



Access to Emerging Technologies and Techniques in the Nigerian Solid Minerals Sector: A Cost-Benefit Analysis

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ABSTRACT

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As the global population increases, the scale and impacts of mining have increased exponentially, and there are emerging trends when considering the sector's future. Therefore, countries are transcending to modern forms of technology to achieve scale economies, decarbonisation, mine health and safety and environmental sustainability through leveraging on Automation, Big Data Analytics, Digital Innovations, and Artificial Intelligence. These innovations have human, social and economic impacts, which can negatively and positively affect the principle of shared value. These complex interdependencies are reshaping the industry on a global scale, and for Nigeria to leverage her mining sector and expand to regional and global value chains, there is a need to scale up access to modern forms of technologies and techniques through linkage optimization, research and development, national and sectoral policies, government intervention, sustainable practices which will ultimately lead to resource-based industrialization. While abundant literature exists on the emergence of technologies in the solid minerals sector, this study, using a desktop and library-based analytical review, finds a dearth of research on the cost-benefit analysis of emerging technologies in the Nigerian mining landscape. This will ensure that technological disruptions are a win-win for communities and stakeholders to drive growth and global competitiveness for the sector. Therefore, Nigeria's mining laws and policies must be reformed to adapt to these trends and interdependencies.

KEYWORDS:

Mining, Technology, Sustainable Development, Shared Value, Resource Based Industrialization, Value Addition, linkage, African Mining Vision, Mining Law and Policy

I. INTRODUCTION

Solid Minerals has been pivotal to human development and the utilization of resources from this sector has been integral to global progress. However, the history of mining also highlights a pattern where the exploitation of mineral reserves has often disregarded sustainable practices, leading to significant environmental and human impacts.

As populations grow and development surges, there's an escalating demand for mineral resources. This surge often intensifies the pressure on extracting these resources without due consideration for sustainable practices. Consequently, the environment bears the brunt of these mining activities. To address this, mining industries are steering towards responsible and advanced practices and a countries nascent stage of mining development is not

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excusable. The industry the world over is evolving through integration of cutting-edge technologies and techniques that not only drive efficiency but also prioritize ecological preservation and worker safety.

The configuration of Nigeria's economy is categorized as that of an underdeveloped nation.¹ The primary sector, notably the oil and gas industry, holds significant sway over the GDP, contributing to over 95 percent of export earnings and approximately 85 percent of government revenue.² On the other hand manufacturing contribution to GDP fell to 10.13% in 2023 from 10.20% in the corresponding period of 2022.³ This industry constitutes

¹. L.N. Chete, J.O. Adeoti, F.M, Adeyinka and O. Ogundele., 'Industrial Development Growth in Nigeria: Lessons and Challenges' (Africa Growth Initiative at Brookings) Available at https://www.brookings.edu/wp-content/uploads/2016/07/12c_wp8_chete-et-al-1.pdf> Accessed 7th February 2024.

². *Id.*

³. See Manufacturing Contribution to GDP falls to 10.13% - Report (*The Punch Online*, 26th May

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oil, refining, cement, food, beverages, tobacco, textile, apparel and footwear.⁴ Challenges such as a lack of foreign exchange, rising energy costs, and hindered sectoral growth have stunted the sectors growth. Hence, development theorists have opined that industrialization is an integral part of the development process.⁵ Consequently, the need to redefine import substitution strategies to promote industrialization and self-sufficiency. Adler opines that:

the “process of import substitution will encompass a complex process of *technological learning* that encompass product specification and design, process choice and change and the social organization of production”.⁶ (emphasis mine)

Access to modern mining technology in developing countries such as Nigeria stands as a pivotal factor in promoting sustainable and responsible mining practices as well as socio-economic development. The absence of these advancements often results in the utilization of outdated and environmentally detrimental methods, undermining both ecological balance and the well-being of those involved in mining operations. At the same time, when considering Nigeria’s mining landscape, where Artisanal and Small-Scale Mining (ASM/SSM) has a growing influence, the problem is not over exploitation but under exploitation of reserves due to the lack of requisite technologies to access geological data and the deployment of technologies and techniques for sustainable exploitation of minerals and metals. Therefore, a careful consideration is vital in ensuring that the deployment of technologies to extract high value minerals are not disruptive but are a win-win and do not undermine the basic principle of shared value.

Nigeria continues to grapple with several classic dependency syndromes.⁷ Essentially, it serves as both a

supplier of raw materials and a consumer market for the advanced, high-tech products of developed nations.⁸ This dynamic is rooted in various factors, including an inadequate educational system, underdevelopment in Science, Technology, Engineering, and Mathematics (STEM), limited access to capital, a lack of managerial expertise, and heavy reliance on external sources for technology, notably from Multinational Corporations (MNCs). These factors collectively contribute to a persistent imbalance of trade for the country. Hence solutions cannot occur until dependencies are perceived and identified.

On the other hand, the bargaining theory, rooted in economics and game theory, posits that reliance on foreign capital and technology can eventually be overcome.⁹ In this scenario, developing nations can accrue learning experiences, gaining access to bargaining power previously monopolized by MNCs. However, despite its accuracy, the bargaining theory faces limitations. This arises because, MNCs bring advanced technologies and expertise to host countries, which can catalyze economic development and innovation. Nonetheless, this may foster a dependence on foreign technology and knowledge, constraining local industries' ability to compete globally and potentially impeding long-term economic autonomy. For example, MNCs often extract natural resources from developing nations, such as oil and minerals, creating a situation where the host country relies heavily on them for revenue generation while MNCs retain control over resources and profits. Such dependencies can yield limited benefits for workers in host countries, such as the rethinking job tasks and terms governing employment.¹⁰ These intricate and complex interdependencies underscore the intertwined nature of economic interests, social justice, and political stability.

This article aims to formulate strategic legal and policy measures to enhance access, deployment, and eventual domestic technological progress in the mining sector. The article also acknowledges the intricate interconnections arising from the imperative of the

2023) Available at <https://punchng.com/manufacturing-contribution-to-gdp-falls-to-10-13-report/> Accessed 24th February 2024.

⁴ . *Id.*

⁵ . See Lynn Kreiger Mytelka, ‘The Unfulfilled Promise of Africa’s Industrialization’ [1989]32(3) African Studies Review. Pp 77-137.

⁶ . *Id.*

⁷ . The literature on dependency draws from classical Marxist theory concerning the development of nations and the evolving role of capitalism. Consequently, developing countries find themselves subject to the influence of politics, institutions, and economies wielded by more developed nations, effectively placing them under the control of wealthier and more dominant

countries. See Todaro M.P, *Economic Development* (New York, Long Man 2000)

⁸ . Chase, D.C., *Dependency Theory* (International Encyclopedia of the Social and Behavioural Sciences, 2nd Edition, 2015) p. 196-198

⁹ . See Theodore Moran, *Multinational Corporations and the Politics of dependence: Copper in Chile* (Princeton, Princeton University Press, 1977) Cited in Emmanuel Adler, *Ideological Guerrillas and the Quest for Technological Autonomy: Brazil’s Domestic Computer Industry*. [1986]40(3) International Organization pp. 674.

