A Plan for Igniting Nigeria's Industrial Revolution

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Abstract: The Industrialization of countries is in every way influenced by forerunner nations. This is exemplified in Western Europe's copying of Britain's technology and manufacturing systems. This work presents a study of the industrialization of nations such as Japan, South Korea, Taiwan, Singapore and several other industrializing countries and the lessons learned revealed that the industrialization of these nations was based on initial imitative-reverse-engineering of products of forerunner nations which then leads to endogenous growth and the onset of innovation under certain constraints. This is a strategic form of import substitution and is in fact the model around which a plan for Nigeria's Industrialization has been built.

Keywords: Imitative-reverse-engineering; Endogenous growth; Import substitution; Industrial revolution

1. Introduction

According to the UN, Nigeria is a poor nation. The wealth of a nation is not only measured by how huge its foreign reserve may be but also by the standard of living of the people of that nation. Although Nigeria is rich in natural and human resources, 6 [out] of every 10 Nigerians live on less than $1 per day (NEEDS-National Economic Empowerment Development Strategy, Abuja, 2005). The government of Nigeria is cognizant of this malady and has been seeking for ways to combat it for several decades (2005 International Monetary Fund). But the standard of living in any nation is reflected in the product and services available to its people. In a nation with a high standard of living, a middle-class family usually owns an automobile, a refrigerator, an electric stove, a dishwasher, a washing machine, a vacuum cleaner, a stereo, and of course a television set. Such a family usually enjoys health care that involves modern equipment and facilities. Such a nation is said to be a rich nation not because there are abundant mineral resources within its territory but because it is able to convert raw materials into manufactured goods and has a manufacturing base. Therefore the more active in manufacturing the people of a nation are the more plentiful goods and services become; as a consequence the standard of living of the people of that nation attains a high level. On the other hand nations that have raw materials but do not fully exploit their resources are poor and considered underdeveloped and such is the case of Nigeria. (El Wakil, 1998.)

It is common knowledge that Nigeria is endowed with a periodic table's worth of mineral, it is only that they are not being harnessed and converted into value added goods as they are supposed to. In our case, this is not more because the capability, know-how and hardware for such a conversion are not available than it is because the people and the government have not made concerted effort to take the bull by the horn and pursue Nigeria's industrialization vigorously, for Nigeria can boast of more than 20 million learned men who can possibly get necessary training for this purpose if they are willing

However, there are manufacturing industries in Nigeria. The matter with manufacturing in Nigeria is that players are few and the industries are not well developed as regards domestic and international marketing. Generally there has been a decline in the number of manufacturing industries in Nigeria and the trend seems to continue. A "spin-off" effect of this is that the large number of graduates churned out by universities in the country every year is not catered for as regards employment. This could lead to social instability and insecurity as can be witnessed in the Niger Delta Region, North Eastern Region and several other parts of Nigeria.

,foreign exchange earnings might experience a precipitous decline in the near future given that developed nations have been investing in research

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for renewable energy sources. In fact, electric cars are on the brink of totally replacing gasoline cars in the US and other advanced countries, while talk of generating electricity from nuclear fuel rather than coal, oil or gas is growing throughout developed nations.

A deep consideration of the foregoing can make one say to Nigeria, "manufacture or perish" as a former president of the Raw Materials Research and Development Council (RMRDC) once enthused. It is as a result of these trends that setting up a blueprint that will help in starting Nigeria's export-oriented industrialization thereby averting pervasive poverty with the realization that an industrialized Nigeria will no longer rely on oil export alone, if at all, but on exports to African countries and beyond of electronic gadgets, machinery, ocean-going vessels and lots more.

The aim of our paper is to present the industrialization and technological culture of industrializing and advanced nations knowing modelling the example of other countries will bring about the industrialization seek in Nigeria. After carrying out the study, our findings will be tweaked for compatibility with the Nigerian setting to ensure a rapid industrialization. That way, what was accomplished in Western European countries during the seventeenth, eighteenth and nineteenth centuries through a slow and persistent process will be achieved in Nigeria in less than 50 years. This was the case with the People's Republic of China founded in 1949 eleven years prior to Nigeria's birth (Gideon, 2016). China started its industrial revolution about 50 years ago and it's close to being considered an advanced nation. For the avoidance of doubt, it is a member of G-20-a group of the twenty most industrialized countries in the world. The immediate objective of this paper is to build an inspiration for agitating constructively for Nigeria's industrialization and to provide a path for its becoming industrialized while the main objectives are long term. We envision that an industrialized Nigeria will

- Boost wealth creation
- Create jobs for its citizenry
- Maintain a high standard of living
- Build a reputation for itself in technology
- Have a say on the international stage
- Be a major exporter of manufactured goods in the world

2. Literature Review

Before the invasion of the entity now called Nigeria, its people engaged in manufacturing activities. The pre-colonial era, that is, the pre-1900 economy of Nigeria featured considerable craft industries in the various clans and kingdoms. The prominent of these craft industries include artifacts of wood, brass and bronze, leather, hand-woven textiles and bags, iron workings and fire-burnt pottery from local clay. Every clan or kingdom had what it was especially known for and traded with one another. The forest zone, especially in and around the old Benin Kingdom, excelled in wood and bronze workings; the Akwa-Nri-lgboUkwu area of the Igbo heartland was famous for pottery, woodcarving, and blacksmithing; the Oyo area excelled in calabash carving and textile weaving and dyeing; the Bida area was noted for glass and brass works; the Hausa-Fulani made leather artifacts while the lbibio-Efik communities were famous in woodcarving and raffia-embroidery. These industries, which were in cottage form with family members as laborers, at the time employed indigenous technology in their production processes. For example, in the clothes weaving industry there were homemade looms and smelters were in use in the smithy of Igbo-Ukwu. (Okoduwa, 2007)

However, the coming of the Europeans as colonial power changed the way manufacturing was carried out for several reasons: *Firstly*, the rate of production was very low that the industries could not meet the demand of locals and the whites because of the slow and tedious manufacturing methods used by these industries.

