceuticals.

EDUCATIONAL DEVELOPMENT AND THE UNIVERSITY SYSTEM

NATIONAL POLICY ON EDUCATION

The need for a national policy on education came about as a result of the 1964 National Curriculum Conference, which was attended by several stakeholders in the educational sector. The conference was a communication of expression of general dissatisfaction with the state of the educational system in terms of its ability to address the national needs, aspirations and goals. The National Policy on Education, which covered both formal and non-formal education, was eventually articulated in 1977 and subsequently revised in 1981, 1998, 2001 and 2004. The National Policy on Education has the following specific objectives:

- The inculcation of national consciousness and national unity.
- Inculcation of the right types of values and attitudes for the survival of the individual and the Nigerian society.
- The training of the mind in understanding the world around it.
- The acquisition of appropriate skills, abilities and competence, both mental and physical, so as to contribute to individual development and the development of the society in general.

Following from the perceived importance of technical education, the policy emphasis for tertiary education is biased in favour of training in the sciences and technology-related disciplines. At the university level, student enrolment policy is 60% for the sciences and engineering and 40% for arts and humanities. For polytechnics, the ratio is 70%-30%

¹⁶ The sources of enzymes include plants, animals and microbes but microbes are the most popular source and specifically, industrial scale enzymes are found in *Bacillus* or *Aspergillus* species, which are harmless and have the characteristic of growing in relatively high concentration in simple media.

¹⁷ Federal Institute of Industrial Research, Oshodi, Lagos. FIRO is the pioneer publicly funded R&D institute on industry in Nigeria.

science to humanities. However, there is currently no evidence that policy implementation has achieved these targets.

The national policy on education recognizes education as an expensive social service that requires relatively high financial provision for the successful implementation of the educational programmes. However, the demand for educational services far outweighs the ability to improve on budgetary allocation to the sector. The total expenditure on education as a percentage of the Gross Domestic Product (GDP) was 1.4% in 1990 but later improved to 11.5% of total expenditure in 1995. It thereafter remained stable in the range of 12% to 14.5 % of the total Federal Budget for a number of years, but dropped to 10.5% and 7% of the total Federal Budget in 2004 and 2005 respectively (Moja, 2006).

The National Universities Commission (NUC) is the regulatory and coordinating agency for university education in Nigeria. A non-statutory NUC was established in 1962; an interim NUC was established in 1968 and a statutory NUC was established by Decree 1 of 1974, which was amended by Decree No 49 of 1988 and Decree No 10 of 1993. It is noteworthy that the emergence of the statutory NUC was in the oil boom years. Nigeria's investment in university education increased substantially with the establishment of ten new universities in the 1970s. The NUC grew in influence and power and had considerable funds of its own. It also acquired the power to disburse funds to the universities. The centralizing role of the NUC has been tremendous in such areas as the preparation of university master plans, setting of standards for physical facilities, enrolment projections, curriculum of universities, setting minimum standards, indices for fund allocation (e.g. staff-student ratio); setting conditions of service for university staff, setting up a system of accreditation for universities, external coordination of Nigerian universities' activities in foreign countries, and recently, the licensing of private universities.

On the issue of curriculum development, it is pertinent to note that the minimum academic standards foisted on the university system several years ago by the NUC are still operational in many universities; despite the apparent disconnect between the acquired skills of the products of the system and the requirements of the industry. Suffice to note that the demand of industry and the economy has changed so much that there is now an apparent disconnect between the university and industry. In order to bridge this gap, entrepreneurship development is now gaining currency in some of the country's universities. Also worthy of note is the advertised interest of the NUC in the introduction of entrepreneurship training in the entire university system. The fear is however being expressed that this might become another set of taught courses under the general studies programme (Odekunle, 2006).

NEW VISION FOR THE UNIVERSITY SYSTEM

Social, religious and intellectual fall outs of the Renaissance, Reformation and Enlightenment era made remarkable impact on the structure and organization of the university, especially in Germany and United States of America. In the 17th Century, the German universities concentrated more on teaching and research, while the British and Scottish universities laid emphasis on liberal education. By the 19th Century, the universities in America expanded their mission to include community service. By the middle of the 20th century, however, the universities all over the world came up with a harmonized mission that includes teaching, research and community service

(Akinkugbe, 1994). Nigerian universities share this mission. Reforming the educational system to be more 'society-relevant' has been a major challenge of Nigeria's current economic and social reform. In this respect, a National Summit on Higher Education was convened by the Federal Ministry of Education in 2002 to examine the problems militating against the quality of delivery and output of the higher education system in Nigeria. As reported by FME (2002), a major outcome of this summit was the new vision and mission of university education, which are as follows:

Vision:

We envision a system of higher education in Nigeria where the curriculum is relevant and responsive to the needs of the Nigerian Society. In implementing the curriculum, the institutions maintain stable academic calendars, facilities are adequate in quantity and quality; staff are committed and well motivated; the environment assures safety of life and property and is conducive to teaching and learning; new entrants are well prepared and adequately motivated to learn, and the products are adequately prepared for a fulfilled life and for positive contribution to society.

Mission:

The mission of university education is to produce qualitative graduates, worthy in character and learning, as well as the creation of new knowledge and innovations through effective teaching, research and public service for the overall socio-economic development of the country.

