



## East African Journal of Arts and Social Sciences

[ejass.eanso.org](http://ejass.eanso.org)

Volume 5, Issue 1, 2022

Print ISSN: 2707-4277 | Online ISSN: 2707-4285

Title DOI: <https://doi.org/10.37284/2707-4285>

**ENSO**

EAST AFRICAN  
NATURE &  
SCIENCE  
ORGANIZATION

Original Article

## Africa's 4th Industrial Revolution Post Covid-19: A Tale of Shenzhen's Enviably Successful.

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Article DOI: <https://doi.org/10.37284/eajass.5.1.535>

### Article history: ABSTRACT

25 January 2022

#### Keywords:

*Forth Industrial  
Revolution,  
Reverse Engineering,  
Special Economic  
Zones,  
Industrial Clusters,  
Shenzhen*

Africa is likely to miss the prospects of the 4th industrial revolution if governments and policymakers do not take the abundance of caution. In the last two centuries, three discoveries changed the world—the steam engine, industrial revolution, and internet. Africa had no stake in any of those discoveries. As developed countries industrialized in the 18th and 19th centuries, the African continent was still reliant on primordial food and material production technologies. Unfortunately, a similar trend is repeating itself, exacerbated by the effects of COVID-19. While advanced nations are transitioning(ed) to digital investments in areas such as artificial intelligence, robotics, mechanized agriculture, 3D printing, and the internet of things, Africa appears to saunter. Not so many African countries are aligning themselves to exploit the opportunities that will come with the economic and social disruptions of the 4th industrial revolution. Challenges such as internet penetration, skill mismatch, poverty, poor governance, inequality, lack of modernization of agriculture, and improper structuring of economies will delay the revolution or truncate it elsewhere in the world. Besides, the COVID-19 pandemic presents new challenges undergirded by disruptions in global supply chains, slow economic projections, and inequalities in mass vaccination in the continent. However, Africa and its leadership can take deliberate, methodical, and timely interventions to seize the moment and lift its population from poverty and dependency. In this study, the author proposes a hybridized model embodying reverse engineering, infrastructural investment, special economic zones, and digital investment as the panacea for expediting Africa's prospects in seizing the possibilities of the 4th industrial revolution pegged on the successes of Shenzhen.

#### APA CITATION

Mutuku, R. K. (2022). Africa's 4th Industrial Revolution Post Covid-19: A Tale of Shenzhen's Enviably Successful. *East African Journal of Arts and Social Sciences*, 5(1), 1-12. <https://doi.org/10.37284/eajass.5.1.535>

#### CHICAGO CITATION

Mutuku, Richard Kyalo. 2022. "Africa's 4th Industrial Revolution Post Covid-19: A Tale of Shenzhen's Enviably Successful". *East African Journal of Arts and Social Sciences* 5 (1), 1-12. <https://doi.org/10.37284/eajass.5.1.535>

#### HARVARD CITATION

Mutuku, R. K. (2022) "Africa's 4th Industrial Revolution Post Covid-19: A Tale of Shenzhen's Enviably Successful", *East African Journal of Arts and Social Sciences*, 5(1), pp. 1-12. doi: 10.37284/eajass.5.1.535.

#### IEEE CITATION

R. K. Mutuku, "Africa's 4th Industrial Revolution Post Covid-19: A Tale of Shenzhen's Enviably Successful", *EAJASS*, vol. 5, no. 1, pp. 1-12, Jan 2022.

#### MLA CITATION

Mutuku, Richard Kyalo. "Africa's 4th Industrial Revolution Post Covid-19: A Tale of Shenzhen's Enviably Successful". *East African Journal of Arts and Social Sciences*, Vol. 5, no. 1, Jan 2022, pp. 1-12, doi:10.37284/eajass.5.1.535.