Secondly, Western European ideas and methods simplified manufacturing to a very great extent compared to the available laborious indigenous methods. This owes credence to the fact that Britain had undergone an industrial revolution that saw that manufacturing was mechanized, replacing handicraft.

Thirdly, the quality of the products churned out by pre-colonial Nigerian industries was very poor compared with what obtained from other parts of the world at the time. For the purpose of exportation, the colonial power had to introduce better and efficient ways of getting items produced.

It was for the aforementioned reasons that the extraction of palm oil from the pulpy pericarp of

palm fruits, which was crudely processed, was by the 1920s better and more efficiently handled in the "pioneer oil mills". Also cotton lint was no longer extracted through the laborious and slow manual extraction process but mainly handled in modern ginneries. The forest logs were processed as sawn lumber mainly in power driven sawmills before being exported to Europe. (Dare, 2007).

The colonization of Nigeria brought about the advent of modern manufacturing and processing. Yet, this transformation faced two major constraints: these were the low level of technological know-how and the small size of the available skilled indigenous workforce. The European masters made tremendous efforts in erecting schools and other institutions to bring science and technology to the people so they could be involved in the modern manufacturing activities and be creative themselves. As a result, the number of industrial establishments increased as indigenous manpower was gradually becoming increasingly available. But as population expanded and the taste of the people changed, the industries were not able to meet the material needs of the people and importation bludgeoned.

After Independence, during the early post-colonial era, the government embarked on a vigorous import substitution policy. This policy of import substitution which was meant to reduce dependence on foreign trade and save foreign exchange led, however, in the direction of the mere assemblage of foreign produced items rather than local manufacturing per se. At Independence, there were only about 150 plants of medium and large-scale size in the industrial sector, the majority of which were established in the late 1950s. By 1965, however, the number of medium and large-scale firms had risen to 380, arising from the intensification of the process of import substitution and the establishment of firms to undertake domestic manufacture of goods hitherto imported, though still largely dominated by low technology light industries (Dare, 2007). Items manufactured include food, beverages, and tobacco. The engineering sector was dominated by metal, furniture and fixtures, structural metal products and fabricated metals. The manufacture of agricultural and special industrial machineries and equipment, household apparatus and transport equipment were non-existent. The growth in the predominantly assemblage industrial sector, however, witnessed a lull following the political crisis which culminated in the Civil War until the early 1970s.

As part of the reconstruction efforts, the Second National Development Plan, 1970-1974, which had the objective of a united, strong and self-reliant nation; a great and dynamic society; a just and egalitarian society; a Land of bright and full employment for all citizens; and a free and democratic society was put up. This led to the expansion and diversification of the industrial sector although still mainly dependent on imported input. Our heavy dependence on imported raw materials and intermediates and the concomitant run—down on our foreign reserves raised the issue of producing some of these materials locally. In this regard, the Raw Materials Research and Development Council (RMRDC) was established to promote the development and use of local raw materials. This culminated in the ban of several raw materials in Nigeria such as wheat, flour, malted barley, etc. and the consequent shutdown of several industries which needed them. Thus the manufacturing sector witnessed a decline since the mid-1980s. For instance, *Table I* shows that the percentage share of manufacturing in Nigeria's gross value-added decreased from about 17% in the early 1980s to 13% in 1987 and to 10.7% in 1993 and 12.1% in 1994. The share of manufacturing in the GDP decreased from 9.2% in 1981 to 6.8% in 1987, 5.5% in 1993 and hovered around 6.0% in the years between 1994 and 2002. The number of industrial establishments, which increased from 421 in 1964 to 1,293 in 1975, and 2,360 in 1989 decreased to 1,891 in 1993.The number of industrial employees that increased from 64,965 in 1964 to 93,270 in 1969 (excluding Eastern Region) decreased to 27,102 in 1989. (FOS, 1979 Federal Ministry of Industries, 1987; MAN, 1993)

Table I: Some aspects of Nigeria's manufacturing, 1981-2002.

Year	Percentage of Total Value-Added	Percentage Domestic Of Product. Gross (GDP.)
1981	17	9.2
1982	17.3	9.6
1983	17.1	10
1984	14.8	7.8
1985	16.4	8.7
1986	16.2	8.7
1987	13	6.8
1988	14.3	7.5
1989	10.5	5.3
1990	10.9	5.5
1991	11.9	5.9
1992	10	4.8
1993	10.7	5.5
1994	12.1	6.6
1995	N/A	6.6
1996	N/A	N/A
1997	N/A	N/A
1998	N/A	5.9
1999	N/A	6
2000	N/A	6
2001	N/A	6.2
2002	N/A	6

Source: Federal Office of Statistics; National Accounts of Nigeria, 1981 to 1994; CBN-Annual Report and Statement of Accounts 2003. [Culled from Dare Ajayi (2007)

Presently, there are industries in Nigeria that provide items that run the gamut from stationeries, furniture, plastics, and electrical fittings to building materials and textiles albeit most of them use imported input and are not highly developed. These industries face major challenges that threaten their survival. These challenges are in the form of competition from similar products of foreign origin that are usually of higher quality than those made locally. Even where such products are banned from being imported in order to support these industries they are usually smuggled into the marketplace.