GROWTH IN THE EDUCATIONAL SYSTEM, SCIENCE-ORIENTATION AND HUMAN RESOURCES REQUIREMENTS

The higher educational institutions in Nigeria have important achievements. Since independence in 1960, they have provided the leadership corps in political, management, industry, science, technology, etc. The universities, in particular, have contributed immensely to the development and transmission of knowledge. Collectively, higher education institutions have supplied both high and middle level manpower, both for the economy as well as development of the education system. Table 5 presents the current state of human resources requirements in the key sectors of the Nigerian economy. The estimated shortfall in manpower requirements apparently suggests the need for expansion and deepening of the education system. While there is growth in the number of educational institutions (see Table 6), the rapidity of political development and the complexities of socio-economic change have manifested shortages of critical skills which pose a challenge to these institutions. The education system has responded to this challenge through the introduction of new curricula, diversification of programmes, and the establishment of specialized higher institutions for manpower development in agriculture, science and technology. In spite of these achievements, there are signs which are perhaps symptomatic of the social malaise that affects higher education as a structural component of the larger Nigerian society. These setbacks are manifested in the increasing worthlessness of graduate qualification as a result of decayed research and teaching infrastructure, disruption of the academic calendar due to labour crises and student unrest, deteriorating student-lecturer ratios, and persistent brain drain from the academic faculties.

Table 5. Graduate human resources requirement for strategic sectors

Sector	Type of human resources	Estimated human resources		
		requirements in the next 5 years	Present number in 2006	Shortfall
Agriculture	Agronomist, Veterinary Doctors; Agricultural Officers, Animal Scientists, Fisheries Officers, and Irrigation Engineers (Agricultural Superintends, Assistant, etc).	28,200	12,950	15,250
Manufacturing	Metallurgical Engineers, Electrical and Electronic Engineers, Mechanical Engineers, Civil Engineers, Textile Technologists, Printers, Accountants and Business Managers.	45,000	36,000	9,000
Petroleum	Petroleum Engineers, Geologists; Geophysicists and Civil Engineers (Welders and Technicians).	6,200	2,300	3,900
Gas	Petroleum Engineers, Geologists, Geophysicists and Civil Engineers (Welders and Technicians).	7,600	2,300	5,250

Source: Field survey 2006

Table 6. Number of tertiary educational institutions in Nigeria and period of establishment

Period	Number of tertiary institutions			Total
	Universities	Polytechnics	Colleges of education	
1960- 1970	6	5	4	15
1971- 1980	10	10	12	32
1981- 1985	7	15	14	36
1986- 1998	13	17	20	50
1999- 2007	45	28	20	93
Total	81	75	70	226

Source: NUC, NBTE¹⁸ and NCCE¹⁹ Annual Reports

Student enrolment in the universities increased from 1,395 in 1960 to 195,759 in 1990/91 and moved up to 723,213 in 2004/05 (NMB, 2005). Similar trends of increase in enrolments were recorded for the polytechnic and colleges of education (see Table 7).

Table 7. Distribution of students' enrolment by type of institution

Type of Institutions	Enrolment					% increase 1987/88-2004/05
	1987/88	1990/91	1994/95	1998/99	2004/05	
University	158,758	195,780	256,780	319,914	723,213	418.53
Polytechnic	72,134	106,926	187,738	219,770	323,684	348.73
College of Education	61,890	85,574	95,502	105,416	331,396	435.46

Source: National Manpower Board, 2005

¹⁸ National Board of Technical Education.

¹⁹ National Commission on Colleges of Education.

For the universities, Table 8 shows that the ratio of enrolment in science-related disciplines increased from 45% in 1998/99 to about 50% in 2004/05, while enrolment in arts and humanities decreased from 55% in 1998/1999 to about 50% in 2004/05. This can be explained by the relatively more effective implementation of education policy under the reform programme of the new democratic government. It is also important to note that while enrolment in the sciences appears to be improving (see Table 9 for comparison of the 2001/02 and 2004/05 sessions), there is no improvement in the proportion of engineering enrolment. Thus, the supply constraints of the core skills requirements by industry are yet to be significantly addressed by the university enrolment. There have also been more advocacies for science education at the lower levels of education, resulting in enrolment being more science-oriented at the university level.

Table 8. Distribution of university students by field of study

Field of Study	1998/99	1999/2000	2000/01	2001/02	2002/03	2003/04	2004/05
Science (Pure and Applied)	177,631 (45.1)	182,140	189,550	243,597	315,902	343,639	358,714 (49.6)
Arts and Management Studies	216,229 (54.9)	216,416	218,962	276,800	342,227	365,393	364,499 (50.4)
Total	393,860 (100%)	398,556	408,512	519,397	658,129	709,032	723,213 (100%)

Source: National Manpower Board, 2005

Table 9. Distribution of students' enrolment by field of study

Field of Study	2001/02		2004/05	
	No	%	No	%
Science(Pure)	66,383	15.9	72,387	16.1
Medicine	30,478	7.3	34,170	7.6
Pharmacy	7,098	1.7	8,542	1.9
Engineering	38,828	9.3	41,814	9.3
Environmental	16,283	3.9	17,535	3.9
Agriculture	28,390	6.8	31,473	7.0
Veterinary	3,858	0.9	4,496	1.0
Education Science	23,798	5.7	26,077	5.8
Total	215,016	51.5	236,497	52.6

