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Harvesting the Benefits of Inventions in China: Making a Case for the Promotion of Reverse Engineering in Nigeria

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Abstract- Innovation and technology are important catalyst in wealth creation and development of societies and nations. Progress in science is advanced by dissemination of know-how, whether by original innovation or by reverse engineering of existing technology. While original innovation is the standard in this regard, the open secret to boosting economic growth has been said to be reverse engineering, which basically involves the creation of inventions and innovations from the study of existing technology. Reverse engineering is said to lead to faster development and innovations as the creations are based on an existing design and less time and fund is spent on trial and error while working on original inventions. China is one of many nations that discovered this well kept open secret decades ago and are currently harvesting the benefits of its use. It has used reverse engineering to rise and transform itself from a developing nation to one of the largest economies in the world, with the highest economic growth rate in the world today. Nigeria, on the other hand can at best be described as a new born, where reverse engineering for economic growth is concerned.

Keywords: *benefits, inventions, china, reverse engineering, nigeria, economic growth.*

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Harvesting the Benefits of Inventions in China: Making a Case for the Promotion of Reverse Engineering in Nigeria

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Abstract- Innovation and technology are important catalyst in wealth creation and development of societies and nations. Progress in science is advanced by dissemination of know-how, whether by original innovation or by reverse engineering of existing technology. While original innovation is the standard in this regard, the open secret to boosting economic growth has been said to be reverse engineering, which basically involves the creation of inventions and innovations from the study of existing technology. Reverse engineering is said to lead to faster development and innovations as the creations are based on an existing design and less time and fund is spent on trial and error while working on original inventions. China is one of many nations that discovered this well kept open secret decades ago and are currently harvesting the benefits of its use. It has used reverse engineering to rise and transform itself from a developing nation to one of the largest economies in the world, with the highest economic growth rate in the world today. Nigeria, on the other hand can at best be described as a new born, where reverse engineering for economic growth is concerned. This article takes a look at reverse engineering, its use in China and the benefits of same to the Chinese economy, with a view to making a case for the use of reverse engineering to boost economic growth in Nigeria.

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I. Introduction

Reverse engineering is simply "trying to figure out how something works." [1] It is the process of discovering the technological principles of a human (or non-human) made device, object or system through analysis of its structure, function and operation. It often involves taking something (e.g., a mechanical device, electronic component, biological, chemical or organic matter or software program) apart and analyzing its workings in detail to be used in maintenance, or to try to make a new device or program that does the same thing without using or simply duplicating[2] (without understanding) the original.[3]

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[1] Jones, P. (2005). Software, reverse engineering and the law. Retrieved on 21/12/14, from http://lwn.net/Articles/134642/.htm

[2] Uhrich, C.L. (2001). Economic Espionage Act--Reverse Engineering and the Intellectual Property Public Policy. *Michigan Telecommunications and Technology Law Review. 7;1.* 147-190.

Reverse engineering is said to be fundamentally directed to discovery and learning, as engineers learn the state of the art by reverse engineering others' products, [4] and has been described as the important supporting technology which digests and absorbs advanced technology and shortens the cycle of product design development. [5] It leads to creation of new goods/products, new processes and new knowledge, which are major sources of technical change. [6]

The process is mainly undertaken with the end aim of learning how to build a technology or make improvements to it[7] and It is one of the endorsed and

[3] See generally on definitions of reverse engineering: Dehaghi, M.R and Goodarzi, M. (2011). Reverse Engineering: A Way of Technology Transfer in Developing Countries like Iran. *International Journal of e-Education, e-Business, e-Management and e-Learning, 1;5.* 347-353; Aginam, E. (2014). Coscharis boosts Covenant University with reverse engineering solution. Vanguard Online Newspaper, 15th September, 2014. Retrieved on 23/11/14 from http://www.vanguardngr.com/2014/09/coscharis-boosts-covenant-university-reverse-engineering-solution/.htm; Khalili, A.H., Maleki, A and Ayatollahi, A. (unknown). Using Combination of Reverse Engineering and Value Engineering for Improvement in Designs, Construction Projects and Manufacturing Industries. *Proceedings of the 41st International Conference on Computers & Industrial Engineering. 518-523*;

[4] Khalili, A.H., Maleki, A and Ayatollahi, A. (unknown). Using Combination of Reverse Engineering and Value Engineering for Improvement in Designs, Construction Projects and Manufacturing Industries. *Proceedings of the 41st International Conference on Computers & Industrial Engineering. 518-523.*

[5] Sha, L. (2012). The Innovation Design of Product Based on Reverse Engineering. International Conference on Computer Science and Information Technology (ICCSIT). IACSIT Press, Singapore.

[6] See generally on its benefits: Guellec, D., & van Pottelsberghe, B. (2001). R&D and Productivity growth: Panel Data Analysis of 16 OECD countries. *OÉCD Economic Studies* No. 33. Cited in Akinwale, Y. O; Dada, D.A, et. al. (2012). Op. cit.; Khalili, A.H., Maleki, A and Ayatollahi, A. (unknown) . Using Combination of Reverse Engineering and Value Engineering for Improvement in Designs, Construction Projects and Manufacturing Industries. *Proceedings of the 41st International Conference on Computers & Industrial Engineering. 518-523;* Samuelson, P & Scotchmer, S. (2001). Op. Cit.