## INTRODUCTION

Africa suffered massive supply chain disruptions at the height of the Covid-19 pandemic. Its industrial base is nascent, and the dependence on imported consumables, especially from China, exposed the continent to massive medical supplies and equipment shortages. These shortfalls and trade disruptions accelerated by travel restrictions and lockdowns exposed Africa's vulnerability for its overdependence on cheap imports from the East. Before the pandemic in 2019, China exported goods worth \$113 billion to the African continent. However, the trade volumes declined by nearly half at the height of the pandemic forcing African countries to look inwards for African solutions to bridge the trade deficits (Peter & Emil, 2021). Many African countries, including Kenya, began manufacturing and producing medical supplies and equipment such as face masks, ventilators, body coats, syringes, and ancillary medical research to support the poorly developed health sectors from the cusp of collapse. As a result, Kenya and Uganda are building vaccine manufacturing plants to supply the continent post-covid, while Ethiopia is positioning itself to become Africa's pharmaceutical hub (Ministry of Health, 2021; Adriaanse, 2021). Lesotho, a country landlocked by South Africa, is introducing mechanized block farming supported by smart technology to feed its population and reduce overdependence on South Africa for agricultural inputs and outputs (Rantšo & Seboka, 2019). Similarly, for Nigeria, the pandemic revived the textile industries in Abia State (AGOA, 2021),

while Egypt is increasing infrastructure investment in industrial zones to revamp exports post-Covid (World Bank, 2021). These exemplars demonstrate the immediacy of the industrial revolution in Africa to increase self-sufficiency and reduce business shocks such as those occasioned by the Covid-19 pandemic. Due to its mature manufacturing capacity, China is the only country globally that did not face massive disruptions in its flow of goods and services. Presciently, China's mass production supported by technology cities such as Shenzhen prevented disruptions triggered by the pandemic. In retrospect, the success of manufacturing hubs in China, such as Shenzhen, in supporting mass production during the pandemic provides enviable lessons for Africa as it gears itself to harness the fourth industrial revolution post-Covid.

## A TALE OF SHENZHEN

For O'Donnell et al. (2017), as the Reform and Open policy began in 1978, Shenzhen was a small fishing village surrounded by paddy plantations (p. 7). It had a population of about 30,000 smallholder fishermen and rice farmers. Three decades later, it would sprawl to a population of 30 million people (Holloman, 2013). The town had neither paved roads, tall buildings, nor active commercial or economic activities. It mirrored the social stratification Mao Zedong intended to address during the Cultural Revolution as just across the town was Hong Kong glowing with opulence and economic might.

Deng Xiaoping established Shenzhen as a Special Economic Zone in 1979 using his genius and market reform agenda. For Deng, Shenzhen was an experimental crucible to test the potential successes of market-Leninism. He described the market-Leninist approach as "crossing the river by touching the stones," meaning opening up the economy in a phased approach. In readers' interest, market-Leninism is a capitalist market economy patronized by a communist party. China and Vietnam offer the best exemplars of this market model. In four decades, the city experienced monumental growth, earning it the moniker 'miracle city.'

In 20 years, the period between 1980 and 2000, the city's GDP grew by 40%, from 0.15 billion Yuan to 200 billion Yuan (Juan, 2020). By 2017, the economy had grown to \$338 billion, surpassing Hong Kong and Singapore (Juan, 2020). The meteoric growth makes Shenzhen a model city for others to emulate, including Africa. It is also a manufacturing hub regarded as the "world factory." The phenomenal transformation exemplifies Mao's and Deng's vision of lifting millions of poor Chinese out of poverty.

Comparatively, by the time Deng commissioned Shenzhen as a special economic zone in 1979, something fascinating happened in Africa. The Bretton Wood institutions—World Bank and the International Monetary Fund—were ushering the Structural Adjustment Programs (SAPs) regime in Africa. After decolonization, most African countries adopted the import-substitution model to entrench domestic manufacturing (Gertz, 2008). However, the West construed the import-substitution model as protectionist, and therefore, they introduced SAPs as red tape requiring African countries to do certain things to qualify for loans. These regulations involved reducing government expenditure, liberalization of markets, devaluation of currencies, privatization, and deregulation. It is essential to point out that the oil crisis of the 1970s slumped African economies that were hitherto doing well and forced them to liberalize to secure loans with the World Bank and IMF (Gertz, 2008). Invariably, liberalization killed uncompetitive manufacturing firms as foreign countries continued to dump substandard and highly subsidized consumer goods in the African markets untrammelled.

