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Critical Minerals and Routes to Diversification in Africa: Opportunities for diversification into Mobile Phone Technologies - The Case of Democratic Republic of Congo

Antonio Andreoni[a,b] and Elvis Avenyo[b]

[a]SOAS University of London, United Kingdom

[b]University of Johannesburg, South Africa

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Abstract

This paper develops a framework that maps the global mobile phone technologies value chain and analyses how the Democratic Republic of the Congo (DRC) can potentially leverage its mineral resources to localise and capture value within mobile phone technologies technologies, including leading the building of regional value chains in Africa. In doing this, we develop an in-depth country case study and highlights DRC's specific routes to diversification and technological deepening, including opportunities for regional coordination and industrial development. The industrial policy lessons for productive transformation across Africa are discussed based on the empirical and sectoral-specific case studies.

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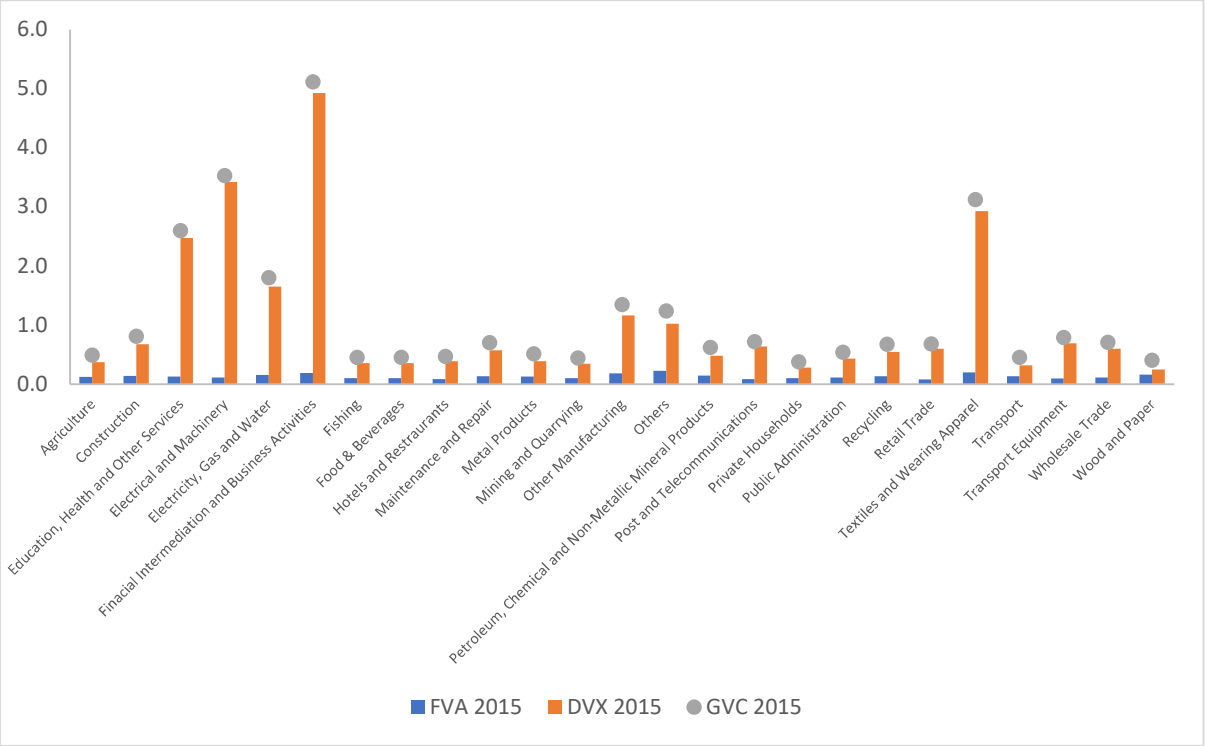
Contents

1. Introduction

The Democratic Republic of Congo (DRC) is a vast country with an enormous wealth of biodiversity and natural resources, including critical minerals. Notwithstanding, over the last decades, continuous conflicts have dramatically affected the country's development trajectory and many opportunities for structural transformation and diversification have remained untapped. The Second Congo War, from 1998 to 2003, has left a difficult legacy of violence, corruption, and human rights abuse, as well as the dominance of exploitative practices in a largely underdeveloped and informal economy.