A survey of several commodities used in Nigeria, considering their origin, backward linkage to the economy, availability of indigenous raw materials, and the capability of developing raw materials where the raw materials are not processed in Nigeria is shown in the table below.

Table 2: Commodities and their origin linkage to the economy and the capability of developing raw materials

Commodities	Number of Industries Making Item in Nigeria.	Backward linkage to the economy.	Availability of raw materials in Nigeria.	Capability of developing raw materials.
Torches	Nil	-	Available	Affirmative
Padlocks/mortise locks.	Nil	-	Available	Affirmative
Eye glasses	Nil	-	Available	Affirmative
Bath tubs	Nil	-	Available	Affirmative
Electric irons	N/A	-	Available	Affirmative
Computers	1	No linkage	Available to a good degree	Affirmative
Kerosene lantern	N/A	-	Available	Affirmative
Spark plugs	N/A	-	Available	Affirmative
Ball bearings	N/A	-	Available	Affirmative
Bicycles	Nil	-	Available	Affirmative
Wheel chairs	Nil	-	Available	Affirmative
Electricity generating sets	2	No linkage	Available	Affirmative
Guns	Nil	-	Available	Affirmative
Electricity meters	Nil	-	Available	Affirmative
Hospital equipments	Nil	-	Available	Affirmative
Grenades	Nil	-	Available to a good degree	Affirmative
Mobile phones	Nil	-	Available to a good degree	Affirmative
Factory plants	Nil	-	Available good degree.	Affirmative
Industrial machinery	Nil	-	Available to a good degree	Affirmative

Source: A rough survey

A study of Table II shows that most commodities used by Nigerians are imported; and where they are not imported, use imported raw materials and intermediates in their manufacture even though there is a possibility of developing these raw materials or intermediates in Nigeria. A further scrutiny of the table will show that capital goods, household appliances, hospital equipments,

armaments, gadgets, aircraft, marine vessels, automobiles, electricity generating sets, factory plants and more do not have a Nigerian manufacturing base. Any industry making any of these items is at best assemblage industries, for example NEWCLIME, makers of air conditioners, fans and other commodities. Generally, Nigeria is heavily dependent on imported products for its needs

Apart from having a paltry manufacturing base the quality of products and the status of the factories in Nigeria are far from what obtains in contemporary times. The manufacturing plants in most factories are not in their best conditions and so the products manufactured are not of competitive quality. It has been observed that when many a factory is established in Nigeria it is left to run without a serious maintenance workforce (which may not be indigenously available since all plants are not made by Nigerians and there is usually no formal training available to them on the working principles and schematics of the plants) resulting in a poor plant condition. In most cases the factories shut down for months (or even forever) until they are able to get expatriates who then fix the plant. Furthermore plans are not made by these manufacturers to upgrade their systems to bang-up-to-date systems on a par with those of industrialized nations. When a plant finally conks out the factory goes moribund as have been seen in several cases. The effect is that the manufacturing base dwindles and importation soars. The following mineral industries were closed down for this reason and remained closed as of 2004.

Table 3: Industries that were closed down due to plant breakdown.

Industry	Location
Aluminum Smelter Co. of Nigeria Ltd	Smelter at Ikot Abasi
Nigercem Co. Plc	Nkalagu
Jos Steel Rolling Co. Ltd	Jos Rolling Mill
Katsina Steel Rolling Co. Ltd	Katsina Rolling Mill
National Fertilizer Co. of Nigeria Ltd	Onne
Makeri Smelting Co. Ltd	Refinery at Jos.

Source: U.S Geological Survey Minerals Yearbook — 2004.

Furthermore, virtually all these manufacturing and processing industries do not have functional R&D sections where they could develop their own technology and technology products for exportation and effective competition. What they do is make products whose principles of manufacture are widely known once they can afford the plant to make them. Federally funded R&D in Nigeria has not been able to help either in this regard as those institutions which are supposed to brew new technologies are mostly trying to catch up with the basics from the rest of the industrialized world, a pursuit which they still do not carry on vigorously. In summary, Nigeria is as yet not an industrial economy

The industrialization of the Asia-pacific and several European countries as a direct consequence of the industrial revolution in Great Britain (1750-1850) after several centuries of individual learning and knowledge gathering as a result of involvement in experimentation or a particular trade in several parts of Europe, especially in Great Britain, leading up to the invention of the steam engine and other labour saving machines Britain spontaneously experienced an Industrial Revolution. A study of *Adam Smith's* treatise on the wealth of nations helps one to note that the Industrial Revolution which occurred in Britain in the 18th and 19th century was a consequence of a gradual knowledge accumulation process over many centuries. Even though a few other countries claim to possess certain indigenous technology before the Industrial Revolution, the Industrial Revolution itself provided the necessary engines of growth and expansion for these countries, the Industrial Revolution which occurred localized in Great Britain spilled into many European countries through trading activities and political reforms in the concerned countries and these countries consequently experienced their own Industrial Revolution although this is better termed industrialization for historical reasons. Germany quickly imitated Britain, France sent spies and study groups to Britain to study their manufacturing systems and how things were being done and many other European countries sought for ways of tapping into the Revolution. Countries in the Asian continent were not privileged to pursue their industrialization at the same time as it was occurring in Europe and the USA.