[7] See generally: Franks, L.S. (2014). The Art of Reverse Engineering. Retrieved on 23/11/14, from http://www.contrarianprofits.com/e-letters,rogue-capitalists-daily/the-art-of-reverse-engineering/.htm;
Khalili, A.H., Maleki, A and Ayatollahi, A. (unknown). Using Combination of Reverse Engineering and Value Engineering for Improvement in Designs, Construction Projects and Manufacturing Industries. *Proceedings of the 41st International Conference on Computers & Industrial Engineering. 518-523.*

legally acceptable means of extracting know-how or knowledge for creation of innovation from a human-made artefact or product, even if the intention is to make a product that will draw customers away from the original product.[8]

In its purest form, an innovator following this path buys, begs, borrows, or steals[9] a product or a system, takes it apart to understand how it works, and duplicates it, usually making it better or upgrading it. By doing this the innovator avoids the design and engineering phase of independent, new or original innovation[10] by using a design originated by somebody else.[11]

When a new product is created as a result of reverse engineering, same is regarded as innovation as well and can be protected by patent under intellectual property[12] in order to generate profit which can be re-invested to create more innovation or channeled into other sectors of the economy to generally boost same.[13] It has therefore been seen as a source of vast development of technology all over the world,[14] and an economically proven as well as legally acceptable[15] way of boosting economic growth.[16] Here, we recall, that it is well known that one of the influential factors that could lead to economic growth is the improvement of technology.[17] This could increase productivity with the same levels of labor, thus accelerating growth and development.[18]

In under developed countries therefore, reverse engineering is viewed as a short-cut method for access to technology, its development and completion. By use of this method, underdeveloped countries can decrease the technologic gap between themselves and industrial countries.[19] This is because it has been shown to be one of the fastest ways to discover what is in a component, in order to improve on it and use the knowledge gained there-from for further advancement of technology. It thrives where there is a good working system that boosts Research and Development (R&D)[20] and its existence helps nations to develop new technologies, create opportunities and improve their

[8] Samuelson, P. & Scotchmer, S. (2002). Op. Cit.

[9] Though the writers hold a firm view that stealing an existing product for the purpose of reverse engineering should be discouraged.

[10] Which usually takes a lot of time, because of the trial and errors in the process of coming up with a new invention and requires a lot of resources and funds until the perfect creation is achieved. We are however not unaware that reverse engineering also entails a detailed study of the item in question and an unpredictable amount of time, effort and cost to produce. It however, still costs less funds and time as a result of less trial and error. See: Cheung, K & Lin, P. (2004). Spill over effects of FDI on innovation in China: Evidence from the provincial data. *China Economic Review 15. 25– 44*

[11] Forden, G. (2007). How the World's Most Underdeveloped Nations Get the World's Most Dangerous Weapons. Retrieved on 24/11/2014, from http://web.mit.ed/stgs/pdfs/TandC_essay_on_WMD.pdf

[12] Intellectual property for this purpose can be defined simply as proprietary information and other kinds of assets that are made protectable for a period of time under law, such that during their period of protection, only the owners of the said property have exclusive rights to same and may use them for economic gain. Depending on its type, intellectual property derives its value from a bundle of nearly exclusive rights defined by statute, common law, or contract. Patent is that form intellectual property given to the owners or creators of inventions, such that the holders of this patent are given certain exclusive ownership and use rights for a period of time specified by the law. Generally, upon the grant of patent, the owner possesses a monopoly over the product extending from the issue date to the expiration of the time as prescribed by the law. This monopoly gives the patent holder the right to exclude others from making, using, selling, or importing any product covered by a claim of the patent. The patentee(s) in this case can also charge a higher price or enjoy a lower marginal cost while excluding others from doing so. See generally on the above: Uhrich, C.L. (2001). Op. cit.; Zhang, H. (2014). Patent Institution, Innovation and Economic Growth in China. Retrieved on 24/11/14, from http://press.anu.edu.au/wp-content/uploads/2014/07/ch20.pdf

[13] All the reverse engineer really has to do to qualify as a creator of invention, is to change one little angle somewhere and it becomes a new design, that can be patented and used to generate profit for the use of the country to boost other aspects of its economy. See: Anuforo, E. (2011). The imperatives of science, technology to national economic development, by Adewoye. *Guardian online news. 9th May, 2011.* Retrieved on 24/11/2014, from http://www.nigerianhomepage.biz/business-in-nigeria/3738-the-imperatives-of-science-technology-to-national-economic-development-by-adewoye.html

[14] See: Anuforo, E. (2011). Ibid. See also: Abbot, J. (2003). Reverse Engineering of Software: Copyright and Interoperability. *Journal of law information and science*. 14; 7, where he opined that reverse engineering plays a crucial role in the development of new or competing programmes because it is often the only way to reveal the ideas underlying computer programmes. We can draw inference from this as well, for the fact that reverse engineering plays a crucial role in the development of new or competing technology because it is often the only way to reveal the ideas underlying existing technology, with an aim of making it better or more cost effective…generally improving technology day by day.

[15] The purchaser of a machine embodying a patented invention, for example, is generally free to disassemble it to study how it works under the first sale principle of patent law. See: Cohen, J.E & Lemley, M.A. (2000), Patent Scope and Innovation in the Software Industry. *California Law Review. 89;1*. 30-35.