Despite, relative economic improvements over the last decade, the state's stability is still fragile and prone to shocks (Institute for Economics & Peace 2017). As a result, when we look at the domestic value addition by sectors of the economy (figure 1 below), and their levels of GVC integration, we find little progress and limited integration. Apart from financial services, traditional sectors like textile and garments and those related to mining activities – i.e., electrical and machinery – are the only ones have shown some increases in domestic value addition.

Figure 1: GVC integration, foreign and domestic value addition, DRC, 2015.



Source: authors based on EORA

The governance of the mining sector has been weak, and cases from the sector have been often used as examples of the 'dark side of mining' (Marin and Goya, 2021). For example, the mining of cobalt in DRC has often been relabelled as the "blood diamonds of this decade" (Wilson, 2017). More critically, mineral rents have fuelled conflicts. Illegal armed groups have fought for control of the mines, exploited widespread artisanal mining, and use profits to fund armaments and continue conflict (Natural Resources Governance Institute, 2017). Between 2013 and 2017, armed groups were reported to be present at 938 of the 2,150 mine sites surveyed by the International Peace Information Service (USGS, 2022).

With the advancement in the peace process and stabilisation of the economy, several initiatives have been put in place to improve the situation in the economy, especially in the mining sector. However, some of these initiatives face implementation and enforcement problems. For example, in April 2013, the Government issued a decree that banned the export of cobalt and copper concentrates to promote domestic downstream processing of cobalt and copper. Companies were given several rounds of moratorium in recognition of the fact that power shortages limited downstream processing of concentrates. In December 2017, the National Assembly approved a new mining code that replaced the 2002 law. Passed in 2018, the law increased royalties on cobalt, copper, and gold to 3.5% of mining revenues and introduced a windfall profits tax; the code also increased the Government's free-carried and non-dilutable

share in mining projects from 5% to 10% and reduced the guaranteed period for contract renegotiation from 10 years to 5 years.

The mining sector is a major employer in DRC, especially in copper and cobalt mines. According to Yager (2022), large-scale mines employed at least 75,572 Congolese nationals in 2015. However, the majority of employers are artisanal miners, which in the diamond mining sector alone were estimated around 450,000. An additional 100,000 artisanal miners were estimated to be employed in cobalt mining. Attempts to formalise artisanal mining have been piloted to improve working conditions and safety standards. In Mutoshi in Lualaba province in the south of the DRC, formalisation of artisanal mining meant that registered miners who extract the cobalt with basic tools got access to a mechanically prepared mine site with open pits where site-safety standards were implemented, among other measures (Baumann-Pauly, 2023).

These improvements are essential for attracting investments in the mining sector and pivot critical minerals for broader diversification of the economy. Artisanal mining accounts for 15% to 30% of cobalt production in DRC. The DRC, in turn, provides over 70% of the cobalt used in rechargeable batteries worldwide. Securing supply chains that meets human rights standards and transparency has become increasingly important for international companies, especially after several countries in Europe have enacted legislation requiring companies to assess their operations for potential human rights violations. In December 2022, the EU released a new regulation replacing the existing Battery Directive of 2006 and requiring companies to source battery minerals "responsibly," which includes conducting human rights due diligence across their entire value chain.
To further understand the emerging opportunities and challenges for diversification into mobile phone technologies value chains by the Democratic Republic of the Congo (DRC), the paper develops a framework that maps the mobile phone technologies value chain and analyses how DRC can potentially localise and capture value within these supply networks, including leading the building and development of mobile phone technology regional value chains.