However, in 1854 a steamed U.S. Naval fleet came to establish trading and diplomatic relations with Japan. Britain, France and Prussia followed. This

encounter with the Western powers greatly changed Japan within two decades through collective introduction of Western knowledge and machines. (Uchida, 1995.) The course of economic transformation of Japan during the last decades of the 19th century was similar to those which occurred in France, Germany and the United States during the first half of the 19th century industrialization which happened through borrowing of technologies developed by the forerunner nation, Britain.

The Development pattern of modern industries, therefore, in Japan a late- starting industrializing country in the late 19th century was through importation of machines, borrowing of technology, learning of the working principles of the imported machines, starting of domestic production to substitute import and finally, exporting of its products abroad as it became competitive internationally. This development pattern is called the ***catching-up product cycle model (CPC)*** (Yamazawa, 1990 and Kojima, 1973). The CPC model fits Japan's industrial growth until the late 1960s, but Japan outgrew this catching up development pattern and began exploring industrial frontiers since the 1970s. Following the examples of Japan, other Asian pacific later-starting industrializing countries such as Taiwan, Korea, Thailand, Indonesia, Malaysia, Singapore and China embarked on the catch-up product cycle (CPC) model but their respective models were patterned to suit their goals.

2.1. The CPC Model

The catching up product cycle pattern of industrial development consists of five development stages viz. Introductory i.e. ***import stage, Import substitution, Export, Mature, Reverse Import***.

At the Introductory phase, a new product is introduced through import from advanced countries and its domestic demand increases gradually. After introduction, domestic production starts through imitation or borrowed technology but the domestic product cannot compete with imported ones because of its inferior quality and high production cost. At the import substitution phase, proper, domestic production increases rapidly thereby decreasing the share of import in the home market. At this stage production technology is standardized and large scale production is established so that the domestic production gradually replaces import with improved quality and cheaper price. At export phase the domestic product starts to be exported abroad. At the mature stage both domestic demand and exports slows down, preventing further expansion of production. Export starts to decrease as domestic products fail to compete with products of later starting countries. Finally at the reverse import phase, products of later starting countries cheap and of no less inferior quality start to be imported and replace, gradually, domestic products at home market thus accelerating the decline of domestic production. However, at this reverse import stage many countries embark on several strategies to avert decline in production. The essence of the CPC model is to catch up with advanced nations.

Generally, the CPC model follows the pattern shown in Figure 1.

I = Introductory phase
II = Import substitution phase
Ill = Export phase
IV = Mature phase

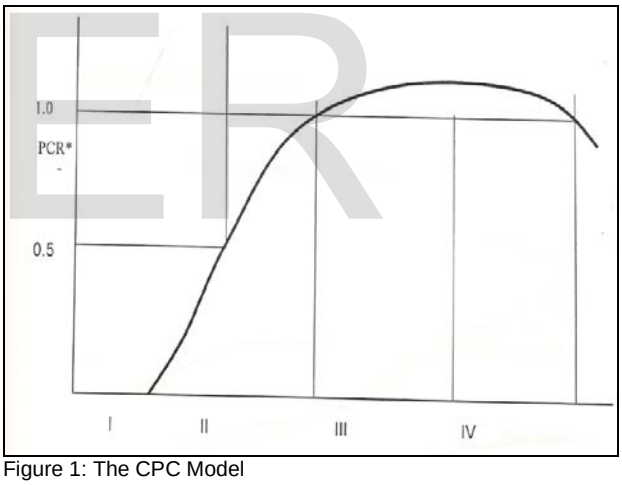

Figure 1: The CPC Model
Source: Yamazawa (1990)
*PCR = Production/consumption ratio.

Following this trend there was significant development in the Asia-Pacific countries by the late 1980s. A consideration of the synthetic fabrics industries and the crude steel industries of these Asia-Pacific countries and those of Japan and the United States shows an increasing trend of the production/consumption ratio which gives evidence of catching-up development of the two industries as shown in Figure 2 and Figure 3.

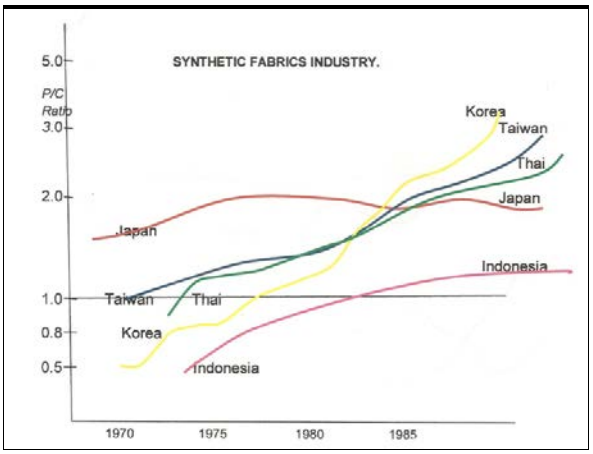

Figure 2: Evidence for CPC Model in the Asia Pacific (**Source:** Yamazawa (1990))