¹⁰ . Nicholas A. Ashford and Christine Ayers. ‘Changes and Opportunities in the Environment for Technological Bargaining’, {1987} 62(5) Notre Dame Law Review.

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government to pursue resource extraction. Importantly, these measures should prioritize safeguarding the interests of the ASM/SSM operators through a comprehensive cost-benefit analysis, while simultaneously encouraging technological innovations that support sustainable mining practices, upholds ethical standards, inclusion and improves efficiencies to avoid a race to the bottom.

The article is divided into seven sections. The introductory section highlights the existing gaps in the topic under review. Next, the methodology is discussed, followed by a general overview of the Nigerian Minerals and Mining Sector in the third section. The fourth section explores a cost-benefit analysis, with a focus on expanding the principle of shared value. In the fifth section, a roadmap is developed for accessing mining technology and techniques, along with strategies to achieve self-sufficiency. The sixth section presents the findings, while the final chapter summarizes and concludes.

II. METHODOLOGY

This study will employ a desktop and library-based analytical review approach to explore the cost-benefit analysis of emerging technologies in Nigeria's mining sector. The methodology is designed to gather, analyze, and synthesize existing literature, laws and policies on technological advancements in the mining industry. Hence, a policy gap analysis to analyze existing mining laws/policies and the requirements of emerging technologies for small scale miners. This will involve identifying areas where reforms are needed to support the integration of new technologies.

The analysis will be specific to Nigeria and focus on the solid mineral sector but will draw on specific global examples for comparison. The goal is to provide a roadmap for Nigeria to effectively integrate modern technologies into its mining sector, fostering sustainable growth and global competitiveness.

III. THE NIGERIAN MINERAL AND MINING SECTOR – AN OVERVIEW

a. Mineral Deposits

The Nigerian mining sector boasts a notable geographical dispersion of solid minerals across the nation's six geopolitical zones. This extensive array encompasses 44 distinct mineral variants, distributed across more than 500 locations spanning the 36 States and the Federal Capital Territory.¹¹ Categorically, these minerals manifest in classifications of high value, development, energy, and energy transition minerals. These can further be categorized into groups such as metallic ore minerals (gold tin, copper). Industrial minerals (like barite and Kaolin) construction

minerals (like granite, laterite and sand) energy minerals (coal, lithium, lignite) and precious stones (sapphire and tourmaline). Central to the strategic objectives aimed at harnessing the sector's vast potential are seven identified minerals deemed pivotal by the Ministry and Mines. These are coal, iron ore, bitumen, gold, limestone, lead-zinc, and barite to constitute the critical cohort.¹² Additionally, certain minerals such as lithium, titanium, tungsten, and cobalt have received designation as essential elements pertinent to industries including aerospace, telecommunications, and the burgeoning electric vehicle manufacturing sector.¹³ The economic significance of these minerals as substantial contributors to export revenue underscores the pressing necessity for a well-defined policy trajectory delineating optimal methods for the extraction and utilization of these reserves.

b. The Nigerian Mining Landscape

In Nigeria, the wealth of mineral resources spread across its geopolitical zones holds tremendous potential. Yet, this potential remains largely untapped due to significant hurdles in the way these resources are exploited. The primary challenges stem from both insufficient technology for extraction and the resultant underuse or disorderly exploitation of these resources. The Nigerian Economic Summit Group (NESG) has highlighted several key issues within the mining sector. Of relevance to this discourse, include” insufficient skilled labor”, “lack of comprehensive skills development initiatives, educational and vocational training strategies”, and “insufficient support programs for ASM operators to enhance their financial and technical capabilities”.¹⁴ Additionally, the lack of essential geological and financially viable data, necessary for attracting significant investments, is hindering the de-risking of investments. Consequently, without comprehensive and reliable information, potential investors will remain hesitant. Finally, the dominance of the informal sector, poses regulatory, safety, and environmental challenges. These challenges collectively weaken the mining sector's potential for growth and development

ASM confronts significant challenges related to suboptimal productivity, adversely affecting the availability of minerals in terms of both quantity and quality for diverse industrial applications. For instance, the production of Barite,¹⁵ fails to meet the substantial demands of the nation's

¹¹ . See ‘Seven Strategic Minerals Identified to Unlock Mining Sector’ (MinDiver, News. June 2020) pp. 6.

¹² . See Nigeria’s Mining Sector Governance Landscape and Prospects: A Diagnostic Report. (Nigerian Economic Summit Group, NESG) pp.52.

¹³ , MinDiver (n 11).

¹⁴ . NESG (n 12) pp 25.

¹⁵ . Barite is an industrial mineral composed of barium sulphate (BaSO₄) that finds extensive use in the oil and gas industry as a weighting agent in drilling fluids. It helps control pressure and prevent blowouts during drilling operations. Additionally,

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oil sector, consequently necessitating extensive mineral imports, thereby impeding the nation's aspiration to bolster the solid minerals' pivotal role in the Gross Domestic Product (GDP). In contemporary mining operations, automation, digitization, and Artificial Intelligence (AI) have become indispensable components, demanding a workforce with specialized skills that are frequently challenging to recruit. Consequently, two interconnected challenges emerge within this context. Firstly, there is a pressing need to formulate inclusive policies that facilitate the integration of individuals with diverse abilities, thereby fostering employment opportunities. Secondly, governmental intervention is essential to foster domestic technological advancements and capacities through national and sector-specific policies. This imperative arises from the necessity to create employment, ensure social and human security, and achieve the ambitious goal of generating 3 million jobs in the mining sector by 2025.¹⁶ Additionally, this measure will contribute to the achievement of Sustainable Development Goals 1, 8, and 10, which aim to eradicate poverty, promote decent work and economic growth, and reduce inequalities, respectively.

Given the prevailing uncertainties within the oil sector, the imperative to champion research, technological advancements, and innovation emerges as pivotal for transitioning the economy from a reliance on imports towards fostering local production of goods and services. However, the implementation of judicious strategies and the adoption of technologies emphasizing sustainability hold the promise of elevating mining's contribution to as much as 30% of the GDP.