Source: NMB, 2005

Higher education is equated with tertiary education and the concept varies from country to country and region to region. In the case of Nigeria, tertiary education comprises universities, polytechnics or colleges of technology, and colleges of education. The role that each of these institutions plays, depends on the type of institution. For example, universities provide higher education to all categories of high-level manpower in the country. For any candidate to gain admission into the university, 5 credits (including Mathematics and English) are required for science students at the school certificate examination, in addition to scoring 200 and above in the university Matriculation Examination (UME). The polytechnics or colleges of technology provide higher education to student technicians, who serve as maintenance officers for industry. The entry qualification is a good grade in SSCE, with credits in English and Mathematics

depending on the field of study, in addition to a pass in the Joint Admission and Matriculation Board (JAMB) examination. Colleges of education in Nigeria provide higher education to student teachers, who serve as teachers in the primary and junior secondary schools. The entry qualification is three credits in SSCE and just above average in the JAMB examination.

Over the years, graduate output from higher education institutions have also increased considerably (see Table 10). The universities that had an output of 141 graduates in 1953 (Ojo, 2006), produced 37,286 graduates in 1987/88, 41,497 graduates in 1994/95 and 97,376 graduates in 2004/05. There was an increase in the polytechnic graduates from 4,039 in 1975/76 to 43,965 in 1994/95 and 100,788 in 2004/05. Colleges of education produced 14,102 in 1980/81, 19,158 in 1994/95 and 45,348 in 2004/05 (NMB, 2005). As shown in Table 11, the ratio of graduates in science-related disciplines to graduates in arts and humanities improved marginally from 40.1:59.9 in 1998/99 to 41.2: 58.8 in 2004/05.

Table 10. Graduate output by type of institution

Type of Institution	Graduate out-turn					% Increase 1987/88-2004/05
	1987/88	1990/91	1994/95	1998/99	2004/05	
University	37,286	41,497	48,219	61,749	97,376	161.16
Polytechnic	25,573	31,321	43,965	58,823	100,788	293.64
College of Education	19,803	21,757	19,158	21,147	45,348	129.00

Source: NMB, 2005

Table 11. University graduate output by field of study

Field of Study	Graduate out-turn						
	1998/99	1999/2000	2000/01	2001/02	2002/03	2003/04	2004/05
Science (Pure and Applied)	25,008 (40.1)	30,599	33,405	36,079	38,369	39,386	40,119 (41.2)
Arts and Management Studies	36,741 (59.9)	44,636	48,711	52,134	55,198	56,444	57,257 (58.8)
Total	61,749	75,145	82,076	88,213	93,567	95,830	97,376

Source: National Manpower Board, 2005

Note: The figures in brackets are in percentages

FUNDING RESEARCH AND UNIVERSITY-INDUSTRY LINKAGES

Funding for research has always been limited in Nigeria. There has been no evidence of significant funding from public sources of university-industry R&D collaboration. The Higher Education Tax Fund (ETF), especially for research in universities, was established in the 1980s. The ETF has a broad mission aimed at delivering competent and forward looking intervention programmes through funding at all levels of the education system. The ETF was intended to facilitate the collaboration between the organized private sector and universities for setting priorities for research activities and funding. Thus far, the fund has disbursed the sum of N47 billion to all levels of education institutions for the purpose of improving the quality of education (Moja, 2006).

Furthermore, an important objective for setting up the Industrial Training Fund (ITF) in the 1970s was to provide students in tertiary institutions in Nigeria the opportunity for gaining industrial work experience, thereby complementing classroom teaching with practical hands-on experience in the world of work. The enabling decree requires all organizations employing more than 25 staff members to contribute 1% of their assessable annual profit to the ITF. The universities organize to ensure that their undergraduates in Engineering and Applied Science disciplines participate in the programme for the duration of 3 months, 6 months and 12 months, as applicable to the disciplines. At the university level, the Student Industrial Work Experience Scheme (SIWES) departments were created in each university. Students undergo this compulsory period of tutelage in the industry relevant to their fields of study and which will be their ultimate employers when they graduate. Every year the ITF expects about 78,800 students to participate in SIWES, for which about N60 million is spent annually for students' allowances and supervision.

STRUCTURAL CHANGE AND THE ROLE OF TECHNOLOGY IN NIGERIA'S AGRICULTURE AND INDUSTRIALIZATION POLICIES

Structural transformation of the Nigerian economy has been a common objective of development policy and plans in Nigeria. However, the economy has not been responsive to various attempts to stimulate structural change. From Table 1, it can be seen that in spite of the enormous revenue from oil exports, the economy remains largely agrarian. At independence, the share of agriculture in GDP was about 64%. This declined to about 55% at the emergence of the oil economy in 1966, 41% in 1970, about 38% in 1986, and about 37% in 1999. The contribution of manufacturing to GDP, which was 3.8% in 1960, was only 4.9% in 1999. Even the successes recorded by recent economic reform programmes from 1999 to date, are yet to significantly affect the structural composition of the economy. Table 12 presents the sectoral contributions to GDP for the period 1999 to 2005. The economy remains largely dominated by the agricultural and petroleum sectors, which contributed more than 65% of the GDP in any year from 1999 to 2005. The share of manufacturing remains stunted at less than 4%, with no indication of significant growth. The only sector with evident sign of growth is the telecommunications sector, which steadily increased its contribution to GDP from 0.45% in 1999 to 1.45% in 2005.