[16] Samuelson, P. & Scotchmer, S. (2001). Op. Cit. Akinwale, Y. O; Dada, D.A, et. al. (2012). Op. Cit.

[17] This is especially because trade in technology goods and services which are knowledge-intensive, tends to be among the fastest-growing in international trade. See: Maskus, K. (2000a) "*Intellectual Property Rights in the Global Economy*", Institute for International Economics, Washington DC, pp.73-79.

[18] Agarwal, P. (2012). Factors leading to Economic Growth. Retrieved on 14/01/15, from http://www.intelligenteconomist.com/factors-leading-to-economic-growth/?hvid=30dnPK; Akinwale, Y. O; Dada, D.A, et. al. (2012). Understanding the Nexus of R&D, Innovation and Economic Growth in Nigeria. *International Business Research. 5;11.* 187-196.

[19] Khalili, A.H., Maleki, A and Ayatollahi, A. (unknown) . Using Combination of Reverse Engineering and Value Engineering for Improvement in Designs, Construction Projects and Manufacturing Industries. *Proceedings of the 41st International Conference on Computers & Industrial Engineering. 518-523.*

[20] Research and Development (R&D) here refers to "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". See: Organization for Economic Cooperation and Development (OECD). (2002). *Proposed Standard Practice for Surveys on Research and Experimental Development* (6th ed.) p. 30.

technological positions on the global scene. [21] Developing countries can use reverse engineering to their benefit by creating innovative products there-from, guaranteeing intellectual property protection of same, using the products for their own markets, and then also exporting them to developed countries.[22]

This innovation which not only determines the extent to which these countries can assimilate and apply foreign technology,[23] but is also the end result of the above described process, has been a key driver of economic growth in most advanced countries and China has risen to the top of the list of countries that have soared to a great economic height worldwide, in so little time, using reverse engineering as a tool for boosting innovations. They gave special attention to their technological development using reverse engineering and this led to a significant increase in their economic growth.

Their path to technology innovation was a result of designs being imported into the country where Chinese engineers were waiting to redesign and re-engineer products, in such a way as to be able to manufacture them quicker and at more affordable prices, thereby making such products more competitive in the global marketplace.[24] In this way, China gradually set itself up to be one of the most robust economies in the world, which goal it has now achieved, being the second largest economy in the world.[25]

The rapid growth of their economy as a result of the benefits of reverse engineering reflects the government's strong focus in this area explains why China's GDP growth rate accelerated strongly in 2009 even as growth rates in most other economies suffered significantly. [26] It is apparent now that the biggest contributors to China's economy are the benefits derived from their reverse engineering[27] activities.

The Nigerian economy in contra-distinction to that of China is a growing economy which has so far focused solely on one aspect and has therefore not made any head way with regard to competition in the international markets. One of the questions that have always been raised is how Nigeria can decrease the technological distance between it and other developed countries in the shortest time, in order to have a suitable share in the global business and compete in the global market. It is evident from the growth of the Chinese economy as a result of the large harvest raked in from the benefits of reverse engineering, that one way Nigeria can achieve its goal above stated is through reverse engineering.[28]

Though the Nigerian government has now begun to lay more emphasis on the technology sector,[29] with the aim of moving the economy from the traditional low-level of productivity to a more automated and efficient system of mass production of goods and services, [30] the use of reverse engineering is still generally foreign, such that in addition to other hindering factors, the performance of the sector leaves much to be desired as general output, capacity utilization and sector contribution to GDP are still comparatively low.

It is in view of the above that there is a need to make a case for the use of reverse engineering to boost economic growth in Nigeria, as with the case in China.

II. The Economic Growth in China

Economic growth is the increase in the market value of the goods and services produced by an economy over time. Economic Growth is conventionally measured as the percent rate of increase in real gross domestic product (GDP)[31] or an increase in national output and national income.[32]

It goes without saying that China which is one of the two most populous countries in the world and accounts for 20.4% of the world's population has not always been the economic world power that it is now,

[21] Charpie, R. A. (1970). Technological Innovation and the International Economy. In M. Goldsmith (Ed.), *Technological Innovation and the Economy*. London: Wiley-Interscience.

[22] PLATT, J.R. (2010). **Reverse Innovation: Changing the Path of Global Development**. *IEEE-USA Todays Engineer, May, 2010.* Retrieved on 21/11/14, from http://www.todaysengineer.org/2010/May/Reverse-Innovation.asp

[23] Radovesic, S. (1999) "*International Technology Transfer and Catch-up in Economic Development*", Elgar. Cheltenham. p.242. Also Saggi, K. (2000) "*Trade, Foreign Direct Investment and International Technology Transfer: A Survey*", World Bank, Washington DC. and Rosenberg, N. (1982) "*Inside the Black Box; Technology and Economics*", Cambridge University Press, Cambridge.