Ostensibly, as the industrial base in Africa was waning, manufacturing hubs like Shenzhen rose to stardom. Caution must be taken not to blame Shenzhen for the woes of Africa. Contextually, Africa's largest economy, Nigeria, is slightly bigger than that of Shenzhen, standing at \$446.5 billion (IMF, 2020) and \$396.9 billion as of 2019, respectively (Xinhua, 2020). However, why is Shenzhen a central paragon in this context? Pragmatism is the answer.

In its infancy, the period 1979 and 1992, Shenzhen experienced an urban population sprawl as skilled and unskilled labour moved from mainland China to the then small developing town. The movement created the ground for urbanization and industrialization. Among these people were 20,000 engineers dispatched by the central government. By 1992, the population had hit 1.79 million people (UN HABITAT, 2019). At the time, smallholder developers, companies, and engineers were beginning to patent their software and hardware innovations through the government-sponsored program dubbed Encouraging Technology Personnel Starting Private Technology Companies under the auspices of the Shenzhen Science and Technology Development Plan.

Further, in 1992-2002, Shenzhen rose from a bottom manufacturing hub to a middle-tier industrialized city in the global supply chain. This phase embodied labour inflows, market economy supply chains, export of hardware, and enabling investment infrastructure. Besides, the population had hit 7 million people (UN HABITAT, 2019, p. 10). As Shenzhen entered the third phase, 2003-2012, it had become a fully-fledged manufacturing hub, and the central government withdrew the institutional and policy dividends preferred to the city (UN HABITAT, 2019, p. 10). In this period, the foreign direct investment was about \$125 billion compared to a measly \$7 billion in 1992 (Holloman, 2013). The period became tumultuous but was necessary for making the city sustainable. Such transformation ushered in an era of innovation and globalization as the government introduced a 25% corporate tax drifting away from the preferential tax holiday offered to the special economic zone.

From 2013 onwards, dubbed the period of innovation and globalization, global brands

established manufacturing firms in Shenzhen to take advantage of the low labour costs, enabling infrastructure and production costs. Global brands such as Foxconn company, Apple, Huawei, Tencent, BYD, Proctor and Gamble, KPMG, Samsung, and Cisco Systems have established their manufacturing foothold in Shenzhen. There is a high chance that most of the electronic products used globally were manufactured in Shenzhen. Even when Shenzhen takes the title of the world's factory, its copy-cut model of accelerating manufacturing remains contentious.

A few lessons emerge from the third part of this tale, which is beneficial for Africa. Firstly, Special Economic Zones are a vital driver for economic growth. Secondly, government interventions and material incentives in the form of infrastructure and digital investment, even in neo-liberal economies, are necessary for spurring growth. Further, labour mobility in Africa, a continent where one has to acquire a visa to travel to the neighbouring country, will become a big impediment in the fourth industrial revolution. But more importantly, for this discussion, reverse engineering is a precursor of innovation, and Africa must journey the route. Besides, Africa needs visionary and nationalistic leaders.

## **SPECIAL ECONOMIC ZONES AND INDUSTRIAL CLUSTERS IN AFRICA**

### **Industrial Clusters**

Africa continues the path of resource dependence. As a result, it has not escaped the wrath of uncertainties in the global product market, erratic export revenues, and intermittent risks of fluctuating exchange rates. The typology of the benefits emerging from economic diversification does not lack in development literature and economics. While economic diversification is necessary, this research adds that economic diversification must follow the path of special economic zones and industrial clusters for accelerated growth if Africa has to harness the opportunities of the fourth industrial revolution post-Covid.

Porter (1990), a revered scholar in development economics, notes that "a nation's competitiveness

depends on the capacity of industry to innovate and upgrade (p. 73)." The key phrases here are "innovate" and "upgrade." Africa must begin to innovate solutions to its problems and upgrade to an industrialized continent through its initiative instead of sitting on the fence and tapping technologies developed elsewhere in the world. The Covid-19 pandemic brought out the essentiality of this statement boldly. Disruptions in the global supply chains exposed the volatility of African economies as their manufacturing capacity could not sustain demand for healthcare supplies, leading to cataclysmic shortages. The proposed strategies here include the continent-wide establishment of special economic zones and industrial clusters. Besides, the author suggests reverse engineering as a model for kick-starting innovation and upgrading Africa to an industrial power base.