Table 12. Nigeria: sectoral 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.

Among the issues that constituted the main features of manufacturing in sub-Saharan Africa, Wohlmuth (1992) observed that lack of structural change was the most important issue. In a less developed economy where the agricultural sector is predominant, the strengthening of the linkages between the agricultural and the industrial sectors become very crucial for structural change to be realized. While agricultural growth stimulates demand for consumer goods and for industrial inputs into agriculture; industrial growth stimulates demand for food and for agricultural inputs into agro-allied processing industries (Siazon, 1992). The pace, scope and direction of this transformation process are determined by the technological capabilities in the agricultural and industrial sectors. It is unlikely that an agricultural production system, that is reluctant to modernize by adopting new production techniques and/or improved seeds, will be able to meet the challenges of increased food demands and increasingly stringent requirements of agricultural raw materials for industry. Similarly, firms that are not technologically innovative are unlikely to be able to compete as suppliers of agro-chemicals and/or processors of agricultural outputs into consumer or intermediate goods. Agricultural and industrial development policies are major determinants of the extent to which a country can achieve these transformations.

AGRICULTURAL DEVELOPMENT POLICIES IN NIGERIA

Agricultural policy in Nigeria has focused mainly on providing incentives for boosting food production, and recently, there are renewed attempts to revive the export crop subsector through a presidential initiative. The presidential initiative aims at diversifying the economy through increased agricultural production. The first national policy on agriculture was adopted in 1988 and was expected to remain valid for about fifteen years.²⁰ Nigeria's agricultural policy is the synthesis of the framework and action plans of Government designed to achieve overall agricultural growth and development. The policy aims at the attainment of self sustaining growth in all the sub-sectors of agriculture and the structural transformation necessary for the overall socio-economic development of the country as well as the improvement in the quality of life of Nigerians.

The specific objectives of the agricultural policy include:

- (i) attainment of self-sufficiency in basic food commodities with particular reference to those which consume considerable shares of Nigerians foreign exchange and for which the country has comparative advantage in local production;
- (ii) increase in production of agricultural raw materials to meet the growth of an expanding industrial sector;
- (iii) increase in production and processing of exportable commodities with a view to increasing their foreign exchange earning capacity and further diversifying the country's export base and sources of foreign exchange earnings;
- (iv) modernization of agricultural production, processing, storage and distribution through the infusion of improved technologies and management so that agriculture can be more responsive to the demands of other sectors of the Nigerian economy;
- (v) creation of more agricultural and rural employment opportunities to increase the income of farmers and rural dwellers, and to productively absorb an increasing labour force;
- (vi) protection and improvement of agricultural land resources and preservation of the environment for sustainable agricultural production; and

²⁰ See the web site of the Federal Ministry of Agriculture for the details of the Nigerian Agricultural policy.

- (vii) establishment of appropriate institutions and creation of administrative organs to facilitate the integrated development and realization of the country's agricultural potentials.

The main features of the strategies for achieving these objectives are:

- introduction and adoption of improved seeds and seedstock, husbandry and appropriate machinery and equipment, efficient utilization of resources, encouragement of ecological specialisation and recognition of the roles and potentials of small scale farmers as the major producers of food in the country;
- reduction in risks and uncertainties through the introduction of the agricultural insurance scheme to reduce natural hazards militating against agricultural production and security of credit outlay through indemnity of sustained losses; and
- a nationwide, unified and all-inclusive extension delivery system under the Agricultural Development Programme (ADP) put in place in a joint Federal and State Government collaborative effort.

The agricultural policy is supported by sub-policies that facilitate the growth of the sector. These sub-policies cover issues of labour, capital and land whose prices affect the profitability of production systems; crops, fisheries, livestock and land use; input supply, pest control and mechanization; water resources and rural infrastructure; agricultural extension, research, technology development and transfer; agricultural produce storage, processing, marketing, credit and insurance; cooperatives, training and manpower development, agricultural statistics and information management. The economy is still largely agrarian and agricultural development activities are largely funded by government. Some NGOs, such as Sasakawa Global 2000, also play an important role by encouraging adoption of improved crop varieties. Besides, international development agencies such as the World Bank, the International Fund for Agricultural Development (IFAD) and the African Development Bank (AfDB), also support specialized agricultural development projects. A good example in this respect is the National Fadama Project being implemented by the World Bank in several states of Nigeria.

At the inception of the democratic government in 1999, it was realized that the contribution of the sector had significantly dropped from being a major foreign exchange earner and resource reservoir to the status of low supply deficits in both food and industrial crops. On this basis, the presidential initiative on agricultural development was introduced to specifically promote major staple and export crops. The scope of the initiative covered tree crops, cassava, rice, and the Vegetable Oil Development Programme (VODEP).²¹

The foregoing notwithstanding, it is important to recall that, like in other parts of sub-Saharan Africa, the green revolution failed to yield expected results in Nigeria. By the 1970s, food imports became a major source of strain on scarce foreign exchange. In the late 1970s, the federal government launched the 'Operation Feed the Nation' programme, which aimed at encouraging citizens to make agricultural production a priority. Subsequently, another programme of agricultural promotion tagged, 'green revolution', was introduced in the early 1980s. These, and subsequent equally orchestrated agricultural policies, have been ineffective in addressing the challenges of agricultural development. Studies on the impact of agricultural policies in Nigeria (e.g.