[24] Rosenstein, A. (2014). Chinas integration into the global economy: who should be worried? Retrieved on 15/1/15, from http://www.anarosenstein.com/chinas-integration-into-the-global-economy-who-should-be-worriednew-page/

[25] China's technological advantage is said to be the major factor that has accompanied its rise to be the world's second-largest economy. See: Lague, D. (2013). China eyes $3.5 billion Russian arms deal despite ire over Sukhoi copy. Retrieved on 21/11/14, from http://www.reuters.com/article/2013/03/27/us-china-russia-arms-idUSBRE92Q0PE20130327

[26] Durden, T. (2014). China Will Revise Its GDP Definition Until Its Hits Government "Growth Targets", Goldman Explains. Retrieved on 24/11/2014, from http://www.zerohedge.com/news/2014-09-02/china-will-revise-its-gdp-definition-until-its-hits-government-growth-targets-goldman

[27] Ibid.

[28] See: Dehaghi, M.R and Goodarzi, M. (2011). Op. Cit.

[29] The government recently approved the National Research and Innovation Fund (NRIF) which is a product of the new national STI policy tailored towards economic transformation and the development of STI in the Nation. See: Akinwale, Y. O; Dada, D.A, et. al. (2012). Op. Cit.

[30] See: Malik, A., Teal, F. and Baptist, S. (2006) *The Performance of Nigerian Manufacturing Firms: Report on the Nigerian Manufacturing Enterprise Survey.* Centre for the Study of African Economies University of Oxford; United Kingdom.

[31] Agarwal, P. (2012). Op. Cit.

[32] Economicshelp.org. (unknown). Causes of Economic Growth. Retrieved on 14/01/15, from http://www.economicshelp.org/macroeconomics/economic-growth/causes-economic-growth/

with economic growth rates more than three times faster than the world average.

The gradual growth of the Chinese economy, started as far back as the 70's, when it began to move to a market economy and to open itself up to the rest of the world. Its pace of reform speeded up in the 1980s and the in 1990s when they began exporting commodities which had been reverse engineered to compete with existing technology. As a result of the robustness of their labour market, foreign companies in partnership with China sent spare parts and already finished products for coupling and putting together in the Chinese industries. Export processing therefore began at the low end with steel production, automotive, and traditional industries and developed into globalized production of high-end goods. [33] Several steps subsequently taken, included the proliferation of special economic zones, increasing receptivity to direct foreign investment, and the decision to join the World Trade Organization in 2001.

Apparently, the turn-around in the economy of China began when they started strengthening their innovation systems through public and private investment in research infrastructure, systematic borrowing from overseas through licensing and other channels and the acceleration of technological progress with the propagation of reverse engineering which eventually enabled them to cross the threshold and become a member of the club of high income economies.[34]

China is now a major global player on the world trade and investment scene. The speed, scope, and scale of its entry into the global system are unprecedented in economic history. It has been growing at 8% to 10% per year since the late 1970s and has become the third largest exporter of merchandise goods. It has earned the reputation as the manufacturing center for the world.[35]

In 2006, the Chinese State Council unveiled the Medium and Long-Term Plan(MLP) blueprint which among other things contained a set of scientific and technological benchmarks to be met by the year 2020. The blueprint was created as a vehicle for establishing China as a science and technology world power. The plan focused on 11 key sectors for using technology development and innovation to solve China's problems. The plan was created to *inter alia,* decrease China's overall dependence on foreign technology to a percentage less than 30% from approximately 60% in 2006.[36]

The plan called for Chinese original innovation or in other words for national entrepreneurs to create their own intellectual property and enrich the state. The government did not however rely solely on creations and inventions from scratch, but also considered reverse engineering, that is slightly altering and enhancing foreign technology as a means of innovation creation as well. The plan in its interpretation of indigenous innovation also included the "enhancing of original innovation through co-innovation and re-innovation based on the assimilation of imported technologies.[37] This full frontal power basically empowered Chinese manufacturers to obtain foreign products and innovations, re-engineer them to make them Chinese and if possible, sell them at a lower cost using cheaper materials thus boosting the said products in the market and increasing the country's exporting power for the said products.

In other to protect their innovations derived from reverse engineering so as to give them a greater fighting chance in the competitive market, they had recourse to intellectual property.[38] Intellectual property law helped fulfil China's further aspira87tions for growth of its economy, as the products created as a result of reverse engineering were patentable, allowing them thrive in the competitive world market. In 2010 therefore, China passed the United States and Japan as the world's largest filer of patent applications.[39]

As a result of all this, China averaged economic expansion of around 10% a year over the past three decades, pushing it up the list of biggest economies and boosting household wealth.[40] The rapid per capita growth rate in China has helped to lift many people out of poverty. The share of persons below the international poverty line of $1day has been reduced to just 17% in China.[41] Its economy, gauged by nominal GDP, grew by a phenomenal 10.3 per cent in 2010 as against 9.2 per cent in 2009, according to IMF data which also shows that global growth in 2010 was largely propelled by China and United States of America[42]

[33] Rosenstein, A. (2014). Op. Cit.

[34] Worldbank.org. (2011). China's Growth through Technological Convergence and Innovation. World Bank Supporting Report 2. 161-228. Retrieved on 24/11/14, from http://www.worldbank.org/content/damWorldbank/document/SR2--161-228.pdf

[35] Dahlman, C.J. (2007). China and India: Emerging Technological Powers. *Issues in Science and Technology.* Retrieved on 24/11/2014, from http://issues.org/23-3/dahlman/

[36] Rosenstein, A. (2014). Op. Cit.

[37] Ibid.

[38] Coming up with policies which empowered their citizens to go around patents of foreign products, but protect their own patents, allowing them to reach their targeted profits from their innovations. This has given China an advantage in copying and reverse engineering foreign technology. See: Dahlman, C.J. (2007). Op. Cit.