Notably, industrial clusters embody the geographic concentration of industries that produce the same line of goods, either as supplements or complementarities. Further, these industries are linked to enabler institutions such as government agencies, educational institutions, financial entities, and social amenities. These clusters become mutually dependent and share synergies through spillovers, aggressive competition, the attraction of foreign direct investment, and creating spillover effect to the economy. Porter (1990) argues that one competitive industry can sprawl to form another, but government intervention is essential in driving such growth (Porter, 1990, p. 86). Ali et al. (2016) enumerated three benefits of industrial clusters. Firstly, the agglomeration provides industries with inputs and specialized services, thereby reducing business costs, and secondly, they leverage collective potential for innovation by fostering learning and discovery. Further, they facilitate the flow of information and expertise exchange through pooled resources and technology transfer (Ali et al., 2016: 2).

Globally, there are explicit examples of successful industrial clusters. The Italian Footwear Districts such as Riviera del Brenta, Veneto, and Barletta district of Puglia exemplify the success of industrial clusters. Riviera del Brenta specializes in producing high-end footwear products, while Barletta is a low-end production district (Amighini & Rabellotti, 2006, p. 3). These industrial clusters are net

exporters of luxury footwear brands and low-end products. As of 2014, an OECD report indicated that those industries contributed at least 30% of Italy's manufacturing exports (OECD, 2014, p. 189). However, what makes these clusters unique and successful compared to non-clustered industries is sharing technology, access and attraction of high-skilled labour, specialized suppliers, research and development, and opportunities for innovation (OECD, 2014, p. 191). Also, Valenza Po, Arezzo, and Vicenza in Italy are emerging as goldsmith districts following the industry cluster model.

In the United States, the establishment of industrial clusters is widespread and has been phenomenal in transforming the industrial and manufacturing upbeat of the country. For instance, NAPA Valley, which comprises over 400 wineries, is a concentration wine production in California. Besides, Detroit has an automotive concentration. It has cut a market niche for producing cars and trucks in the United States. Also, Silicon Valley in California produces software and computers chips and has become a technology hub in the United States. Another example is Hollywood in Los Angeles, a global leader in the production of movies. Further, New York also is a financial district for the United States and the international stage. These examples in the United States demonstrate isolated market niches, which began as industry clusters, to industrial districts and morphed into global frontiers for industry solutions and competitiveness.

There are numerous successful industrial clusters in China: some that emerged organically while others are state-anchored. The textile industries in Xiqiao, Guangdong Province; coal industries in Shanxi Province; Pu-erh tea industries in Shinnan; and Zhongguancun high-tech Park in Beijing are industrial clusters contributing immensely to the Chinese manufacturing base. These industrial clusters developed meteorically because of their strategic location, foreign direct investment since the 1970s, government pragmatism in incentives, and political non-interference.

In Africa, only three countries are quirky in capturing the centrality of industrial clusters in economic development. These countries include Ethiopia, Nigeria, and Mauritius. In Ethiopia,

industrial clusters emerged organically through market forces. Examples of these industrial clusters include the Mercato footwear cluster, the Mekel wood and metal works cluster, and the Hawassa bamboo work cluster (Ali et al., 2016, p. 5). For Ali et al. (2016), the most successful among the three is the Mercato footwear cluster, as there was at least 1500 middle and small enterprise (MSE) manufacturers operating in the industrial cluster as of 2016 (p. 5). The others are survivalist industries, which is a common phenomenon in African industrialization, undergirded by restrictive regulations, structural and administrative flaws, high corporate taxes, improper business infrastructure, and difficulties accessing local and international markets.