²¹ For details of the presidential Initiative in Agriculture see:
<http://www.mistowa.org/files/CAFSTON/Presidential%20Initiative%20-%20FDA.pdf>.

Idachaba, 2000, 2006b; Ikpi, 2002; Idumajogwu, 2005), indicate that important shortcomings that affect the development of technological capability and the evolution of the national system of innovation include:

- While the policies achieved the establishment of many agricultural related research and development institutes, the policy viewpoint with respect to innovation is limited by the linear model of innovation that expects research outputs (inventions) to be automatically adopted by farmers or industries. This has generated unresolved, and often naïve, expectations of commercialization of research outputs.
- Support for agricultural mechanization has been limited and agricultural productivity at the level of subsistence agriculture has not improved significantly.
- Post harvest losses have remained a major problem, and the scale and scope of agricultural processing lag far behind requirements even in years of relatively poor yields.
- Technology applications, both at the farm level and at the industrial processing level, are still generally relatively backward in international comparison.

INDUSTRIAL DEVELOPMENT POLICY OF NIGERIA

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. At 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 the development of Small and Medium Enterprises (SMEs).²² Specifically, this policy contained the following initiatives by government:

- The expansion of the industrial estates concept. The federal government was to assist the state governments with matching grants to establish industrial estates for the promotion of SMEs.
- Intensification and improvement of the Entrepreneurial Development Programme (EDP), such as Working for Yourself Programme (WFYP) and Training the Trainers Scheme (TTS).
- Promotion and enhancement of the Industrial Development Centres.
- Establishment of the Nigeria Investment Promotion Commission (NIPC), whose functions include approval of technology transfer agreements (in terms of assistance in the procurement of machinery, plants, equipment and components, engineering design services, plant installation, and plant commissioning).
- Technology Business Incubator (TBI) project as institutional support for nurturing SMEs.

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

²² To date, SMEs predominate and account for about 87% of business activities in Nigeria, but only accounts for about 10% of the total manufacturing output (MAN, 2004).

in the primary state. Emphasis is to be placed on total factor productivity by encouraging knowledge and skill-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.

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 capacity for entrepreneurship and technical skills in order to create more direct and indirect employment opportunities;
- vi) increase the competitiveness of Nigerian manufactures;
- vii) facilitate inflow of foreign capital and technologies; and
- viii) encourage geographical dispersal of industries.

From these specific objectives, it appears that technology is regarded as a given input, which is not directly promoted as a driver of the industrialization process.

CAPACITY FOR INNOVATION IN FIRM AND INDUSTRY STRUCTURE

Firms of various sizes and with various structures of ownership exist within the NSI in Nigeria. As discussed earlier (in section two), in the 1960s and 1970s the popular view in Nigeria was that large scale enterprises were the cornerstone of industrialization. Many of these large firms were owned by foreign investors and multinationals. The government at various levels (Local, State and Federal) also own firms (solely or in partnerships), with the aim of stimulating industrial growth and regional development. However, in line with on-going reforms in Nigeria, there is a significant move to privatization of government owned firms, such that the government's role in the industrial sector will become limited to that of an enabler or facilitator implementing policy initiatives that allow the private sector to take the lead role, particularly in manufacturing activities (NISER, 2006). Development of small and medium-sized enterprises (SMEs) has also been accorded significance under the current economic reform because it engenders the development of local industries, the generation of employment and income, and the extension of industrial production over a greatly diversified base. The development of SMEs is linked to priority projects, which include those that can create forward and backward linkages with the rest of the economy; promotion of export-oriented industries that utilizes large volumes of local raw materials; and adoption of technologies that significantly improve performance. This notwithstanding, a high proportion of SMEs in Nigeria still lack the necessary support mechanisms for improving innovation capacity and promotion of industrial competitiveness. Oyeyinka et al (1995) identified some of the constraints of the innovation capacity of SMEs in Nigeria:

- low technological capacity of SME support institution;
- poor infrastructure, especially in the area of electric power;
- low skills intensity;
- poor management of resources;
- strong links between domestic enterprises and foreign parent companies, which prevent backward linkages and patronage of local research institutes;
- lack of significant capital goods sector; and

- local research institutes that should support the technical change process in SMEs are grossly under-funded.

The profile of industrial sector firms in Nigeria is characterized by a high level of imported plants and machinery and a weak science and technological infrastructure in the form of requisite human capital, as well as R&D capability for adoption, adaptation and assimilation of imported technologies. Table 13 gives the structure of capital goods, machinery and equipment importation in Nigeria between 2000 and 2004. The table confirms that the bulk of the demand for capital goods by Nigerian firms, as well as the supply of machinery and equipment, has been met through imports for many years. Also, the ratio of capital goods imports to consumer goods had remained almost stagnant at about 1 to 2 for almost five consecutive years. This scenario demonstrates the fact that capital goods importation of iron and steel products, for example, which are supposed to catalyze local production of consumer durable goods, continue to lag behind imported manufactured consumer goods.

Table 13. Structure of imports of capital goods (2000-2004)

	2000	2001	2002	2003	2004
Ratio of Capital Good to Consumer Goods	1:1.8	1:1.8	1:1.9	1:1.9	1:2
Ratio of Capital Goods to Total Imports	1:5	1:4.7	1:4.8	1:1.7	1:4
Ratio of Consumer Goods to Total Imports	1:2.6	1:3.0	1:2.6	1:2.5	1:2
Ratio of Machinery & Equipment to Total Imports	1:4.2	1:4.2	1:4.2	1:4.2	1:4

Source: Derived from the Central Bank of Nigeria Annual Report, 2003.