[39] Segal, A. (2011). Why American innovation will beat out China's. *CNN online news, 10th March, 2011.* Retrieved on 23/11/2014, from http://globalpublicsquare.blogs.cnn.com/2011/03/10/why-american-innovation-will-beat-out-china/

[40] Yan, S (2015). China posts its worst growth in 24 years. *CNN online news report, 20th January, 2014.* Retrieved on 20/1/2015, from http://money.cnn.com/2015/01/19/news/economy/china-gdp/

[41] Dahlman, C.J. (2007). Op. Cit.

[42] African Development Bank Group. (2013). Economic Report on Nigeria. 1;1. Retrieved on 24/11/14, from

China is now recognised world-wide as the world's second-largest economy[43] and even though their growth rate reduced at the end of 2014, China is still growing more rapidly than any other major economy[44] in the world, including the United States.[45]

III. Reverse Engineering, Inventions and China: Harvesting the Benefits

Reverse engineering, as discussed above, is basically the process of invention by starting with a known product and working backwards to divine the process which aided in its development or manufacture.[46] It is as far as it goes, a legitimate means of creating innovation and is an economically valuable activity that encourages fresh innovation.[47] In 1989, the U.S. Supreme Court decision, in *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, [48] characterized reverse engineering as "an essential part of innovation," likely to yield variations on products that "could lead to significant advances in technology." The Court added that "the competitive reality of reverse engineering may act as a spur to the inventor" to develop patentable ideas.[49]

It has been said that since its inception in 1949 as the People's Republic of China, the country has been reverse engineering.[50] They have successfully shown the world that the above arguments with regard to the contributions of reverse engineering to innovations and inventions and therefore economic growth, is far from being a myth. It is in fact, reality, as it is not news that the Chinese economy is currently harvesting the benefits of its focus on its technology/manufacturing sector via propagation of reverse engineering.

They simply used reverse engineering as a means of technology absorption from foreign countries and to improve learning in these aspects in their country, thereby building their technological capabilities, [51] following a simple four-stage development process which saw them gather in more and more profits and benefits to their economy with every stage:[52]

The first stage is an awareness stage, which involves their recognition that a product had been introduced into the market that is potentially worth the time, expense and effort of reverse engineering. To succeed in doing this (constantly keeping track of recent technologies) they had to encourage foreigners into their borders to invest through good Foreign Direct Investment (FDI) policies and open up their borders to allow for spill-over of technologies through relationship ties between them and other developed nations.[53] This has generally benefitted them as the entry of multinational companies into the economy not only boosted investment and returns to their economy, but also led to certain infrastructural and technical development, aside its direct contribution to the possibility of reverse engineering products.

Second is the reverse engineering stage, which began with the obtaining of the innovator's product[54] and continues with the disassembly and analysis of the said product to discern of what and how it was made. To do this effectively, the government put a lot of funds

http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Nigeria_-_Economic_Review_-_Volume_1_-_Issue_1_-_September_2013.pdf

[43] Yan, S (2015). Op. Cit.

[44] Ibid.

[45] Censky, A. (2012). U.S. companies betting big in China. Retrieved on 21/11/14, from http://money.cnn.com/galleries/2012/news/economy/1204/gallery.us-companies-in-china/

[46] See the American case of Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 476 (1974), where reverse engineering was defined as such.

[47] Samuelson, P. (1998). Intellectual property and economic development: opportunities for China in the information age. *Paper prepared for the 1998 International Symposium on the Protection of Intellectual Property for the 21st Century, October 28-30, 1998, in Beijing, PRC*. Retrieved on the 14/01/15 from http://people.ischool.berkeley.edu/~pam/papers/chinaip.html

[48] 489 U.S. 141, 160 (1989),

[49] Ibid. 489 U.S. at 160

[50] Franks, L.S. (2014). The Art of Reverse Engineering. Retrieved on 23/11/14, from http://www.contrarianprofits.com/e-letters,rogue-capitalists-daily/the-art-of-reverse-engineering/.htm

[51] Kumar, N. (2014). Enabling Policies for Transfer of Technology for Development. Being a presentation at the WTO Workshop on Trade and Transfer of Technology Geneva, 16 June 2014. 3.

[52] China was basically eating their cake and having it, in a very circular motion that benefitted them at every stage, as we shall soon discover form subsequent stages as well.

[53] Through the integration of the local market with the international operators, labour mobility between subsidiaries and indigenous firms resulting in knowledge spill-over, learning from the demonstration of new technologies represented in foreign subsidiaries and when indigenous firms receive technical assistance. UNCTAD (2005) emphasizes that FDI-led Technology spill-over can play a significant role in the productivity growth of indigenous enterprises in a host economy. See generally: UNCTAD, (2005) *Report of the Commission on Investment, Technology and Related Financial Issues, 8*th session, Trade and Development Board, Geneva; Available at *http://www.unctad.org/en/docs/c2d60&c1_en.pdf cited in* Dutse, A.Y, Okwoli, A.A and kurfi, A.K. (*2011).* Promoting FDI-related Technology Spill over in Nigeria's Manufacturing Sector: Active-firms Targeted Policy Approach. *IPEDR vol.10. IACSIT Press, Singapore.* Xu, B. (2000) Multinational enterprises, technology diffusion, and host country productivity growth', *Journal of Development Economics*. 62. 477–493; Sun, Y. (2010) What Matters for Industrial Innovation in China: R&D, Technology Transfer or Spill over Impacts from Foreign Investment? *International Journal of Business and Systems Research, 4;5/6.*