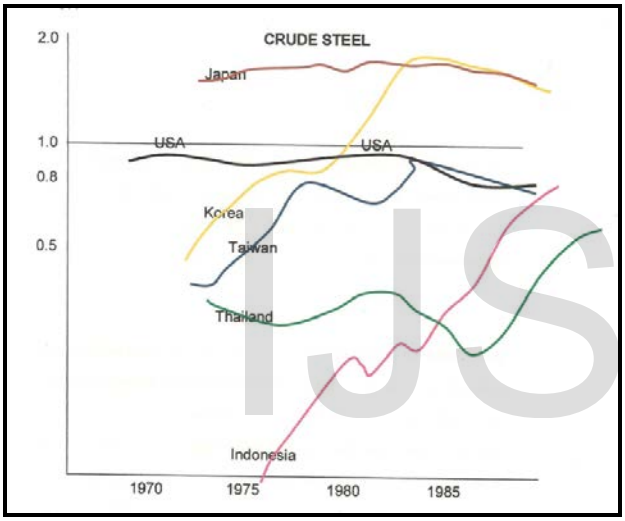

Figure 3: Evidence for CPC Model in the Asia Pacific (cont) PCR. (**Source:** Yamazawa (1990))

Synthetic fabric weaving was introduced, developed after cotton fabric weaving without much delay, and became a core of textile industry in these Asian countries. Taiwan began earlier and started export before 1970. Korea followed closely and reached Taiwan's level of export expansion by the mid 1970s. In Thailand, the production/consumption ratio exceeded unity in early expansion, partly taking advantage of the earlier development of its cotton textile industry. For Indonesia, only a long-run trend is drawn due to the lack of consistent time series data of production and trade. But judging from ad hoc information, the development of Indonesia synthetic fabric production was delayed until the mid1970s and exceeded unity only after 1980. (Yamazawa, 1990). Japanese synthetic fabric production has already been declining at its mature phase. Japan's production/consumption ratio is still as high as 1.7 reflecting the competitive edge of its fiber production. The same ratio for cotton has already decreased below unity.

Steel industry development occurred in the mid-1970s for Asian Newly Industrializing Countries (NIEs) and ASEAN countries, lagging five to ten years behind the synthetic fabric production. Korea quickly developed this industry and succeeded in reaching the export phase by 1980, whereas Taiwan remained below unity throughout the 1980s, partly being handicapped by the small size of its domestic market. Production/consumption ratios of both Thailand and Indonesia stayed below 0.3 until the mid-1980s but then started to increase steadily. On the other hand, both Japan and the United States have already entered the mature and reverse import stage respectively. Japanese steel industry developed rapidly in the 1950s and its export expanded in the 1960s. The catching-up had proceeded in other industries as well, especially in the 1980s. The foregoing analyses are evidence that these late-starting industrializing countries adopted the CPC model.

The catching-up proceeded in machineries as well. Tables 5 and 6 summarize a survey conducted by Nihon-Keizai Shinbun on how closely Asian neighbors have caught-up with Japan in individual industrial production mainly of machineries. Japanese multinational companies (MNCs) were requested to assess the degree of catching up with Japan by top producers in Asian neighbor countries in individual commodity production according to the following six grades:

1. Already exceeded
2. Exceeded only in price
3. Just catch-up
4. Will catch up in three years
5. Will catch up in six years
6. Will catch up in ten years

Table 4: Evidence for catching up in tune with the CPC Model

Not within
Already
Exceeded
Consumer goods 10 years 6 years 3 years caught-up
Pricewise All

Household Telephone		C	TH.M	S	K, H	T
VTR					K,T	
ColorTV					K,T, H,C,M,TH,S	
Radio-cassette	M.TH	H	K,T,S			
Headphone stereo			S,M		K,T	
Radio			S,M	K,T	H,C	
Refrigerator		C.M.TH	T,H	S	K	
Micro-wave oven				T,S	K	
Electric fans		C	H		K,T,S,M,TH	
Calculator		C	K	T	H	
Watch			C	S,TH,M	K,T,H	
Sport Wear		TH	S	T	H	K

C= China; K=Korea; H=Hong Kong; M=Malaysia; S=Singapore; T=Taiwan; TH=Thailand. SOURCE: The Japanese Economic Journal, June 1988.

Table 5**:** Evidence for Catching-up in tune with the CPC model (cont.)

Not within
Already
Exceeded
Consumer goods 10 years 6 years 3 years caught-up
Pricewise All

Ball bearing	K,C,M				S.TH	
Motors					K.T.S.TH	
Cement	C,M,TH				K.T	
Industrial robot	C,M,TH		K.T.H.S			
Injection moulding machines	C,M,TH	H.S	K.T			
Numerical-control lathes	C,M,TH	S	K.T			
Auto parts	C,M,S,H	TH	K.T			
Super LSI	T	K	S.M			
Steel (plate)	C		K.T			
Semi-conductor	C,M,TH	T.H.S	K			
Forklifts	C	T	K			

C= China; K=Korea; H=Hong Kong; M=Malaysia; S=Singapore; T=Taiwan; TH=Thailand. SOURCE: The Japanese Economic Journal, June 1988.

Having looked at the basic trend of emergence of industrialized nations in Asia and the Pacific, the question should be: how does it relate to Nigeria? From our study of the history of manufacturing in Nigeria we noted that after Independence, during the early post-colonial era, the government embarked on a vigorous import substitution policy which was meant to reduce dependence on foreign trade and save foreign exchange. However, the import substitution led in the direction of the mere assemblage of foreign produced items rather than local manufacturing per Se. (Dare, 2007). Therefore Nigeria can be said to have tried the catching up product cycle pattern of Industrialization and have failed. The main ingredient of the catching up product cycle model that makes it work is import substitution which helps these latecomers emerge as industrial powers. We have said before that any late-starting country uses the CPC model because it has to do with the borrowing of technology. Even though it may appear as if the development patterns of every nation differ, in general as the above statistical evidence (figures 1 and 2) has shown, these development patterns conform to the CPC model. The variation that lies in the model of industrialization of the different countries lies in their mechanisms of import substitution and certain other trends. Actually it is this import substitution phase that Nigeria has not gotten right.