In Nigeria, the Nnewi automotive industrial cluster in Anambra State is poised as the Japan of Africa. It agglomerates indigenous auto-manufacturing firms such as Cutix PLC, Omata holdings, Ibeto Group, among other prominent brands in Nigeria. The industrial cluster has cut a niche in the assembly and production of auto spares for bicycles, motorbikes, and vehicles targeting the Southeastern region (Ekesiobi et al., 2018, p. 136). As of 2018, it was estimated that Nnewi industrial cluster produced approximately 102,000 cars, 500,000 motorbikes, and 55,000 commercial vehicles even though the industrial zone formalized government support and infrastructure (Ekesiobi et al., 2018, p. 137). The reasons behind this include technology transfer from Chinese merchants to the local communities, industrial associations in the automotive industry, and globalization (Ekesiobi et al., 2018). In Mauritius, the textile industry emerged from an economic processing zone and became an industrial miracle in five decades. As of 2017, Anganan (2017) indicated that the textile industry contributed 4% of the country's GDP, employed at least 8.3% percent of the workforce, and contributed about 47% of total Mauritian exports. While the industry is diversifying, it also faces challenges, especially lack of competitiveness against Asian cheap imports and foreign exchange fluctuation.

Based on the global and African case studies of industry clusters discussed above, it is apparent that Africa is not utilizing the full potential of industrial clusters. Nadvi (1997), in his collective efficiency theory, enumerates four precursors of

competitiveness in industrial clusters. These factors include the view that industrial clusters must have access to specialized labour, a ready supply of inputs, technological transfer, and access to markets (Nadvi, 1997, p. 83). The scholar takes a classical approach to development economics by ignoring the central role played by governments in spurring economic growth. In a World Bank report, Zeng (2010) captures this perspective by elaborating underpinning factors that have made the Chinese industrial clusters successful through government interventions. These include pragmatism of political leadership, institutional autonomy and political non-interference, proactive government involvement, diaspora foreign direct investments, and innovative culture (Zeng, 2010: 16-23). Besides, the location of the industrial clusters and entrepreneurial knowledge matter. Therefore, Africa must abandon old business methods and adopt the collective efficiency model integrated with Zeng's lessons to innovate and upgrade. Some sectors that offer Africa an opportunity to innovate and upgrade are agriculture, pharmaceuticals, textile industries, the mining sector, financial solutions, the internet of things, and robotics.

### Special Economic Zones

While industrial clusters are necessary for spurring industrialization, they suffer from the free-rider problem, especially due to lack of cooperation in the agglomeration and competition (Nadvi, 1999, p. 85). Therefore, the continent must complement industrial clusters with special economic zones. As indicated earlier, industrial clusters can grow organically, like Ethiopia's footwear industry and Nigeria's Newi automotive industry. However, special economic zones require full government support, especially at the inception, to attract investment and spur growth. Zeng (2010) provides eccentric features of a special economic zone. They must be in a delimited geographical area, be run by a centralized administration, and operate under special duty-free customs compared to the rest of the country (Zeng, 2010, p. 4). In retrospect, special economic zones are more liberal and provide investors with incentivized regimes such as fiscal favours and infrastructure. Now, it is critical to mention that special economic zones are not a new concept in Africa. The author does not purport to introduce a new economic miracle in this context.

However, the existing special economic zones, particularly export processing zones, common in Africa lack competitiveness and have not created disruption anticipated in theory and practice. In this section, the author reimagines special economic zones shadowing the Shenzhen social experiment as vehicles of economic transformation in Africa.

This far, Africa's experience with special economic zones has been tumultuous. In Northern Ghana, tomato processing farms organized as special economic zones such as the Pwalugu Tomato Factory failed woefully. It faced underfunding, poor infrastructure, bureaucratic red tape, high corporate taxation, dumping of cheap imports, expensive inputs, and blatant lack of government support (Boamah & Sumberg, 2019). Governments in Africa have also tended to prioritize short-term paybacks in place of medium-term and long-term prospects. In Nigeria, the Lekki Special Economic Zone established in 2006 by the Nigerian government in collaboration with the Chinese government, aimed to develop a modern city with multi-functional utilities to support trade, manufacturing, tourism, employment, and foreign direct investment. Almost a decade and a half later, the economic zone still struggles to take shape. The issues have primarily been the government's insistence on crowding out private investors through ownership. The Lagos State Government and its subsidiary, Lekki Worldwide Investment, own 40%. Another 40% is owned by an investment company called Ibile Holdings, a subsidiary of Lagos State (World Bank, 2011, p. 46). In this regard, Lagos State owns about 80% of the special economic zone cumulatively, which creates a complex environment for private investors to operate. This example demonstrates the desire by many African governments to control special economic zones by sitting in company boards and taking part in bilateral coordination instead of creating an enabling regulatory environment and letting private investors do business freely.