Nasarawa State which lies in the central zone of Nigeria is known as the home of solid minerals arising from the vast deposits of mineral resources in the 13 local government areas. Some of the minerals include Barite, Coal, Clay, Lead-Zinc, Sault, Gemstone, Silica Sand, Iron Ore, Granite, Tantalite Marble, Mica, Cassiterite, Limestone,

it's utilized in the manufacturing of paints, rubber, plastics, and as a filler in textiles, paper, and ceramics due to its inertness and high density. In the medical field, barite is used as a contrast medium for X-ray imaging of the digestive system. Its high density makes it suitable for highlighting certain areas within the body for clearer imaging. Overall, its properties make barite a valuable mineral in several industries, contributing significantly to various applications. It is found in commercial quantities in Cross River State, Benue Nasarawa, Plateau, Taraba, Adamawa, Zamfara and Gombe

¹⁶ . RoadMap for the Growth and Development of the Nigerian Mining industry: On the Road to Shared Mining Prosperity, 2016 (Ministry of Mines and Steel Development)

Aquamarine¹⁷ and Lithium. Lithium which is considered one of the most attractive and most expensive minerals is being traded in the world today and as at 2022, costs about £61,000 per ton.¹⁸ Lithium is a highly valuable, toxic and reactive metal used in energy dense rechargeable batteries used in cell phones, electric vehicles and grid storage. It is also used for heart pacemakers, toys, laptops, digital cameras, clocks and in some cases used as a drug to cure clinical depression in the form of lithium carbonate.¹⁹ Thus, by world bank projections the demand could increase by roughly 500 per cent by 2050.²⁰ High grade Lithium is currently mined in Nasarawa, Kogi, Kwara, Ekiti and Cross River States.²¹

Lithium extraction does come with its own set of challenges. First, it involves water-intensive processes, potentially impacting local water supplies and ecosystems, requires significant energy inputs and large amount of land.²² International best practices dictate that regulations should be in place for operators to treat wastewater containing valuable ions, making it suitable for reuse.²³ Additionally, there is a necessity for the development of technologies aimed at reducing energy costs, consumption, and emissions in wastewater treatment processes. Secondly, lithium, akin to other resources like the illicit gold plundering in the Zamfara State region of Northwestern Nigeria, has the capacity to exacerbate conflicts and

¹⁷ . See Nasarawa State, (Nigerian Investment Promotion Commission) Available at <https://www.nipc.gov.ng/nigeria-states/nassarawa-state/#:~:text=Solid%20minerals%3A%20Barite%2C%20Coal%2C.%2C%20Cassiterite%2C%20Limestone%2C%20Aquamarine.>> Assessed 13th February 2024.

¹⁸ . Lithium Reserves, The New Investment Bride Reshaping Nasarawa's Economy. Available at <https://leadership.ng/lithium-reserves-the-new-investment-bride-reshaping-nasarawas-economy/>> Accessed 3rd January 2024.

¹⁹ . Lithium (The Royal Society of Chemistry) Available at <https://www.rsc.org/periodic-table/element/3/lithium#:~:text=The%20most%20important%20use%20of,heart%20pacemakers%2C%20toys%20and%20clocks> Assessed 13th February 2024.

²⁰ . See "Nigeria taps into global Lithium market" Available at <67135006#:~:text=Lithium%20is%20currently%20mined%20in,Ekiti%2C%20and%20Cross%20River%20States> Accessed 13th February 2024.

²¹ . *Id.*

²² . See Energy Recovery for Lithium and Lithium-ion industries. Available at <https://energyrecovery.com/lithium/#:~:text=Lithium%20extraction%20often%20relies%20on,is%20a%20energy%20intensive%20process> Accessed 24th February 2024.

²³ . *Id.*

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contribute to violence.²⁴ This underscores the multifaceted importance of a policy, not solely as a measure of national security to curb illegal export of solid minerals, but also as a means to uphold the sustainability of this mineral resource, foster environmental preservation, and promote ethical trade practices within the industry.²⁵ Furthermore, the inexorable surge of numerous mining corporations in pursuit of substantial and economically viable quantities of lithium holds the inherent prospect of marginalizing indigenous participants from engaging in this profitable enterprise.²⁶ Consequently, there exists an imperative for the implementation of inclusive policies designed to equip small scale operators to effectively participate and harness these reserves, while concurrently prioritizing sustainable exploitation. Failure to do so, will result in a race to the bottom, with the depletion of these invaluable resources, using unscrupulous extraction techniques by miners with few resources, thereby burdening host communities with the adverse consequences thereof.

c. Artisanal and Small-Scale Mining.

Ninety percent of mining activities in Nigeria are carried out by ASM.²⁷ This is perhaps why the government created the department for ASM in the Ministry of Solid Minerals to take over oversight and regulation, though the department is not established under the Nigerian Minerals and Mining Act,

2007.²⁸ ASM is greatly misunderstood and that is why in many cases operators are referred to as ‘illegal miners.’²⁹ With a large country like Nigeria with vast deposits, it has driven the low - income earners to mining as a form of ‘survival’, regardless of the hazards associated with the practice. However, ASM is hindered by many issues, these are (i) weak implementation and enforcement of Mining laws, (ii) limited awareness of environmental health and safety issues (iii) host community conflicts (iv) poor infrastructure and; (v) lack of access to technology and financing. More often than not, these operations are done haphazardly with severe consequences to the environment, the surrounding and even distant communities and the miners themselves. The problem is that most mining initiatives have been isolated and do not reverse the poverty cycle that inhibit the formalization process. There is limited evidence of any participatory integrated approach that aim to promote and develop the ASM sector through putting clear cut policies, strategies and an implementation plan.

Inclusiveness and formalization remain a major constraint, regardless of governments reforms over the years. For instance, mining titles are held by speculators, consisting of the wealthy and influential that can easily obtain licenses. The governments introduced the formation of mines cooperatives to enable groups of miners to have the capacity and capability to obtain licenses and formalize their

²⁴ . See “How illegal Gold Mining Fuels Violent Crimes in Zamfara – ICPC”. Available at <s://www.premiumtimesng.com/news/top-news/493226-how-illegal-gold-mining-fuels-violent-crimes-in-zamfara-icpc.html>> Accessed 3rd January 2023. This narrative also extends to the Niger Delta, Democratic Republic of Congo (DRC), Sierra Leone, Liberia and Angola, where valuable resources has become instruments of conflictts

²⁵ . See Charles Asiegbu., ‘Lithium Could Fuel the next Conflict in Nigeria’. Available at <https://blogs.lse.ac.uk/africaatlse/2023/08/24/lithium-could-fuel-the-next-conflict-in-nigeria/>> Accessed 3rd January 2023.

²⁶ . The construction of a \$250million lithium factory in Nasarawa State was inaugurated in 2023 by the President of the Federal Republic of Nigeria. The Ganfeng Lithium Industry Factory is located in the Endo Community of Udege Development Area. The factory is scheduled to process 18,000 metric tons of lithium per day and 4.5 million metric tons annually. The project has a total duration of 24 months. See “Tinubu lay foundation for \$250m Lithium factory in Nasarawa” (The Vanguard, Online, 12 October 2023) Available at <https://www.vanguardngr.com/2023/10/tinubu-lays-foundation-for-250m-lithium-factory-in-nasarawa/> Accessed 4th January 2023.