It therefore implies that industrial development planning must look in the direction of realizing import substitution for Nigeria. However, Import Substitution Industrialization led to certain distortions and inefficiencies in all the developing countries which embarked on it after World War II (WW II) and as a result of this emphasis have shifted from Import Substitution Industrialization to the "New Economic Model" which relies on the market as the driver of growth and development. There are several variations of import substitution industrialization. ***An analysis shall be carry out of import substitution industrialization vis-à-vis the outward oriented "New Economic Model" and then try to recommend the optimum path that Nigeria will follow if it is to become industrialized in a short time.***

3. ENDOGENOUS IMITATION AND REVERSE ENGINEERING AS THE WAY OUT

Simply put, reverse engineering is a mechanism through which technology embedded in imports is "decoded". Imitative reverse engineering of existing foreign products became the backbone of Korea's industrialization up to the mid1980s (Kim, 1997, p.38). Imports of technology intensive goods from advanced countries provide an avenue for developing countries to improve their lot through the use of improved inputs in production and more significantly through reverse engineering of these goods. This constitutes to their domestic imitation capacity and improved technological know-how.

Diffusion of knowledge has been a central factor in the economic growth of countries across the world. Studies have shown that economic integration between countries leads to a higher overall rate of growth. Diffusion of knowledge through imitation from a technologically superior nation to a less developed one (Vernon, 1966; Krugman, 1979; Dollar, 1986 and Grossman and Helpman, 1991) is shown to be equally crucial for technological catch-up. This is possible because knowledge is a public good that can be freely appropriated by producers anywhere. Integration into the international economy provides a country the necessary access to this "knowledge base". There is no doubt that Nigeria is well integrated into the international economy given the openness of its market. Several empirical studies have considered trade in Counterfeits and knock offs are duplicative imitation, but one is illegal and the other is legal. Counterfeits are copies that sell under the same premium brand name as the original, often (but not always) of low quality, robbing the innovator of due profits. In contrast, knock offs or clones are in most cases legal products in their own right, copying closely the pioneering products in the absence or expiration of patent copyrights and trademarks but selling with their own brand names at far lower prices. Clones often surpass the original in quality (Kim, 1994). Duplicative imitation conveys no sustainable competitive advantage to the imitator in a technological sense, but it sustains competitive edge in price if the imitator's wage cost is significantly lower than the originator's. For this reason duplicative imitation, if legal, is an astute strategy in the early industrialization of low-wage catching up countries as the technology involved is generally mature and readily available and duplicative imitation of mature technology is relatively easy to undertake.

Duplicative imitation alone, however, is insufficient if a NIE is to achieve further industrialization. Both creative imitation and innovation are required not only to catch up in existing industries but also to challenge advanced countries in new industries. Design copies, creative adaptation, technological leapfrogging and adaptation to another industry are creative imitations. Design copies mimic the style or design of the market leader but carry their own brand name and unique engineering specifications. Creative adaptations are innovative in the sense that they are inspired by existing products but differ from them. Technological leapfrogging can occur to a late entrant's advantage when the latecomer gains access to newer technology and uses it with a more accurate understanding of the growing market than was possessed by the original innovator. Adaptation to another industry illustrates the application of innovation in one industry for use in another. Creative imitations aim at generating imitative products but with new performance features. They involve not only such activities as benchmarking but also notable learning through investment in R&D activities to create imitative products, the performance of which may be significantly better or production cost considerably lower than the original. Bolton (1983) argues that the Japanese strategy represents these features.

Innovation is defined as a pioneering activity, rooted primarily in a firm's internal competencies, to develop and introduce a new product to the market for the first time. The distinction between innovation and imitation is blurred. Most innovations do not involve breakthrough inventions but are deeply rooted in existing ideas. We can therefore conclude that Imitation leads to the onset of innovation.

3.1. The Process of Imitation

"Imitation represents the stylized facts of a country that lacks the ability to conduct basic research but has the capacity to emulate the technologies of industrialized economies. To do this the country initially imports technology intensive intermediate goods from industrialized countries (e.g. a new generation of computers.) The intermediate goods sector then employs human capital to undertake "reverse engineering" in order to unravel the

technology embodied in the imported good and thus create new "imitated designs". These designs are used to produce clones. The imitator country's final goods sector uses the locally copied intermediate goods along with imported intermediates (not yet copied) and combines them to produce final goods. Finally, to close the model, the manufacturing sector sells part of its output domestically and exports the rest". (Datta and Mohtadi, 2006.)

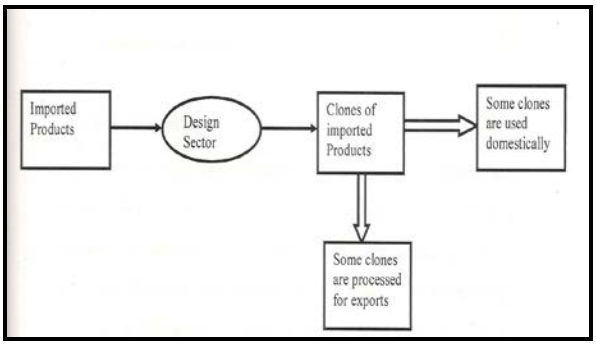

Figure 4: The Endogenous Imitation Model

Therefore, for reverse engineering to be effective in absorbing technology and improving technological capability there have to be the following ingredients within the host country:

1. Imitation driven R&D sector also called the imitative design sector.
2. Intermediate goods sector
3. Final goods sector.