Moreover, in Kenya, the Konza technology city established in 2008 for better words is a High-Tech Industrial Development Zone with all the hallmarks of a special economic zone. It forms part of Kenya's vision 2030 as a flagship project aiming to create 200,000 jobs. The framers envisioned the city to become the Kenyan Silicon Valley akin to

America's California Silicon Valley, China's Shenzhen, and South Korea's Bundang-gu. Though at the time of writing this journal, the city is leap-frogging to establish horizontal infrastructure as an enabler to attract private investment, at the initial stages, it has faced land acquisition challenges and underfunding by the government. These issues have led to cost and time overruns and delays for key milestone phases.

Having mentioned the challenges facing special economic zones in Africa using case examples, reference can be made to Shenzhen to establish a panacea. Firstly, Africa must address land acquisition issues, carry out proper geospatial planning, identify appropriate locations for special economic zones and address land-use policies. In 1980, a year after the commissioning of Shenzhen as a special economic zone, the Shenzhen Real Estate Corporation was established to address land issues and commercialization (Zeng, 2010, p. 67). The corporation helped address housing challenges in the city through gentrification, promoted the commercialization of properties through market forces, and managed access to construction capital.

As of 1980, Shenzhen was a small town of less than a square kilometre. Its economic and telecommunication foundation was rudimentary. Bhardwaj (1992) estimates that the town had 200 small enterprises and an output of less than 60 million Yuan. However, by 1985, the city had constructed infrastructural enablers such as roads, housing, telecommunication, drainage systems, and electric connectivity. As a result of expediting the infrastructural development, the city, including three other special economic zones, Zhuhai, Xiamen, and Shantou, commissioned in 1979, attracted 1,655 foreign investment firms and investments worth \$1.17 billion (Bhardwaj, 1992, p. 359). In Africa, delayed construction of ancillary infrastructural development such as electricity, communication, drainage, and roads in record time, causes these special economic zones to miss foreign investment. As the delay continues, it makes these projects less competitive.

In the mid-1985, Shenzhen received criticisms for lacking a strong industrial base, over-reliance on the export market, and ignoring the domestic market (Bhardwaj, 1992, p. 362). The discovery criticism

was a milestone as it helped Shenzhen take stock of its achievements and failures, which African governments hardly take seriously. There is a rigidity to criticism and less reliance on scientific and data-driven strategies. Politicians opt for political expediency when establishing special economic zones, which are sometimes less competitive. Therefore, based on the evaluation made in 1985, Shenzhen reviewed its macro-economic perspective and export-oriented business. Besides, there were reforms in the investment and financial system, culminating in the establishment of the Shenzhen Foreign Exchange Centre to aid in the allocation of foreign exchange, unification of income tax as part of macro-economic reforms to help the city move towards a market economy from a planned economy (Zeng, 2010, p. 68). Contextually, for Africa to succeed in the special economic zones, it must reform the financial systems to attract investment and become more inclusive even for small and medium enterprises to support industrial clusters and medium enterprises intending to invest in the economic zones.

Further, the government's pragmatism in the success of special economic has immense impetus. The success of many Chinese special economic zones is steeped in the government's active participation. Shenzhen, for instance, was the first city in China to adopt the slogan "24 hours approval" for all government services sought by investors during the social experiment. The results were magical. In Africa, bureaucracy and delays in government approvals are rampant. Building and constructions approvals, business permit applications, licenses, and other statutory requirements take ages for approval. Shenzhen began by setting up a civil service system for the economic zones, removing administrative layers, privatization, and price reforms to foster competition. These reforms created an ecosystem of efficiency and government-supported initiatives.