[54] In the process of obtaining technology, the government of China left no stone unturned as they took all steps necessary, by licensing, buying, borrowing and they were even accused of stealing certain designs, but this did not deter them. The Chinese government for instance, was accused of theft by way of reverse engineering a fighter jet known as the Shenyang J-15 carrier-based fighter from the model of a Russian fighter jet. Meanwhile, the fact remained that stolen or not, the Chinese have been credited with the development of the new J-15 which they argued in the People's Daily–a state media organization–is more advanced than the Su-33. See: Majumdar, D. (2012). China upset at being called out for reverse engineering Su-33. Retrieved on 23/10/14, from http://www.flightglobal.com/blogs/the-dewline/2012/12/china-upset-at-being-called-out/.mht

into the boost and support of reverse engineering by increasing spending on R & D,[55] as well as on the technical training of the upcoming generation, especially in more advanced countries.[56] This allowed them to have the technical know-how for the actual understanding of technology and improvement of same. These steps aside from contributing to reverse engineering in China, also led to actual original innovations from China and has also ensured continuity in the growth of the technology and manufacturing sector, as knowledge passed on from generation to the other basically has seen the Chinese technology and manufacturing sector maintaining its lead and competing favourably in the world economy.

Third is the implementation stage which follows after a successful reverse engineering of the innovator's product. In this case, the knowledge acquired from the reverse engineering process is put to work in designing and developing a new product/invention to compete in the same market. Suffice it to say that this was the power house of the reverse engineering process. It was at this stage that it was ensured that whatever product was invented from the reverse engineering process was such that could boast of being a timely product at the level of international standards and one that could better satisfy the customer's needs by ensuring better performance, adding characteristics and eliminating deficiencies of the product, while also satisfying the needs of the market by changing or improving of the technology or reducing cost of same.[57] The steps taken by the Chinese government as highlighted above basically assisted with the achievement of this phase/stage as well.

The fourth stage is the introduction of any new product, the result of reverse engineering to the market[58] where it competed with existing products. Here, the admirable quality of China was its application of intellectual property to make its products have a better fighting chance at generating profit in the world economy. Intellectual property was used to further derive the benefits of their inventions and protect same from infringement, while ensuring the legalisation of the use of reverse engineering to create innovations. The Chinese patent regime was in furtherance of this, designed to protect attempts by Chinese companies to replicate foreign products.[59] This in turn encouraged the creation of more innovations and inventions and therefore the filing of more patent[60] and therefore as well, the raking in of more profit to further boost the Chinese economy by channelling it to the improvement of other sectors of the economy as well. The more affordable or better improved products were a hit on the international markets, thereby allowing companies to make huge profits which were re-invested in expansion of industries, leading to more employment of labour and reduction in the poverty level in the Country and ultimately increasing the Gross Domestic Product (GDP) of the country and fuelling its economic growth.

China has therefore as a result of reverse engineering and the accompanying steps above, made great strides in reforming its economy and becoming a major force in the world economy.[61] They have now successfully developed mechanisms for replicating products at drastically lower prices and this has opened up their market for the greater percentage of the world population, looking to have the best of the world's comforts at the most affordable rates,[62] such that since it launched major economic reforms in the late 1970's, its economy has experienced tremendous growth,[63] and has not relapsed.

IV. Nigeria's Economy in Perspective

The Nigerian economy has so far in its history, portrayed the role of a dysfunctional seesaw, with only

[55] They gradually increased their spending on R & D activities, such that spending on R&D as a percentage of China's GDP tripled over in the past 15 years from half a percent to 1.5% and it is predicted that by 2020, about 2.5% of China's GDP which will have also increased considerably, will likely go to R&D. See: Franks, L.S. (2014). Op. Cit.

[56] China has been sending more tertiary level students abroad for education and training. In 2004, more than 15% of all the 2.7 million students studying outside their home country were from China. See: Dahlman, C.J. (2007). Op. Cit.

[57] Dehaghi, M.R and Goodarzi, M. (2011). Op. Cit.

[58] See generally on the above stages: Samuelson, P & Scotchmer, S. (2001). Op. Cit.; Sha, L. (2012). Op. Cit.

[59] The Chinese patent law for instance adopted what has been described as the utility model of patents which only require vague descriptions of products, thereby allowing people to file patents on products already owned by others by merely changing a few minute details. The Patent law also allows the use of domestic patents to retaliate against foreign companies that file intellectual property infringement lawsuits offshore that stymie the international expansion plans of Chinese companies. Then in addition, the law uses the European "first to file" policy in registration of patent rather than the "first to invent" policy used in the United States, which allows Chinese companies to file patents on products they did not necessarily design if they beat the actual owners to the punch. Finally, defines invention as including "any new technical solution relating to a product, process or improvement…" These Chinese patent rules were designed to help natively conceived products and block those that were not wholly designed and produced in the country from having ground in the Chinese markets. This model is similar to that used by the Germans. See: Rosenstein, A. (2014). Op. Cit.