²⁷ . NESG (n 12) pp.40.

²⁸ . There is currently a Bill before the National Assembly titled the Nigerian Minerals and Mining (Amendment) Bill 2023 that seeks to give the ASM sector statutory backing.

²⁹ . There is currently no definition of artisanal and small- scale mining. There is an apparent lack of consensus and varies from country to country. Nigerian Minerals and Mining Act, 2007 defines ‘*Small Scale Mining*’ as *Artisanal, Alluvial, and other forms of Mining operations involving the use of low-level technology or application of methods not requiring substantial expenditures for the Conduct of Mining operations within a small scale*. See s. 164. “The World Bank defines ASM “as a type of manual, low technology mining conducted on a small scale, predominantly, in rural areas of the developing world” In comparism, Ghana defines it based on “Capital Investment and ‘Number of Participants”, whilst South Africa defines based on “Capital Investments”. In general, ASM/SSM is labour intensive, with low levels of capital investment and production capacity, but with room for potential to transform from purely manual artisanal activities to more advanced operations that apply mechanical equipment and basic technology, employing basic mining and processing technology such as mechanized drilling and water pumping, blasting, mechanical hoisting, milling with gravity concentrate and other similar techniques.

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operations, but the law has not had any appreciable effect.³⁰ Establishing an efficient legal framework in isolation proves insufficient for eradicating the informal sector unless accompanied by bolstered financial capacities for miners and heightened awareness of their legal obligations. Likewise, enacting regulations aimed at advancing health, safety, and environmental standards lacks efficacy without concurrent improvements in accessing technology, financial resources, information dissemination, and support services.³¹ Moreover, the effectiveness of these measures hinges on broader considerations, including the governmental capability, both in terms of human resources and technical expertise, to effectively support and enforce these regulations in a sustainable manner.

Overall, ASM/SSM typically requires a lot of manual work, involves minimal capital investment and limited production capability. However, there's potential for it to evolve from traditional manual artisanal methods to more sophisticated operations utilizing machinery and fundamental technology. This transition would involve using basic mining and processing technology like mechanized drilling, water pumping, mechanical blasting, hoisting, and gravity-based milling for concentrate, among other comparable techniques. In summary, there is need for a deeper understanding of the ASM to develop sustainable frameworks and strategies.

d. Governance Challenges

The Nigerian mining sector faces substantial impediments attributed to deficient regulatory, policy, and institutional capabilities, pervasive corruption throughout the mining value chain, covert operations, security concerns, investor apathy, limited integration of mining sector gains into comprehensive development initiatives, tax irregularities, infrastructural deficiencies, inadequate coordination among governmental tiers (Federal, State, and Local), and inter-agency rivalries. Other emerging threats include “quick revenue versus long term addition”, “brain drain” and “human capacity”.³² During the timeframe spanning from 2018 to 2022, the sector's contribution to the GDP was only

0.17%.³³ It is pivotal to underscore that Nigeria's historical narrative is marked by a series of conflicts pertaining to natural resources, exacerbated by disputes surrounding resource accessibility, control, management and governance, alongside the disproportionate allocation of benefits derived from these resources. A good example is the lethal conflict between Enugu-Otu Aguleri in Anambra East Local Government Area of Anambra State and Ashonwo/Odeke in Ibaji Local Government Council of Kogi State over oil-rich boundary lands.³⁴ This further elucidates the enduring concept known as the “resource curse.” Consequently, the realization of optimal returns from this sector is markedly hindered by the government's approach to addressing risks and inefficiencies.

Essentially, the crux lies in the criticality of capacity enhancement and adaptive measures essential for harnessing the objectives outlined in the African Mining Vision (AMV) to establish a robust mineral supply chain. However, the pace at which the government is addressing these issues has significantly impeded the productivity and overall performance of the mining sector.

IV. COST - BENEFIT ANALYSIS: TOWARDS A BROADER PERSPECTIVE OF THE ‘SHARED VALUE’ PRINCIPLE

In the realm of mining, “shared value” denotes the creation of economic worth for the company alongside fostering benefits for the surrounding communities, environment, and impacted stakeholders. This concept strives to guarantee that nations abundant in resources receive optimal advantages from resource extraction, while also allowing the private sector a valid opportunity to profit from these resources responsibly. It involves issues of local procurement of goods and services, local employment and content, downstream uses of natural resources beneficiation and value addition.³⁵

The emergence of shared value is particularly pertinent within the context of developing nations, wherein the imperatives of poverty alleviation, social advancement, and environmental sustainability stand as paramount developmental challenges. This paradigm underscores the

³⁰ . Section 49(b) Nigerian Minerals and Mining Act, NMMA 2007

³¹ . Section 34 and 91 of the NMMA outline the creation of the Solid Minerals Development Fund (SMDF), which aims to support small-scale and artisanal mining operators. The fund is dedicated to providing essential services, including training in mining techniques and facilitating the adoption of new mining technologies to enhance their skills and efficiency. The organization has not yet reached full operational capacity.

³² . See “PWC Decries Neglect of Mining Sector” (The Punch Online, 12TH August 2023) Available at <https://punchng.com/pwc-decries-neglect-of-mining-sector/> Accessed 13th February 2024.

³³ . Nigerian Mining- Progress, But Still a Long Way to go. (PwC Global Mines Report 2023, Nigeria Minerals and Mining Act, PwC Analysis). pp 3.

³⁴ . See “7 feared dead, 52 houses torched as Anambra, Kogi Communities fight over oil wells” Available at <https://www.vanguardngr.com/2013/04/7-feared-dead-52-houses-torched-as-anambra-kogi-communities-fight-over-oil-wells/>> Assessed 14th February 2024.

³⁵ . Mining a Mirage? Reassessing the Shared Value Paradigm in light of the technological advances in the Mining Sector. (1st September, 2016) Available at <https://www.jstor.org/stable/resrep14796.5?seq=1>> Accessed 5th January 2023.

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intrinsic interdependence between economic progress, societal well-being and advocating for strategies that concurrently generate economic value for businesses. In the specific milieu of developing economies, the shared value framework assumes heightened significance by advocating for innovative approaches that not only foster economic growth but also contribute substantively to the amelioration of social disparities and preservation of environmental integrity. This approach, when integrated into business strategies and policy formulations, holds the potential to yield enduring positive impacts by aligning commercial interests with broader societal aspirations, thereby fostering sustainable and inclusive development.

Within the sphere of technological advancement in the mining sector, it becomes evident that the integration of novel technologies and techniques has the potential to significantly alter the role of mining personnel, shifting their engagement from active agents to passive service providers. The introduction of automation stands poised to curtail the workforce demand despite anticipated growth within the mining industry. This transformation poses the risk of diminishing job creation opportunities that would otherwise accompany the envisioned expansion of the sector. Therefore, whilst technology has its benefits it can be evidently disruptive to developing industries.