### **Reverse Engineering**

In the discussion above, the concept of innovation appears contextually as a quintessential milestone for industrial growth. However, Africa has fewer known unique innovations to trigger an industrial revolution. Other than MPESA, a Kenyan innovation for mobile money transfer, which has

transformed financial inclusion and created millions of jobs, there is no other quirky innovation known to me that Africa can position globally. The question then is how can Africa hasten innovation and be at par with the rest of the world? The solution lies in reverse engineering without necessarily following the path of imitation and counterfeiting allegedly used by manufacturers in Shenzhen and other Chinese firms.

Right off the bat, readers should not construe reverse engineering advocated in this material as an express approval of counterfeiting, imitation, copying, or violation of trademarks and patents. The author does not promote or condone any form of abuse of copyrights and intellectual property rights. Imitation of products, copying, counterfeiting, and violation of trademarks and intellectual property rights have known consequences as documented in the original works of Grossman and Shapiro (1986), Hensey and Gwee (2016), and Lee et al. (2017). These vices can lead to unfair business competition in contravention of anti-trust laws, endanger the safety of consumers, trigger low economic growth and destroy the reputation and competitiveness of a company's products.

The reverse engineering model adopted and popularized in this work borrows acumen from The Society of Manufacturing Engineers (SME), as Kumar et al. (2013) explain. Kumar et al. stated that reverse engineering embodies "starting with a finished product or process and working backward in a logical fashion to discover the underlying new technology (p. 665)." A pedestrian deconstruction of reverse engineering based on the SME's definition would be a potential manufacturer looking at a finished wooden table from another company and imitating/copying to recreate their own. However, in complex terms, a method that finds predilection from the author's perspective is looking at a table, and instead of copying or imitating, the potential manufacturer would change the process or upgrade to make a better table through a cost-effective process within existing copyright doctrines.

Africa will not be the first continent to pursue the route of reverse engineering to innovation and industrialization. It is a route that all latecomers in industrialization and innovation have taken to catch

up with the industrialized countries. In the 1950s and 60s, Japan relied heavily on reverse engineering to technologically catch up with the West. After catching up, companies such as Hitachi and Sharp, who originally relied on reverse engineering, began experimenting with original ideas through product development and heavy investment in research and development (R&D) (Butticè et al., 2020: 2). Kidanemariam (2014) pointed out that Japan became the first non-western country to receive, modify and innovate American technologies in the 19<sup>th</sup> Century (p. 6). The Japanese *Kaizen* philosophy, *Kai* means change and *Zen* for the best, seems to have inspired Japanese reverse engineering, which eventually led to the birth of better ideas and products. In Japan, reverse engineering is unlawful (Mishra, 2004). South Korea pursued a similar path to industrialization through the Chaebols system. Chaebols are business conglomerates owned as family enterprises. The success of Japan and South Korea in using reverse engineering to catch up with the West makes scholars consider the technique as a design process, primarily based on the ease to which Computer-Aided Design delivers results (Nathan & Sarkar, 2014, p. 8).

The success of India's pharmaceutical industry in manufacturing generic drugs is borne out of reverse engineering. Before India joined the World Trade Organization (WTO), Indian Pharmaceutical companies with technical expertise used the loophole of non-patented processes to reverse engineer the manufacturing of drugs. They produced a generic drug by changing the process (Nathan & Sarkar, 2014, p. 9). For example, through the use of computer models and simulations, Indian pharmaceutical companies reverse engineered the drug used to treat myeloid leukaemia and ended up producing a cheaper product. The drug initially cost about \$13. After reverse engineering, the generic's price plummeted to about \$1.2 (Nathan & Sarkar, 2014, p. 9). Usually, patented products are expensive, and reverse engineering could benefit consumers through reduced prices, especially in low-income countries in Sub-Saharan Africa.