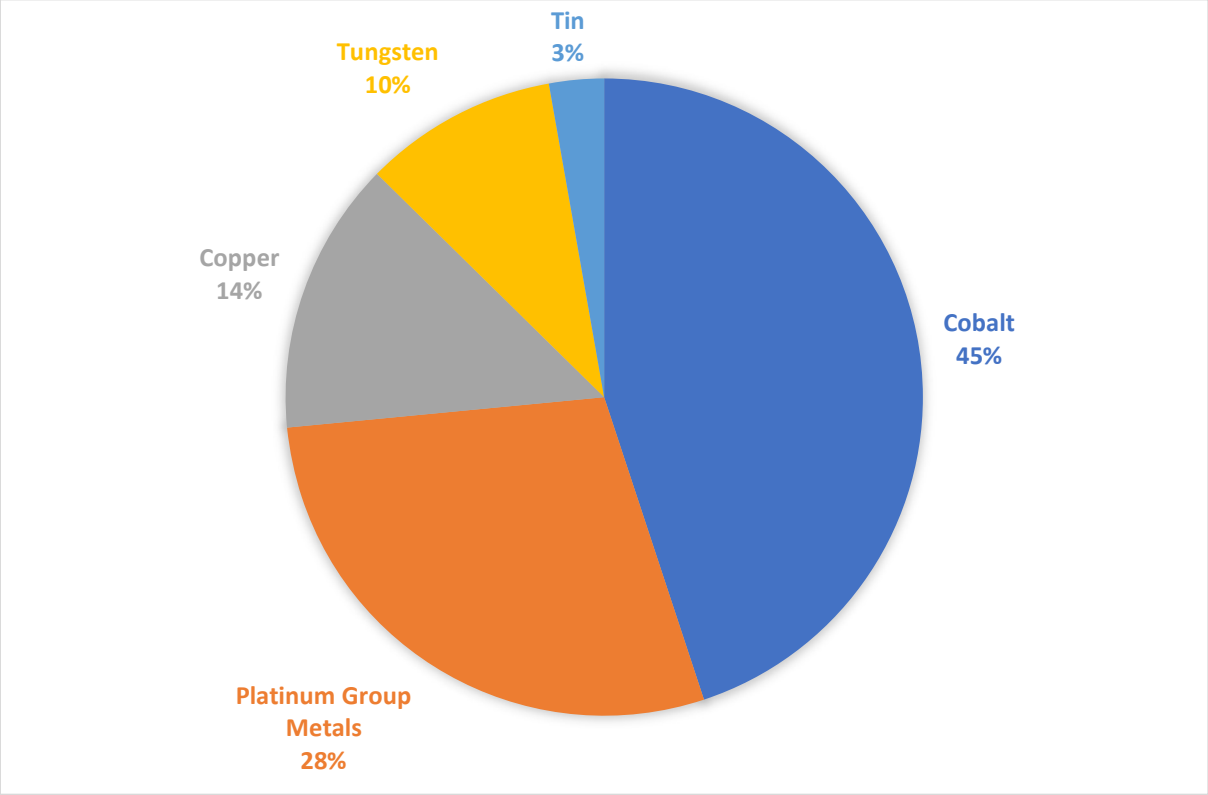
The remainder of the paper is structured as follows. Section 2 discusses the role DRC's natural endowments could play in driving medium-and-high technology industrialisation in DRC and on the continent. Sections 3 critically discusses two diversification routes for DRC and 4 concludes the paper with policy recommendations.

2. Critical minerals in DRC

Despite political economy and structural challenges, DRC is increasingly playing a significant role in the world's production of cobalt, copper, diamond, gold, tantalum, and tin. In 2017, the country's share of the world's mined cobalt production was more than 60%; tantalum, 42%;

diamond, 12%; copper, 5%; tin, 3%; and gold, 1%. DRC also accounted for about 49% of the world's cobalt reserves. (USGS, 2022). If we look at the critical minerals export basket portfolio of DRC in 2021 (see figure 2 below), it is clear that cobalt accounts for almost half of the export basket given its high value and increasing international demand for electronic products and projected cobalt gap. In addition to unprecedented demand, this risk and supply gap is in part due to the way that cobalt is mined. Cobalt is mined as a by-product of either nickel or copper and therefore can be dependent on price fluctuations and demand of the two. DRC also export significant amounts of PGMs, copper and tungsten.