Nigeria possesses extensive reserves across its six geopolitical zones, promising a robust mining sector. However, the predominant participants are the ASM/SSM which are largely underserved despite constituting the majority of operations. The government's focus remains on extracting high-value minerals by foreign and domestic large investors which appears to overshadow its support for ASM/SSM, potentially leading to a crowding out and neglect. For instance, metals such as Lithium demands advanced technologies and techniques beyond the capabilities of indigenous miners. Without the required technological capabilities, there's a high chance that ASM/SSM might struggle or resort to crude methods that harm the environment in order to participate in a highly lucrative endeavour, thus creating a clandestine market that deprives the government of royalties.³⁶ Consequently, focusing mainly on large domestic/foreign major companies could limit the chances of fostering shared value that bolsters local resources and capacities. It is not just about foreign investors transferring or deploying their technology, extracting high value minerals, generating revenue, addressing community and environmental concerns, but more crucial, the government's ability to actively prioritize the development of local expertise and resources through the

formulation of policies to develop these critical minerals. Therefore, I broaden the scope of 'shared value' by emphasizing the active involvement of the government in developing the domestic exploration industry and junior miners as an imperative. Thus, there exists the potential for multiplier effects—an economic phenomenon resulting from policies implementing access to technological advancements to local participants throughout the entire mining value chain by focusing on low value and development minerals that have a local demand to meet the SDG goals. These would include Iron Ore, Limestone, Lead/Zinc. Bitumen, Baryte and Gold. This would ensure that the abundance of mineral reserves would have an impact on our economy which is in line with the African Mining Vision which advocates integrating mining into development policies at local, national and regional levels. Hence, moving from exporter of cheap raw materials to manufacturer and supplier of Knowledge based services. Hence ensuring indigenous direct participation as opposed to the reliance on the collection of royalties only.

Nigeria must adopt a diverse and pragmatic range of policy measures within its mining sector to fulfill various goals of economic and social progress. These should revolve around a strategy of state-driven industrialization and the nurturing of domestic human capital. Prioritizing the early development of local talent over depending solely on foreign entities for resource extraction is crucial. This approach will empower Nigeria to compete effectively with more affluent and technologically superior rivals, despite being a developing nation in the early phases of solid minerals exploration. For Nigeria to safeguard its industrialization journey from being overshadowed, it must consciously make strategic ideological choices. This involves implementing policies that foster national technological advancement and industrial capacity. Emphasizing sector-specific investment in human capital will be pivotal in promoting lasting economic sustainability. However, an industrial base and the stocks of human capital are not an end, public policy must be simultaneously involved to solve crucial coordination problems.

In comparison, upon its inception in 1954, Brazil's Petrobras encountered formidable challenges, lacking substantial oil reserves or expertise in extraction, refining, and marketing refined products.³⁷ The absence of proficient human resources, particularly in onshore exploration, posed a significant obstacle. However, Petrobras successfully augmented its production, notably delving into deep offshore drilling through strategic institutional processes. The company underwent restructuring mirroring the

³⁶. See "Sanitising Lithium mining in Nigeria" (Thisday Online) Available at <<https://www.thisdaylive.com/index.php/2023/08/17/sanitising-lithium-mining-in-nasarawa>> Assessed 14th February 2024.

³⁷. De Oliveira, A. Petrobras: Strategy and Performance. In *Oil and Governance: State Owned Enterprises and the World Energy Supply*. (eds) David, G.V et al (Cambridge University Press, 2011) pp. 515 -556.

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organizational setup of MNCs, adopting a centralized structure to oversee research and exploration.

Petrobras further established PROCAP, a program dedicated to technological advancements in equipment capable of withstanding the rigorous conditions of deep-water drilling and oil production.³⁸ Initiatives like the Pre-Salt Skills Development Program (PRODESAL) and Pre-Salt Technology Program (Prosal) were launched to cultivate necessary technologies and skilled technicians for exploiting pre-salt areas.³⁹ Central to the sectoral policy was FINEP's role in managing sectoral funds, aiming to support Research and Development (R&D), cultivate human capital, and bolster domestic production.⁴⁰ This strategic emphasis on stimulating R&D fostered an environment conducive to innovation.⁴¹

Petrobras experienced significant advantages by tapping into a wide-ranging pool of knowledge sourced from multiple public organizations involved in extensive deep offshore exploration. Depending solely on agreements with MNCs and using imported technologies wouldn't have led to the impressive growth of Brazil's oil reserves, particularly in the deep offshore zones. Conversely, for MNCs, delving into deep offshore territories posed financial challenges because of constrained profit opportunities. Petrobras played a key role in helping Brazil transform a situation that could have led to a 'resource curse' into a path towards economic sustainability.

Alternatively, Nigeria's significant dependence on MNCs rather than prioritizing substantial independent growth in upstream operations, hasn't yielded developmental benefits akin to those seen in Brazil. The country's reliance on MNC technology has potentially led to greater expenses due to mismanagement, inadequate investment, and limited development. It's crucial for policy-makers to advocate for decisions that promote the advancement of domestic technological and industrial capabilities and resource processing that can provide the necessary feedstock for manufacturing and industrialization emphasizing sector-specific investments in human resources.

V. ROADMAP TO ACCESS MINING TECHNOLOGY AND TECHNIQUES: STRATEGIES FOR SELF-SUFFICIENCY

Nigeria exhibits a tendency to engage with external sources or entities (such as MNCs through joint ventures (JVs), production sharing agreements (PSCs) or such other arrangements that allow for exploration and extraction to meet the country's demands while also participating in the global market through exports needs. This inclination is rooted in the recognition that a prolonged history of economic reliance can adversely affect domestic private enterprises, hinder export diversification, and impede the progress of Resource-Based Industrialization (RBI).⁴² Therefore, achieving a balance between harnessing natural resources for economic development, avoiding over reliance on a resource and reducing dependencies requires careful planning, institutional governance which will constitute short, medium to long-term strategic policy making. These strategies would entail allocating resources towards HRD and R&D to cultivate a favorable business climate for the expansion of diverse industries and the eventual broadening of the economic foundation.

a. Linkage Optimization

Enhancing indigenous technological development holds the potential to amplify trade, elevate productivity, optimize the capital-labor equation, diminish inequality and poverty, promote diversification and foster improved regional integration. Nigeria, facing susceptibility to external shocks, necessitates policymakers to proactively tackle this vulnerability, aligning strategies with the AMV to achieve the SDG goals. The imperative transcends mere commodity exports or royalty receipts, but more pivotal towards fostering local domestic capital within the mining industry.