[60] Indeed, the number of patents filed by the Chinese has increased rapidly in recent years and as stated earlier, China shocked the world as a matter of fact, when in 2010 they passed the United States and Japan as the world's largest filer of patent applications. See: Durden, T. (2014). Op. Cit.; Franks, L.S. (2014). Op. Cit.

[61] Samuelson, P. (1998). Op. Cit

[62] African Development Bank Group. (2013). Economic Report on Nigeria. 1;1. Retrieved on 24/11/14, from http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Nigeria_-_Economic_Review_-_Volume_1_-_Issue_1_-_September_2013.pdf

[63] Gao, L. (1998). China's Intellectual Property System in Progress. *China in the world trading system: defining the principles of engagement*. Abbott, F. M. ed. 128. Cited in Samuelson, P. (1998). Op. Cit.

one of its arms working and consistently moving its riders up and down without any warning. The very young economy continues to grapple with a number of challenges that has hampered efforts at economic growth.

The Nigerian economy is yet to achieve the necessary structural changes that will spring it to a rapid and sustainable growth and development. Aside disarticulated and narrow productive base, sectoral linkages in the economy are weak. Primary production comprising agriculture, mining and quarrying inclusive of oil and gas dominate national output while the manufacturing sector role in the economy is decidedly small in terms of share of gross output, contribution to growth, foreign exchange earnings, government revenues and employment generation.[64]

The economy also faces monumental challenges in the form of dilapidated and chronically non-functional infrastructure. [65] The decay in the country's infrastructural base reflects decades of poor maintenance and weak technological base. The weak technological base is a consequence of low research and development efforts and disconnect between research findings and industry. The private sector is equally weak and diffuse with poor response record to industrial incentives.[66] All sectors of the economy are affected by deep seated corruption, [67] lack of proper management of resources, lack of foresight and bad leadership.[68]

Although the economy experienced respectable GDP growth rates, averaging over 6.5 percent per annum between 2006[69] and 2010, this growth did not spawn corresponding employment nor resulted in attenuation of poverty. Moreover, growth rates of the non-oil output remains unsatisfactory and the even more recent fall in oil prices has taken a huge tow on the country. Concomitantly, there has been gradual decline in the level of competitiveness of the Nigerian economy to the extent that the country has become one of the least competitive economies in Africa. The narrow base of government revenue and the near monolithic nature of exports constitute additional challenges confronting the economy.[70]

The oil sector growth performance which is the focal point of the economy and has been greatly relied on for the funds of the government was not as impressive with 3.4%, -2.3% and 5.3% estimated growth rates in 2011, 2012 and 2013, correspondingly. Growth of the oil sector has been said to have been hampered throughout 2013 by supply disruptions arising from oil theft and pipeline vandalism, and by weak investment in upstream activities with no new oil finds.[71] Besides, the over reliance on the country's oil sector without attempts at sustainable use of the natural resource has been said to spell doom for the country and it has been predicted that Nigeria has only about three decades to exhaust its crude oil reserves.[72]

In the light of the fast rate of depletion of this natural resource and the failure of the Nigerian economy as stated above, in global competitiveness, it has become imperative for Nigeria to source for other means such as the use of reverse engineering to boost innovation as a vital tool for accelerating their economic growth. Meanwhile, Nigeria is yet to fully harness reverse engineering to boost its economy. Veritable tools such as reverse engineering have been given little or no attention by the Nigerian government in the past, especially as the major focus has been on the oil and gas sectors of the economy.

Though the government of Nigeria is said to have begun to set up policies that prescribe the attraction of FDI and the integration/absorption of related technology spill over,[73] there is still a lot to be done in this regard, especially on the use of reverse engineering to boost economic growth in Nigeria.[74]

[64] African Development Bank Group. (2013). Op. Cit.

[65] Nigeria depends heavily on imports and this has drastically affected infrastructural development. Its dependence on the developed nations has inhibited the evolution of its engineering infrastructural base. See: Siyanbola, W.O, Egbetokun, A.A, et.al. (2012). Indigenous Technologies and Innovation in Nigeria: Opportunities for SMEs. *American Journal of Industrial and Business Management.* 2, 64-75.

[66] African Development Bank Group. (2013). Op. Cit..

[67] Abasiekong, O. 2012. The Nigerian leadership debacle. *The Nigerian Voice,* 8 August 2012. Retrieved on 23/6/14, from http://www.thenigerianvoice.com/news/96035/1/the-nigerian-leadership-debacle.html

[68] Waziri, K. M. & Awomolo, O. F. (2014) Protection of Traditional Knowledge in Nigeria: Breaking the Barriers. *Journal of Law, Policy and Globalization.* 29. 176-186.

[69] It is worthy of note that Yauri had reported about this time that FDI-related foreign economic policies received most significant attention of the Nigerian government in the last decade and a half before that year. See: Yauri, N. M. (2006) Foreign Direct Investment and Technology Transfer to Nigerian Manufacturing Firms-Evidence from Empirical Data, *Central Bank of Nigeria, Economic and Financial Review, 44;2. 18-38;*

[70] African Development Bank Group. (2013). Op. Cit.

[71] Ibid.