At the height of the pandemic, there were calls by the international community for vaccine manufacturers to lift patents on vaccine manufacturing. Should vaccines manufacturers



heed the calls, unpatented vaccines will provide an opportunity for African nations such as Kenya and Uganda to start manufacturing vaccines through reverse engineering and build capacity for sustainable production of other related drugs. For Nathan and Sarkar (2014), reverse engineering is not necessarily the business of copying ideas or imitation. It may result in cost reduction, as demonstrated by the case of India's generic drugs.

In the West and the East today, imitation and copying of original ideas were the hallmarks of learning and innovation (Corniani, 2012, p. 38). The Phoenix Technologies company in the 1980s reverse-engineered the IBM BIOS program using an approach dubbed the cleanroom or Chinese wall. They invited a group of software engineers who examined IBM's source code of about 8kb and described its functionality without referring to the original code or taking notes. A second team came onboard without a prior understanding of the IBM's BIOS code (Schwartz, 2001). The functionalities were explained to them, and they were asked to write a new code. This was the cleanroom or Chinese wall approach. The end result was a code that operated the same as the original, and in some instances, there were identical codes. Interestingly, Phoenix did not infringe any copyright laws. The sale of the new code by Phoenix led to the development of personal computers with IBM's BIOS (Schwartz, 2001).

The notoriety of Shenzhen in using reverse engineering, imitation, and copying to grow its industrial base is now an open secret. However, companies and manufacturers can transcend from copying and marginal imitation to the path of innovation. Huawei, which is one of the tech giants with its headquarters in Shenzhen, multiplied its customer base and profits by imitating Apple and Sony Xperia products (Wiens, 2016). From a longstanding history of copying and imitation, the Chinese company, including many others, is now investing heavily in R&D to chart an independent path of innovation. Osawa and Schechner (2016) reported that Huawei had outspent Samsung and Apple in R&D by a margin of a billion dollars in 2016. In 2020, Huawei overtook Samsung to become the leading smartphone seller globally (Kirton, 2020). Huawei's case mirrors many other Shenzhen companies that began their

manufacturing journey through reverse engineering, imitation, and copying and have become innovative giants competing in the global market. Besides, Unicorns such as Megvii, Tencent, Alibaba, and Alipay are tech giants using the infrastructure in Shenzhen to grow their enterprise. The cases illustrated above demonstrate limitless possibilities of reverse engineering. Africa can follow the path taken by Japan, South Korea, or even Shenzhen to reverse engineer, innovate African solutions and upgrade its way to the fourth industrial revolution.

## CONCLUSION

The fourth industrial revolution is going to take place in the African continent. It shall embody ubiquitous connectivity between humans and machines, opening Africa for mass markets and technological innovation to unlock economic growth potential for the continent and the rest of the world. Unfortunately, Africa bears certain existential risks that may prevent it from harnessing the full potential of the fourth industrial revolution, such as technical skill gaps, insufficient infrastructure to support innovation, poor governance, and lack of consolidated efforts to spearhead the process. Invariably, Shenzhen, otherwise regarded as the world factory, provides meaningful lessons for Africa as it prepares to usher in the Fourth Industrial revolution. Firstly, the Chinese government premeditatedly established special economic zones in Shenzhen in the late 1970s, aiming to spur innovation and lift millions of poor rural folks out of poverty. Such deliberate efforts four decades later have made Shenzhen a leading innovation hub globally. Similar models of special economic zones and industrial clusters can hasten Africa's technological innovation, manufacturing capability, and open hinterland for the internet of things connectivity. The second lesson that Africa can draw from Shenzhen is the power of reverse engineering in kick-starting innovation. Manufacturing giants such as Japan, the United States, South Korea, and lately Shenzhen followed a similar model of reverse engineering to build manufacturing hubs and established pathways for research and development and innovative ideas. Many African states that are members of the World Trade Organization can take advantage of unpatented innovations, especially in pharmaceutical, technology, and open-source

artificial intelligence technologies, to undertake reverse engineering to build manufacturing capacity. These lessons are not keystrokes for industrialization. They do not eschew the responsibility of governments to take methodical, deliberate, and coordinated efforts to establish the foundations for industrialization. Else, Africa will miss the Fourth Industrial Revolution opportunities post-Covid period.

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