Acknowledging the temporal and financial investments entailed in industrial progress, it becomes paramount to prioritize the optimization of linkages as the initial focus. The choice of linkages will predominantly

³⁸. De Gouvea Neto, R. *Brazilian Emerging Multinationals: A Conduit for Export Technology* [1995] 37(6) *The International Executive*. P. 583-597.

³⁹. Fishman, A.D. *Petroleum in Brazil: Petrobras, Petrosal, Legislative Changes and the Role of Foreign Investment* (George Washington University, 2007).

⁴⁰. Sa Crespo, 'Research Policy in Emerging Economies: Brazil Sector Funds' [2005] 43(3) *Minerva*. Pp. 245-263.

⁴¹. *Id.*

⁴². The African Mining Vision emphasizes the importance of tailoring resource extraction technologies to suit local circumstances, aiming to cultivate specialized technological expertise within the resource sector. Additionally, the Vision acknowledges the sector's reliance on knowledge and suggests the necessity of investing in human resources development (HRD) and research and development (R&D) to stimulate growth. Furthermore, it suggests that the sector possesses the potential to diversify beyond resource extraction by transferring its technological skills to create innovative products for different markets. The process of diversification is often termed as "lateral migration," aimed at achieving Resource-Based Industrialization. See African Mining Vision (February 2009) pp.13.

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hinge on the unique dynamics of the country and the prevailing knowledge and expertise accessible within its borders.⁴³ The intricacies of local conditions play a pivotal role in determining the most effective and sustainable connections for fostering industrial development. This would largely depend on what is realistic for the country to achieve in the short term.

Mining is inherently interconnected, existing as part of a broader chain of processes known as the 'value chain.' Within this continuum, opportunities for linkages emerge. Recognizing mining's integral place in the larger value chain is essential for understanding both its opportunities and the risks. The value chain is a sequence of activities that transform input into product. A typical value chain will consist of (i) exploration and feasibility (which requires geologists, geoscientists) (ii) site development (building roads, processing facilities) (iii) production stage (recovery of minerals and process of extracting using a variety of technologies for extraction) (iv) beneficiation and (v) reclamation.⁴⁴ The value chain analysis supports activities that support the process along the value chain. Opportunities for upstream linkages during the production stage are extensive, generating a multitude of direct and indirect prospects that involve both specialized and less specialized skills.⁴⁵ In developing countries, a lack of expertise and financial access hampers domestic production. To address this, knowledge transfer, and technological support from

more developed counterparts are essential. Policymakers should prioritize upstream linkages, implementing technological transfer and industrial upgrading policies to empower domestic companies for self-sufficiency and sustainable growth. This would require the implementation of a local content policy for the mining sector. Currently, there is there is a bill, known as the Nigerian Content Development and Enforcement Bill,⁴⁶ which seeks to amend the Nigerian Oil and Gas Industry Content Development Act by expanding it to include four additional sectors ICT, Power, Construction and Solid Minerals/Mining. There are a few clauses in the bill that adequately refers to transfer of technology; labour clauses, mandating the use of a minimum percentage of Nigerian labour force, Employment and Training Plan etc. However, for any local content policy to work, there should be a conducive business environment, i.e. transportation, power supply, and access to finance must be adequate for the development of a robust supply chain.

b. Technological Policies

A long - term trade policy lies in formulating and implementing strategic technological policies, which should place a significant emphasis on HRD, Research, Innovation and Technological Development (RI&TD). This strategic focus is pivotal as it can pave the way for obtaining essential capital crucial for both industrial and technological expansion. The establishment of a robust HRD & RI&TD framework serves as the bedrock for innovation and knowledge creation, enabling a nation to propel itself towards self-reliance and sustainable development. For this paradigm shift to materialize effectively, a strong political will is indispensable. Political leaders must demonstrate a commitment to making informed technological decisions that align with the overarching goal of reducing dependency. By this, Nigeria can harness its intellectual capital, drive technological advancements and lay the foundation for homegrown solutions to economic challenges.

Mitigating dependence involves extending efforts beyond sector-specific policies to focus prominently on establishing a comprehensive national strategy for technological access and autonomy that constitute learning solutions, the cultivation of indigenous innovation capacities with active governmental participation and strategic regulation of foreign technological infusion and investment (the latter constituting an aggressive and nationalistic ideology) with each facet contributing substantively to the over-arching objective. Achieving this objective could be facilitated through the creation of an autonomous Research

⁴³. Linkages to the Resource Sector: The Role of Companies, Governments and International Development Cooperations (Columbia Center on Sustainable Development, 2018)

⁴⁴. See Energy and Mining "Mining Industry Value Chain" Available at <https://www.energymining.sa.gov.au/industry/minerals-and-mining/invest/minerals-industry-value-chain#:~:text=The%20minerals%20industry%20value%2Dchain,Investment%20opportunities> Assessed 13th January 2024.

⁴⁵. Due to the early industrialization in the mining industry, South Africa has developed the capability to produce and export various products, including coal-washing spirals, water pumps, hydropower systems, tracked mining and underground locomotives, ventilation equipment, shaft sinking technology, and turnkey designs and operations for new mines. The abundant but low-quality coal in South Africa necessitated washing to eliminate impurities, driving significant advancements in spiral washing technology. This expertise has found application in diverse areas, such as the oil sands in Canada. See South Africa Horizontal Linkages: Building Expertise by Overcoming Specific Constraints (IGF on Mining, Minerals, Metals and Sustainable Development) Available at <https://www.iisd.org/sites/default/files/publications/case-study-south-africa-horizontal-linkages.pdf> Assessed 13th January 2024.

⁴⁶. In December 2019, the National Assembly proposed a bill to repeal the subsisting Nigerian Oil and Gas Industry Content Development Act (NOGICDA), 2010, and replace it with the Nigerian Local Content Development and Enforcement Commission Bill ("the Bill"), 2020.

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and Development Financing Agency or Fund. This entity would play a pivotal role as the primary funding mechanism for scientific and technological advancements within the Federation. Additionally, it could also function as an industrial technological secretariat, responsible for formulating, coordinating, and executing policies related to scientific and technological development. By this, the State can act as a facilitator in connecting domestic industries with scientific and technological infrastructure, ensuring a coordinated approach to development and a robust innovation ecosystem. To bring this vision to fruition, a suggestion is the prudent allocation of funds designated for R&D from the national budget to be managed by the R&D Financing Agency.⁴⁷ Undoubtedly, the significance of allocating resources to R&D cannot be overstated. Industrialized economies, exemplified by the likes of the Asian Tigers,⁴⁸ BRICs (Brazil, Russia, India, China), and notably the United Kingdom,⁴⁹ and the United States⁵⁰ have

substantially augmented their Gross National Product (GNP) expenditures dedicated to R&D. This strategic investment aims to secure substantial market shares in global markets through the cultivation and dissemination of innovative technologies.