[72] See generally: Anon. 2012. Rescuing the Economy from Looming Debacle. *Thisdaylive online newspaper.* 25 Dec 2012. Retrieved on 23/6/14 from http://www.thisdaylive.com/articles/rescuing-the-economy-from-looming-debacle/134462/.htm; Abasiekong, O. 2012. Op. Cit.; Waziri, K. M. & Awomolo, O. F. (2014) Op. Cit.

[73] UNCTAD, (2009) Investment Policy Review–Nigeria; Available at *http://www.unctad.org/en/docs/diaepcb20081_en.pdf. cited in* Dutse, A.Y, Okwoli, A.A and kurfi, A.K. (*2011).* Op. Cit..

[74] For instance there exists in Nigeria, the National Agency for Science and Engineering Infrastructure (NASENI), which it is said has as part of its scope of duties the propagation of the use of reverse engineering. However, in an interview with the Guardian news, the director of the agency, Prof. Olusegun Oyeleke Adewoye, stated that though the agency was created majorly for reverse engineering, a lot of head-way has not been made by it because the successive governments in the country, with their different agendas and policies usually do not abide by the law establishing NASENI, especially with regards to finance and funding. See: Anuforo, E. (2011). Op. Cit.

V. Prospects for Nigeria: Making a Case for use of Reverse Engineering in Nigeria

Nigeria as a Country still has ways to go with regard to the use of reverse engineering for technology development and general increase of its GDP. While steps have been taken by the government in this regard, not much success has been registered.[75]

Using this reverse engineering, Nigeria can design and mass produce several products,[76] which are currently being mass imported at costly rates into its borders from other more technology manufacturing and patenting countries, such as fashion wrist watches, safety pins, textile materials, toys, electronics, utility equipment, cars, ships, trains, auto spares, electrical, mechanical and scientific equipment, ICT equipment parts, weapons, and so on.

Recently, it was reported that Coscharis Technologies Limited deployed a state of the art-reverse engineering technology at the Covenant University, Otta, Nigeria.[77] This was said to have been done with the aim of bringing up a technology development and improvement conscious generation, by catching them young. Such step will aid with training capable hands in the reverse engineering market, so that Nigeria can focus on it and boost it as a veritable tool for economic growth in Nigeria, just as successfully done by China.

If truly, one of the Nigerian 2020 goals includes the raising the capacity for a knowledge-based and innovation-driven economy, then reverse engineering must be promoted as it leads to innovation,[78] which ultimately leads to economic growth. Consider the analysis below:

a. Innovation is the same thing as invention, which leads to the right to patents and generation of income from use of such innovation, while same is protected by intellectual property.
b. Such generated income can be channelled towards further research and further innovation and further generation of income.
c. Such income can also be injected in to boost other aspects of the economy of the country in other to further diversify same and generally boost income.
d. On the other hand, the ability to create such innovations reduces reliance on other countries for the production of such commodities and therefore reduces reliance on imports.
e. Meanwhile, it increases the ability of the country to create commodities for exports especially where more efficient and advanced technology is developed as a result of the reverse engineering process and this in turn generates income for the country thereby boosting the economy.
f. It also reduces the level of poverty and unemployment as the fostering of the process creates more opportunities for the knowledge and skill acquisition, which in turn provides sources of income for the citizens for expansion of businesses and production capacities, in a revolving cycle that sees an increase in job creations and reduction in unemployment and poverty.
g. It gradually increases the confidence in the country's market for its exportable commodities, thereby increasing spending from foreigners in the country's economy and therefore generating income, boosting investment in the country's market and setting up standards for the country, which all lead to generation of income to boost the country's GDP.
h. It leads to discovery and use of more raw materials in the search for ways to improve products by the reverse engineering process and this in turn creates further export and innovation opportunities for the country.
i. The increase in income generation, leads to increased wages and salaries which in turn provides better labour productivity and reduces emigration of working class citizens as a result of general satisfaction derived from working conditions.
j. On the other hand it increases immigration of labour into the country, leading to increased productivity and therefore income generation.

All these pointers eventually lead to economic growth of the country and as seen with the case in China, are all traceable to the propagation and promotion of technological development via reverse engineering. Nigeria can fully tap into this amazing wealth creator, only by ensuring that it focuses on the use of reverse engineering to achieve innovation.

VI. Summary/Conclusion

In this paper, we argue that reverse engineering is the next best step the government of Nigeria can take, as was done in China, in order to uplift the economy and give Nigeria more competitive advantage in the world economy.

Nigeria must therefore give reverse engineering sufficient focus and attention to allow it to grow into a huge income generating sector of its economy, as it is public knowledge now that reverse engineering was the platform used to achieve what China has achieved.

We might say we are just beginning and therefore just require monitoring, diligence and more focus to thrive in this aspect of the economy. If that be the case, then government must be reassured that they

[75] Aginam, E. (2014). Op. Cit.
[76] Ibid.
[77] Ibid.
[78] PLATT, J.R. (2010). Ibid.

are on the right path and encouraged to do more, as the benefits of persistence on this path cannot be over-emphasized. This is what is evident in the system and process used by China in its amazing transformation from a developing economy to the second largest economy in the world.

The Nigerian government must therefore in like manner, commit itself to innovation creation through support for reverse engineering as well as developing polices to boost same thereby, bolstering and diversifying the economy to enable economic growth and an enviable economy, for the resource, culture, and people rich nation, that is Nigeria.

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