The weakness of the capital goods industry continues to hinder the development of the manufacturing activities in Nigeria. Critical firms that can stimulate radical change in the industrial landscape have been unable to perform in spite of huge public sector investments in them. For example, the main petrochemical complex located in Warri is yet to make significant impact on the economy; and attempts to revive the Ajaokuta Steel Complex and the Delta Steel Plant through privatization, are still in progress. In particular, the stunted and uninspiring growth of the steel industry has truncated the development of the capital goods industry.

Table 14 shows the investment profile for the industrial sector for the period, 2001 to 2003. Investment in R&D activities has always, and continues, to account for a very low share of total investments. For example, investment in R&D accounted for only 1.4%, while plant and machinery accounted for about 59.3% of investment within the period under consideration. In the agro-food processing sub-sector (food & beverages), only 0.3% of investment was in R&D. Also, of the total investment in the iron and steel sub-sector, R&D accounted for only 0.2%, while in the electrical and electronics and motor vehicle sub-sectors, R&D accounted for only 0.5% and 5.8% of investment, respectively. The low level of investment in R&D explains, in part, why the level of innovation has been disappointingly low. The relatively high level of investment in plant and machinery and equipment, as reflected in almost all the sub-sectors, is an indication that the capacity to produce technology in Nigeria did not improve during the period as the bulk of these investments are in new plants and replacement of aged production equipment, which are mainly sourced through imports.

Table 14. Investment by sector and type, 2001-2003 (N million)

Sector	Land & Building	Plant & Machinery	Equipment	Spare Parts	R&D	Vehicle	Others	Total	Sectoral %
Food, Beverage & Tobacco	1,490.8	4,623.0	648.2	610.8	29.9	1,513.3	281.7	9,197.7	26.8
Textiles, Apparel Footwear	326.6	437.8	12.14	2.54	14.5	9.32	0	802.8	2.3
Wood and Wood Products	39.8	22.0	2.2	53.2	1.45	2.5	0	121.2	0.3
Pulp & Paper Products	5.0	644.5	5.0	55.6	0	9.7	0	719.8	2.1
Chemicals & Pharmaceuticals	1,540.0	7,545.6	747.0	444.7	140.0	356.3	72.9	10,846.5	31.6
Non-metallic & Mineral Products	110.3	519.0	96.0	16.4	13.69	11.1	0	766.5	2.2
Domestic & Industrial Plastic	511.7	575.4	8.9	19.2	6.2	25.0	0.93	1,147.3	3.3
Electrical & Electronics	2.5	452.3	0	0.3	2.2	9.3	0.7	467.3	1.4
Basic Metal, Iron & Steel	755.6	4,353.4	33.0	231.2	12.3	239.5	239.7	5,864.7	17.0
Motor Vehicle & Miscellaneous Assembly	999.4	1,209.8	939.9	131.6	257.5	866.9	0	4,405.1	12.8
TOTAL	5,781.7	20,382.8	2,492.3	1,565.5	477.7	3,042.9	595.9	34,338.8	100
% of Total	16.8	59.3	7.3	4.6	1.4	8.9	1.7	-	100

Source: Derived from MAN's Economic Review, 2002 and Annual Report and Accounts, 2003

CONCLUSION: FORGING A TRANSITION INTO THE INNOVATION SYSTEM IN NIGERIA

It is widely acknowledged that the global competitiveness of any economy depends on its science, technology and innovation (STI) capacity. As this paper demonstrates, until very recently the development planning process in Nigeria failed to appreciate the central role of STI in economic and social development. Nigeria's approach to science and technology (S&T) development in the past has been based on 'science push'. It focused on the supply of scientific knowledge without due consideration for effective linkages to and the relevance of the knowledge generated to the expected user. Presently, Nigeria has about 66 R&D institutes covering various sectors of the economy, 81 universities conducting teaching and research, and several polytechnics and colleges of technology. While Nigeria has made diverse and widespread attempts to develop S&T, the national system of innovation is still considerably weak. The existing apparatus for achieving the objective of scientific development and technological innovation is highly disjointed in establishment, management and operation.

Although the first phase of the current economic reform programme (NEEDS) did not acknowledge the strategic role of innovation as an engine of growth, the second phase of the economic reform (tagged "NEEDS2") has now made explicit reference to the role of STI as a cross-cutting issue required to drive development in every sector of the economy. Moreover, major initiatives in the S&T sector from 1999 to date signified that Nigeria is beginning to appreciate the significance of S&T in socio-economic development. Some of these initiatives in the S&T domain include:

- i) National Science and Technology Manpower Survey
- ii) Design work on the proposed Science Park in Abuja
- iii) Promotion of entrepreneurship in the university system
- iv) Nigerian Policy on Information Technology
- v) National Biotechnology Policy
- vi) New National policy on S&T
- vii) Launch of the African Institute of Science and Technology in collaboration with the Nigerian in Diaspora Organization
- viii) Local content development in the Oil and Gas Industry
- ix) Computer for All Nigerians Initiative (CANI)
- x) Launching of NigeriaSAT-1
- xi) Communication Satellite Project (NIGCOMSAT-1) in collaboration with the China Great Wall Industry Corporation launched in 2007
- xii) Proposal to establish a Nigerian Science Foundation with an endowment of US\$5 billion.