While a policy may be well-intentioned, it is crucial to acknowledge the potential obstacles posed by government inertia and bureaucracies. Consequently, individuals entrusted with the responsibility for policy formulation and implementation must possess pertinent background knowledge and experience. In other words, there is a necessity for the appointment of technocrats—individuals well-versed in the fields of Science, Technology, Engineering, and Mathematics (STEM)—to helm the affairs of the proposed agency and ensure effective execution. This will enable the development of intermediate technologies to take advantage of scale economies.

c. Educational Policies

The ability to harness technology depends on "persons and institutions" rather than the implementation of hardware or tangible items.⁵¹ Hence, to acquire these capabilities requires building up HRD and institutions. Tertiarily, the Nigerian university system needs a comprehensive graduate studies plan, including fellowships, grants, and specialization in mining engineering and technology. The proposed Research and Development Financing Agency would support R&D efforts, university projects, and the formation of experts in the field through fellowships, research grants, and international studies. Also, to strengthen HRD, dedicated research centers and innovation hubs for mining technology are crucial for knowledge exchange between academia and industry. Hence, this can be used to essentially expand into mining technology programs. This holistic approach will aim to enhance education, stimulate technological advancements, and boost indigenous manufacturing in the mining sector. Given the particular significance of mining to the economy, it is crucial to facilitate specialized access and technological development within this sector.

d. Trade Policies

The direction of an economic policy framework that embodies strategic trade policies, and a robust legal framework that balance imports and exports, safeguard

⁴⁷. See How FG spent two trillion on Research and Development in four years with little to show (Nigeria Tribune Online, October 9, 2022) Available at <https://trinuneonline.com/revealed-how-fg-spent-over-two-trillion-on-research-and-development-in-four-years-with-little-to-show/> Accessed 13th January 2024.

⁴⁸. The term "Asian Tigers" refers to the highly developed and fast-growing economies of four East Asian countries: Hong Kong, Singapore, South Korea, and Taiwan. These nations experienced rapid industrialization, economic growth, and technological advancement during the latter half of the 20th century. **Their success is often attributed to factors such as export-oriented industrialization, strong emphasis on education, government intervention, and favorable economic policies.** The term "Tigers" reflects the dynamic and robust economic performance of these Asian nations during their periods of rapid growth.

⁴⁹. The net expenditure on R&D in UK stood at £14.5 billion in 2021. See Office for National Statistics. Available at <https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgovernmentexpenditureonscienceengineeringandtechnology/2021#:~:text=The%20UK%20government's%20net%20expenditure,%C2%A314.5%20billion%20in%202021.>> Access 15th January 2023.

⁵⁰. The U.S. research and development (R&D) framework involve a variety of R&D contributors and funding entities. This encompasses private corporations, the federal government, non-federal governments, higher education institutions, and other nonprofit organizations. Entities engaged in R&D activities frequently receive substantial external funding, and those providing R&D funding may also engage as performers in the process. Cumulatively, a total of \$792 billion have

been spent on R&D between the periods of 2020 and 2021. See National Center for Science and Engineering. Available at <https://nces.nsf.gov/pubs/nsf23320> Accessed 15th January 2023.

⁵¹. Carl J. Dahlman, 'Technological Change in Industry in Developing Countries: The main trends, and the issues they pose for government policy' (International Monetary Fund eLibrary, 1 January 1989) Available at <https://www.elibrary.imf.org/view/journals/022/0026/002/article-A004-en.xml> Accessed 15th January 2024.

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domestic industries and promote fair trade practices can contribute to access to technology and technological independence. Trade policies can also include regulations that encourage the transfer of technology from foreign companies to domestic ones. This could be achieved through partnerships, joint ventures, or licensing agreements that facilitate the sharing of technological knowledge.⁵² This would first include a robust Intellectual Property legal framework to encourage local innovators and businesses to invest in the creation of new technologies.⁵³ Effectively

⁵² . In Nigeria, there are several mechanisms to facilitate technology transfer, such as the National Office for Technology Acquisition and Promotion (NOTAP) established by Decree No. 70 of 1979, amended by Decree No.82 of 1992 and now referred to as NOTAP Act Cap N68 LFN 2004. This is a parastatal under the Federal Ministry of Science and Technology, which amongst others is to provide for a more efficient process for the adaptation of imported technology and the registration of all contracts or agreements having effect in Nigeria. Additionally, the National Technology Business Incubation Programme (NTBIP), initiated in 2005 within the jurisdiction of the Federal Ministry of Science and Technology, aims to enhance the pace of technology commercialization. It achieves this by efficiently connecting skilled individuals, technological advancements, financial resources, and expertise to expedite the growth of novel innovation-driven ventures. See Mohammed Jibrin, Mahdi Makoyo and Mike Amony, 'Technology Incubation Programme for Development of Sustainable Entrepreneurial Skills in Nigeria' [2013] 2(12) International Journal of Engineering Research and Technology.

⁵³ . The National Intellectual Property Office (NIPO) is a governmental entity tasked with overseeing and upholding intellectual property rights within Nigeria. Its pivotal role lies in facilitating technology exchange by safeguarding and aiding in the transfer of technology between domestic and international entities. Its core functions include facilitating the negotiation and formulation of technology transfer agreements to ensure equitable and transparent technology exchange processes. Despite the significance of intellectual property (IP) protection, many local businesses and entrepreneurs encounter difficulties in safeguarding their innovations against theft and infringement. This challenge often stems from a lack of understanding of IP legislation and constraints in enforcing IP rights, compounded by limited resources. See Chukwuanu Stanley Chukwuma and Obinna C. Obiefuna, 'Reviewing the Technology Transfer and Acquisition Regime Under the Nigerian Legal Framework for Indigenization' [2023]13 Journal of Public and Private Law, UNIZIK. PP 120

acquiring technology from abroad and adapting it to meet local economic demands can yield optimal results, especially as a short-term strategy to avoid technological dependence. However, for sustainable growth and resilience, a strategic approach involves transitioning from acquiring to gradual adaptation, ultimately aiming for technological independence. This last phase serves as a long-term strategy, ensuring self-sufficiency and fostering innovation within the local context.

Implementing policies that encourage or require a certain percentage of technology components or products to be produced locally can help build a more self-sufficient technological base. For instance, the removal of high import duties, sales tax, VAT and others have constrained the deployment of technology to small scale miners. The reality is that government has focused mainly on the importation of capital equipment free of duty and sales tax for the development of capital expenditures for large scale mining investment.⁵⁴ Recently, the FG declared a tax waiver on imported mining equipment as a way to foster partnerships with the Saudi Arabian government to boost invest in the Mining sector.⁵⁵ These incentives are however not extended to the small-scale miners. There is need for tax waivers and reduced import duties for small scale miners to access technologies.

e. Tripartite Governance Model

The preceding conversations have highlighted the significance of a national strategy for technological access. While some initiatives are in force, the issue of implementation consistently hampers well-intentioned policies. Evident in this challenge is the insufficient funding allocated to R&D and the absence of political determination to propel these initiatives forward. Hence, some new strategies were discussed to propel the State.