For the purpose of this paper these ingredients are grouped under two broad heading and carry out an analysis to ascertain their presence in Nigeria and hence justify the applicability of reverse engineering to the Nigerian setting in a vigorous and large-scale manner, viz.

1. Human Capital
2. Domestic Industrial Sector.

a. HUMAN CAPITAL

The term human capital does not imply all the people of a country but those with a certain level of skill and training for absorbing technology. The reverse engineering process which allows a country to assimilate new technologies will only work if the country possesses the requisite human capital for technology absorption. In other words, the country on a whole must possess the necessary absorptive capacity. Absorptive capacity is about the ability to absorb available knowledge (Cohen and Levinthal, 1989), or the ability to learn and implement the technologies and associated practices of already developed countries (Dahima and Nelson 1995).

Absorptive capacity supports further accumulation of technological knowledge and technological advances support the further development of absorptive capacity in a cumulative, interactive and virtuous process during the catching-up stage. However, this virtuous circle of technology accumulation takes place only if an "adequate" minimum level of absorptive capacity already exists. This threshold level of absorptive capacity is most significantly associated with the development of what Rasiah (2002) terms "basic infrastructure". Acquiring and sustaining this threshold level of absorptive capacity occurs in the "pre catching- up" stage (Criscuolo and Narula 2002).

It remains to show that Nigeria possesses about the threshold level of human capital required to maintain the aforementioned "threshold absorptive capacity". An indicator of the level of human capital available within Nigeria is, easily, the tertiary level enrolment of the population. The table below gives an evidence of the assertion above.

TABLE 6: Education Enrolment at Tertiary Level (Nigeria).

Year	Amount
1980	150,072
1981	176,904
1982	193,731
1983	208,051
1984	240,889
1985	266,679
1986	267,862
1987	276,352
1988	304,536
1989	335,824
1993	207,982
2002	947,538

Source: UNESCO UIS (UNESCO Institute for Statistics) Data.

Therefore we can confidently say that the human capital element for endogenous imitation or Reverse engineering is satisfied in Nigeria's case.

b. DOMESTIC INDUSTRIAL SECTOR

As with human capital, a domestic industrial sector must exist for the reverse engineering strategy to

work. The role of the domestic industrial sector is as follows:

1. It represents already formed capital.
2. It embodies the absorptive capacity needed for reverse engineering in what is termed "Imitative R & D" as opposed to "innovative R & D".

Paraphrasing the statement of Narula (2002), indeed, the presence and condition of the domestic industrial sector is crucial. If no domestic sector were to exist there can be no opportunity to absorb spillovers from technology embedded in imports. The benefits of reverse engineering occur when there is domestic investment and where the domestic investment has the ability and propensity to internalize the externalities from imported input in the form of embedded technology. It is now our duty to show that there exist domestic industrial sectors in Nigeria which can absorb positive externalities from import — embedded technology. At present in the manufacturing sector which employs intermediates and capital goods, we have the following statistics about the industrial landscape.

TABLE 7: The number of firms by Stratum's NMES sample

	Food and Garment	Wood, Furniture	Paper Chemicals	Textiles and	Metal, Machinery	All Sectors
Micro including Informal	1	5	18	4	28	
Small Including Informal	4	15	24	10	53	
Medium	5	12	10	19	46	
Large& Macro	5	9	14	21	49	
All Size Groups	15	41	66	54	176	

Note: The table shows the number of firms interviewed, by size and sector. The size categories are defined as follows. Micro: less than or equal to five employees. Small: more than five and less than or equal to 20 employees. Medium: more than 20 and less than or equal to 75 employees. Large: more than 75 and less than or equal to 500 employees. Macro: more than 500 employees.

Source: UNIDO and Centre for the Study of African Economies. "The Performance of Nigerian Manufacturing: Enterprise Survey, 2001.

Given that employees in the management and engineering sector of most of these firm are learned, (some studied overseas) we can without doubt infer that the likelihood of the firm themselves having the "threshold" absorptive capacity is considerable. The question then arises: why then is imitative reverse engineering not being utilized by the manufacturing sector? The answer lies in the lack of the imitative R&D sector or the design sector and hence an elaborate imitative R&D mechanism.

The following data is an evidence of this assertion. This data was obtained through the effort of a survey carried out in these firms by us inquiring if they have their own private R&D sections.

TABLE 8: Evidence for non-existence of private R&D in Nigeria

Name of firm	Business	R&D section?
STECO, Auchi.	Manufacture of industrial machineries, parts, and agricultural implements.	NO
Louis Carter, Nnewi.	Manufacture of auto parts	NO
IRU Industries, Nnewi.	Manufacture of auto parts.	NO
Omatha Industries, Nnewi.	Manufacture of Oil filter, pumps and auto exhaust systems.	NO

Source: A survey conducted 2010.