The scientific research activities have produced a host of nationally patented inventions, the vast majority of which remains on the shelf, not commercialized or turned into innovations. Adeoti (2007) provides an example of a case study of the Cocoa Research Institute of Nigeria (CRIN) which has only one partially commercialized²³ invention out of a list of 20 R&D outputs relevant for industry. Currently, the scale of resources and capabilities for exploiting technology and generating innovation in Nigeria lags far behind what might be expected on the basis of international comparisons with dynamic newly industrializing economies elsewhere. For example, it has been demonstrated that as a result of a lack of commitment to building STI capacity, Nigeria's investment in STI lags far behind efforts in the advanced late industrializers (e.g. South Korea, Singapore, Taiwan, Malaysia). In a cross-country comparative analysis, Oyeyinka (2006) demonstrated that Nigeria would remain 20-30 years behind the newly industrializing countries of Asia unless enormous investments and efforts are made in building STI capacity. The lag is obvious across most sectors of the economy, but it is particularly worrying in key sectors that are considered centrally important for the country's future competitiveness in the world economy. Such key sectors include an array of industries in agro-processing, information technology and computer hardware assembly, metal working and capital goods.

Due to the often expensive nature of investments in STI there is the impression that S&T is a luxury, and it is thus unwise for less developed countries to invest scarce resources in this way. However, evidence shows that investment in STI is very crucial for wealth

²³ This is described by CRIN as a limited in-house pilot scheme commercialization. The invention is a recipe of bread with cocoa powder supplementation in the dough. Taste, appearance and storage assessment were rated higher for this bread than for normal bread. The bread is produced by a small CRIN factory and sold to staff. It is still uncertain whether a wider commercial application would be successful.

creation and poverty reduction: An important aspect of the vision of Nigeria's NEEDS2 is to build STI capacity for economic empowerment and rapid development of every sector of the Nigerian economy. It is expected that STI will be applied to reduce poverty, improve productivity in the formal and informal sectors, and achieve the competitiveness of the economy. Existing local knowledge resources (both indigenous and modern) would be utilized for the production of goods and services, while at the same time exploiting opportunities for technological learning based on adaptation and absorption of imported technologies.

From the analysis in this report, the following are the key issues and challenges for the evolution of the NSI in Nigeria:

- Technological backwardness remains a major development challenge, and the NSI is still relatively weak.
- Linkages between universities, R&D institutions and manufacturing firms appeared to be generally undeveloped.
- There are key challenges of technological adaptation and diffusion based on local conditions and knowledge. These may include the exploitation of science and technology for solutions that boost agricultural productivity and food storage capacity, reduce post-harvest losses, promote renewable energy (including bio-fuels and solar), develop rain water harvesting systems, deliver potable water to rural villages, and improve basic health care.
- Promotion of issues of how firms learn to innovate and government support to stimulate this learning process.
- Exploration of the role of Foreign Direct Investment (FDI) in the technology upgrading process.
- Production of scientists, engineers and technicians that have requisite skills required by industry, and how to ensure that they are gainfully employed or self-employed in activities that relate to their technological skills.
- Creation of more productive, higher paying jobs based on the application of S&T in agricultural production. This will require adding value to agricultural produce, developing new higher value added exports (whether or not the industry is considered high-tech), and establishing supply chain linkages between local firms, and between local firms and transnational exporters. Since the economy is dominated by natural resource-based sectors, increasing the productivity of these sectors is the first step to addressing the challenge of wealth and job creation as the main outcome of the NSI.
- Application of S&T to meet quality standards, increase output, and improve products, whether in horticulture, food production and processing, or extraction industries such as solid minerals, oil and gas.
- R&D in new technologies, especially in areas of local concern such as developing new vaccines for tropical diseases or new drought resistant crop varieties, application of modern biotechnology, information and communication technologies, nanotechnology, renewable energy technologies, new materials and nuclear technology for peaceful uses.
- Linking government support for purposeful and sustainable R&D to private sector growth and demand for R&D.
- Participation of Nigerian scientists in the Diaspora in local R&D efforts.
- Linking local R&D projects with similar global initiatives especially in the context of south-south cooperation.

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APPENDIX 1: PUBLIC R & D INSTITUTES IN NIGERIA