This aspect identifies sector-specific approaches aimed at facilitating technology access. A primary focus is the restructuring of the Ministry of Mines and Steel Development into three independent institutions. This includes establishing an independent Regulator, a commercial entity incorporated under the Companies and Allied Matters Act, 2020 to operate as a self-sustaining entity guided by economic imperatives, and retaining the Ministry as the government's policy arm. Adopting a tripartite governance model is crucial for defining clear roles, rules, and responsibilities, thereby preventing potential conflicts of interest and provides a more favorable climate for investments. Hence, decentralization will limit the governments interventionist role.

⁵⁴ . See section 23 – 28 NMMA 2007.

⁵⁵ . See FG plans tax waiver on imported mining equipment (Nairametrics) Available at <<https://nairametrics.com/2024/01/11/fg-plans-tax-waiver-on-imported-mining-equipment/>> Accessed 15th January 2023.

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Presently, there is a demand for a policy shift from the regulation carried out by specialized technical departments operating under the Ministry to the establishment of an independent regulator.⁵⁶ The logical conclusion to be drawn is that the administration and regulation of the mining sector by these technical departments were deemed unsatisfactory.⁵⁷ Poor funding of regulatory departments has rendered them ineffective and susceptible to regulatory capture. In addition, the absence of a policy board to direct the affairs of the regulatory departments to set targets and monitor performance has hindered the discharge of regulatory functions. This has contributed to the disorderly operating environment experienced in the mining sector which has unwillingly inhibited formalization, loss of revenue that would have accrued to the sector, environmental degradation and a host of health, safety, social and community issues associated with mining.

An independent regulator, according to this proposal, should assume a dual role, functioning both as a technical overseer and an economic steward. In advocating for the establishment of an independent regulator with a dual focus on technical and economic aspects, the proposal envisions a regulatory body that would serve as a cornerstone for the mining industry. The technical facet of this envisioned regulator would involve the incubation and dissemination of knowledge, particularly through specialized training services tailored for ASM/SSM operators. This encompasses comprehensive training programs covering geology, exploration techniques, and the latest advancements in mining and mineral processing technology.

The regulator would take a proactive role in infrastructure development by setting up assay laboratories and permanent demonstration plants. These facilities would not only serve as centers for practical learning but also as showcases for efficient mining and processing techniques. Through such initiatives, the regulator aims to equip ASM/SSM with the skills and knowledge needed for sustainable and technologically advanced mining practices.

On the economic front, the proposed regulator seeks to address cost constraints faced by individual mines. This involves strategic interventions, such as supplying necessary equipment to mining sites and actively contributing to the reduction of operational expenses. The establishment of permanent demonstration plants would not only aid in disseminating best practices but also showcase the viability of modern technologies in improving economic outcomes for mining operations. Crucially, the regulator would be mandated to ensure the availability and access to cutting-edge technologies within the mining industry, by facilitating collaboration between the regulator, industry stakeholders, and research institutions, thus creating a dynamic ecosystem for technological advancement. This collaborative approach is essential for keeping the mining sector abreast of the latest developments and innovations, ensuring sustained growth and competitiveness. In essence, the proposed independent regulator emerges as a vital entity poised to support the mining industry comprehensively. By integrating technical expertise with economic considerations, the regulator aims to create an environment conducive to innovation, efficiency, and the overall advancement of the mining sector.

VI. FINDINGS

The mining industry is undergoing a transformative shift, guided by technology and a conscious effort to harmonize economic growth with environmental sustainability and the safety of its workforce. This integration isn't merely about progress, it's about fostering a future where industries thrive without compromising the environment.

The Nigerian mining industry plays a crucial and strategic role in the economy, with the potential to fuel widespread economic growth if effective policies are put in place to expedite sustainable exploitation and generate revenue for the government. However, Nigeria faces significant deficiencies in HRD and R&D, which deters the road to industrialization. The mining sector demands substantial knowledge and expertise, yet both regulatory bodies and industry players lack sufficient capacity. It's clear that only large major companies, and often foreign ones, possess the necessary technical know-how to effectively exploit the country's mineral reserves. This leads to an imbalance and crowding out of indigenous small players, particularly small-scale miners. The fact is, there are currently no comprehensive national or sectoral strategies aimed at fostering technological advancement within the mining industry that promote inclusivity. Rather than actively encouraging the direct involvement and engagement of local participants through building technological capacities, there's a notable reliance on the government to promote MNCs with more advanced technologies to exploit these resources. Consequently, this dynamic often leads to a

⁵⁶ . Under the NMMA 2007, there are three technical departments, namely Mining Cadastre Office (MCO) Section 5; Mines Inspectorate and Mines Environmental Compliance with specific statutory mandates designed to enable them function effectively. Section 16(1). Although not specifically established by the Act, the ASM Department was also created with a mandate to exercise regulatory oversight over such operations.

⁵⁷ . P.T Akper and Laura Ani, 'Towards and Independent Regulator for the Nigerian Minerals and Mining Sector: Is the Proposed the Nigerian Minerals and Mining Commission a Case of New Wine in Old Wine Skins'? [2020] *Ife Journal of International and Comparative Law*. P 1-16.)

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race to the bottom among miners who then resort to unethical extraction techniques.

Addressing these challenges necessitates a collaborative, concerted and multifaceted effort involving government initiatives, through national and sectoral policies to boost technological advancements and private sector engagement. Only then can Nigeria effectively and responsibly leverage its abundant mineral resources for sustainable development and economic growth

VII. CONCLUSION

Implementing modern technology in small-scale mining operations can yield long term benefits, including increased efficiency, improved safety and access to new markets and RBI. However, the initial benefits of technological deployment should be carefully evaluated against the potential costs. Hence, the imperative to strike an equilibrium between leveraging external technology and investment whilst promoting indigenous technological capabilities. Therefore, the adoption of policy measures will progressively mitigate reliance on external sources, empower local industries, and position Nigeria as a substantive contributor to the global technological milieu. Further, the harmonious integration of learning, strategic control, innovation, and state intervention constitutes a robust and adaptable framework for sustainable development. Therefore, aligning with the goals outlined in the African Mining Vision to meet the developmental exigencies of the sector.

Tertiarily, the cultivation of a robust innovation ecosystem emerges as a sine qua non. This encompasses the provision of substantive support for R&D initiatives, the incentivization of corporate investments in innovation, and the institution of frameworks facilitating the development of local technologies. Also, the encouragement of entrepreneurship and the safeguarding of intellectual property rights constitute indispensable components of this paradigm. Finally, government support and political buy-in will play a crucial role in facilitating the adoption of modern technological policies for the indigenous mining participant.

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