It must be stated that we have not surveyed industries which make primary commodities but industries which make products of considerable complexity as it is on these products that Nigeria mostly rely on importation. The result of the survey shows that these firms do not have R&D investments. According to Goedhuys and Veugelers (2008) countries tend to acquire technology more readily when domestic firms have R&D programs. The imitative R&D section in a manufacturing concern entails a group of research engineers who reverse engineer a particular product already in existence in the market with a view to coming up with a developmental design of better quality and which will under- price the already existing one in the market. These engineers are not to be engaged in the daily activity of the production or factory floor. This section usually contains a marketing consultant In Korea, Taiwan, Singapore and other Asian NIEs it this Imitative R&D sector that was the backbone of their Industrialization. From survey, our domestic Industrial sector consists mainly of turnkey plants

built by expatriates and then run by Nigerian operators who have been trained for the purpose. The factory keeps running without any significant change In Its production processes or product design until another product comes in from abroad and under-prices It. This trend has led to the shutdown of many plants or in a case where the plant is not shutdown, it produces below capacity because of market constraints.

From the foregoing, it is glaring that the missing link in the Nigerian manufacturing sector is private R&D investment. Therefore, if Nigeria's industrialization is to happen, ways must be found of implementing the results of this study.

Private R&D will have the following effects in the Nigerian industrial sector:

- It will introduce great flexibility into manufacturing as its presence in a firm helps to add to the family of products the firm makes through the traditional reverse engineering approach for a catching-up industrializing country.
- The R&D section which employs human capital, after coming up with their designs, formulates the manufacturing processes and sequence required for low cost production of the clones.
- The activities of R&D employees have positive externalities that can be absorbed by other Nigerians in that the trend of imitation will become popular among industrialists and entry into manufacturing enterprise will become easier and risk-evasiveness will reduce as the case was in Korea and even China, keeping in mind that imitation, from our previous analysis, is not essentially an illegal act.
- Repeated reverse engineering brings about the onset of innovation.

The best way to introduce this design (Imitative R&D) sector is through government policy. It must be remarked that in those industrialized and fast industrializing countries mentioned in this work, the government stand by the cradle of manufacturing and take hold of its destiny with energetic hands, It will be very easy for government, for the purpose of industrial development, to enact that firms employing above 15 workers should run a mandatory R&D section, whether innovative or imitative, employing researchers or "reverse engineers" as the case may be, who are solely devoted to products development. This R&D segment of the manufacturing industry need not necessarily be robust at the start. R&D investment should initially be in recruitment of qualified research engineers, It need not be stated that they are going to be imitators because, naturally, a late-starting industrializing country initially imitates. And as we have observed in our study, imitation brings about the onset of innovation. But first there have to exist private R&D investment. The model recommended is thus shown below.

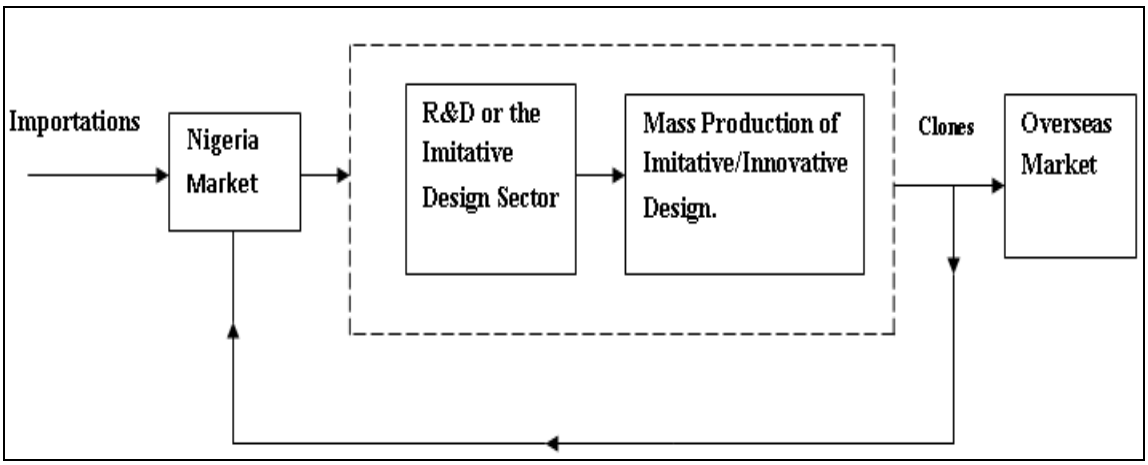

Figure 5: The "New Nigerian Model"

4. CONCLUSION

From the study of industrializing and already industrialized countries, endogenous-growth

industrialization model based on reverse engineering is developed. A key finding of the study is that economic growth is tied to technological advancement and know-how. Given the openness of our economy to foreign- made products there lies the opportunity of acquiring technological know-how by reverse engineering these products and using this know-how as a springboard for manufacturing developmental versions of many of the products that flood our market. This will lead to an increasing trend in the production/consumption ratio and inevitably lead to export-oriented growth. As noted in this paper, this strategy was the backbone of South Korea's industrial development. However, a study of our domestic industrial sector revealed the reasons why imitative reverse engineering is not really being applied which is that there is no design sector in the industrial system of Nigeria. We therefore developed our plan around establishing this missing link in the economy through government policies and the effort of the National Planning Commission. While emphasis in this work have been on establishing the missing link in the domestic industrial sector (the design sector), it should be noted that infrastructural facilities such as power, good roads and pipe borne water are incentives for low cost production and industrial development. However, while a lot of stakeholders argue vehemently for the provision of power and other infrastructural facilities our study on this area shows that in those Asian countries the effect of imitation is that a lot of IPP (Independent Power Plants) owners and operators emerged and so many of the Power Stations in those countries are not state-owned or monopolistic

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