Name	Location	Year established	Functions
1. Institute for Agricultural Research (IAR)	Samaru	1924	Conduct research into the genetic and agronomic improvement of sorghum, groundnut, cotton, cowpea and sunflower. Coordinates the total farming system research and extension activities in the northwest zone.
2. Nigeria Institute for Oil Palm Research (NIFOR)	Benin-City	1939	Conduct research into the genetic and agronomic improvement, production and utilisation of oil palm, coconut, date palm and raffia palm, and is responsible for the nationally coordinated research programme on oil palm.
3. Cocoa Research Institute of Nigeria (CRIN)	Ibadan	1944	Conduct research into the genetic and agronomic improvement, and development of husbandry practices of cocoa, kola, cashew, coffee and tea; and is responsible for the nationally coordinated research programme on cocoa.
4. Nigerian Stored Products Research Institute (NSPRI)	Ilorin	1950	Conduct research into post-harvest technology of agricultural crops with particular reference to handling and storage of food crops; and the biotic and abiotic factors that cause or promote deterioration of harvest crops
5. Forestry Research Institute of Nigeria (FRIN)	Ibadan	1954	Conduct research in all aspects of forestry and forest products utilisation in the country as well as agro-forestry and wildlife management and technical education in these fields.
6. Federal Institute of Industrial Research, Oshodi (FIIRO)	Lagos	1956	To assist in accelerating the industrialisation of the country through matching the country's raw material with industrialisation projects and upgrading indigenous production techniques.
7. Rubber Research Institute of Nigeria (RRIN)	Benin-City	1961	Conduct research into the genetic and agronomic improvement of rubber and gum Arabic; quality of Nigerian rubber and other latex producing plants of economic importance; and is responsible for the nationally coordinated research programme on rubber.
8. National Agricultural Extension and Research Liaison Services (NAERLS)	Zaria	1963	Development, collation and dissemination of agricultural technologies, monitoring, and providing overall support to research extension farmer linkage activities; and is responsible for the nationally coordinated research programme on research-extension linkage and delivery system.
9. National Institute for Trypanosomiasis	Kaduna	1964	Conduct research into the study of trypanosomiasis and encephalitis, the methods of treatment and control of these in livestock and human beings, and socio-economic effects on rural populations
10. Institute of Agricultural Research and Training (IAR&T)	Ibadan	1969	Conduct research into the genetic and agronomic improvement of maize, kenaf, and jute and sisal hemp; and undertake national research on soils and fertilizer use. Coordinates the total farming system research and extension activities in the southwest zone.
11. National Cereals Research Institute (NCRI)	Badeggi	1975	Conduct research into the genetic and agronomic improvement of rice, soybean, sugar cane and beniseed. Coordinates the total farming system research and extension activities in the central zones; and is responsible for the nationally coordinated research programme on rice and soybean
12. National Institute for Horticultural Research (NIHORT)	Ibadan	1975	Conduct research into the genetic and agronomic and processing improvement of local and exotic fruits and vegetables, and the development of ornamental plants of economic importance; and is responsible for the nationally coordinated research programme on fruits and vegetables.
13. National Institute for	New	1975	Conduct research into the genetic improvement freshwater fisheries production through rational

Fresh-water Fisheries Research (NIFFR)	Bussa		exploitation and utilisation of freshwater aquatic resource; and is responsible for the nationally coordinated research programme on freshwater fisheries
14. National Institute for Oceanography and Marine Research (NIOMR)	Lagos	1975	Conduct research into the resources and physical characteristics of the Nigerian territorial water and high seas, with the overall aim of ensuring sustainable fisheries production in marine and brackish water environments; and is responsible for the nationally coordinated research programme on marine fisheries
15. Lake Chad Research Institute (LCRI)	Maiduguri	1975	Conduct research into the genetic and agronomic improvement of wheat, millet and barley. Coordinates the total farming system research and extension activities in the northwest zones; and is responsible for the nationally coordinated research programme on wheat and barley.
16. National Root Crops Research Institute (NRCRI)	Umudike	1975	Conduct research into the genetic and agronomic improvement of yam, cassava, potato, sweet potato, cocoyam and ginger. Coordinates the total farming system research and extension activities in the southeast zones, and is responsible for the nationally coordinated research programme on yam and cassava.
17. National Animal Production Research Institute (NAPRI)	Zaria	1976	Conduct research into the genetic, reproductive improvement of cattle, sheep, goats and other livestock; develop pastures and other plants for use as animal feed; and improve livestock production and management; and is responsible for the nationally coordinated research programme on large ruminants and feeds and feed resources
18. National Veterinary Research Institute (NVRI)	Vom	1976	Conduct research on all aspects of animal disease, their treatment and control; the production of vaccines and sera; and is responsible for the nationally coordinated research programme on diseases of animals.
19. Agricultural and Rural Management Training Institute (ARMTI)	Ilorin	1981	Conduct management research, offer courses in management, and provides information and consultancy services to the public and private sector that have interest or responsibility for improving research, development and production in the agricultural sector in Nigeria.
20. Projects Development Institution (PRODA)	Enugu	1970	PRODA's main mandate is to develop industrial projects using local raw materials and indigenous human resources, through laboratory and pilot-plant investigations.
21. National Research Institute for Chemical Technology (NARICT)	Kaduna	1964	The National Research Institute for Chemical Technology (NARICT), formerly the Leather Research Institute of Nigeria, has a partial mandate that covers development of leather auxiliaries, industrial chemicals, chemical pollution, etc.
22. Nigerian Building and Roads Research Institute (NBRI)	Lagos	1977	NBRI has an overall mandate to conduct integrated applied research and development in the diverse fields of building and construction.
23. National Institute for Medical Research (NIMR)	Lagos	1940	Conduct research and carry out studies that influence health policy-making in Nigeria. NIMR serves as an advisory body to the government.
24. National Institute for Pharmaceutical Research and development (NIPRD)	Abuja	1987	This institution has a mandate to exploit local raw materials through the application of modern scientific R&D methods, into high quality pharmaceutical grade raw materials, drugs and biological products for the management of tropical diseases and other global ailments.
25. National Centre for Agricultural Mechanization	Ilorin	n.a	Conduct research into the fabrication of agricultural equipment and machinery for post harvest processing of agricultural commodities.

n.a. = not available