Figure 2: Critical minerals export basket of DRC in 2021



Source: Authors based on UNCOMTRADE

In the mineral and mining industry we find the state-owned company La Générale des Carrières et des Mines (Gécamines), producing cobalt and copper both directly and indirectly via shareholding of between 5% and 40% in numerous cobalt and copper mining operations. Glencore is the leading producer of cobalt, with about 31% of global capacity coming from its Katanga and Mutanda mines in the DRC. China Molybdenum's (CMOC) Tenke Fugurume mine in the DRC produced about 15,436 tons of cobalt in 2020. It plans to produce about 16,500 to 20,000 tons in 2021. Some of the recent investments in these DRC mines have been at the centre of international tensions, especially because of Chinese increasing dominance of upstream and midstream segments. Mining activities under control of Chinese companies

accelerated between 2013 to 2018, to reach almost 7% of the total value of African mines by the end of the period. This figure peaks in countries like the DRC (24%) and Zambia (12%), where Chinese companies were more able than transnational competitors to bear the country risk and revamp production in high-grade copper deposits which had been abandoned by nationally owned companies (e.g., Gecamines in the DRC). In the DRC, Chinese companies control 41% of cobalt production, as well as around 28% of copper in the DRC and Zambia (Ericsson, et al. 2020).

Refining capability remains limited. In 2017, the share of copper and cobalt production that was refined prior to export was 76% and less than 1%, respectively. Additional cobalt and copper mine production was exported after processing to intermediate products, such as cobalt carbonate, cobalt hydroxide, and black copper (USGS, 2022). Energy shortage and lack of reliability of the energy supply are among the main factors responsible for low levels of domestic cobalt refining. As a result, domestic value addition remains limited, and even when mineral rents are effectively extracted, reinvestment in industrial activities has lagged behind. However, initial business cases have been advanced which suggest both domestic and regional opportunities for diversification.

3. Pivot for industrial diversification and technological deepening in the DRC

In this section, we critically discuss two main diversification route and opportunities into mobile phone technologies value chains by the Democratic Republic of the Congo (DRC).

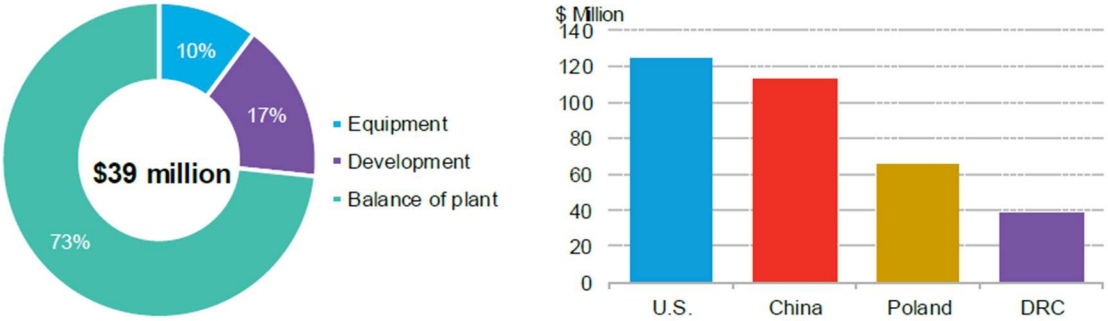
3.1 Diversification route 1: Precursors industry development

As discussed above, alongside lithium, cobalt is widely used in the battery industry, with applications in the automotive and electronics industry amongst many others. BloombergNEF (2021) has recently published a study modelling a business case for developing a precursors industry in DRC, as shown in figure 3. Positive initiatives have been also emerging in DRC which seems to go in the same direction. In April 2022, a new Centre of Excellence for Advanced Battery Research was officially launched. The Centre is hosted within the University of Lubumbashi.

According to this study, annual lithium-battery demand is expected to reach 4.5 terawatt hours (TWh) annually by 2035. This creates a huge demand upstream in the value chain for critical minerals, metals, precursor and cell production. The demand for cobalt from the lithium-ion industry alone will grow 1.5 times between 2021 and 2030 (the demand for Nickel is expected to grow five times, the one for copper six times in the same period). As discussed above, the

battery industry is segmenting with OEMs producing passenger electric vehicles using high nickel and cobalt chemistry batteries for performance applications, and lithium-iron-phosphate (LFP) for low-cost entry-level vehicles. DRC could capture this massive market expansion by targeting production of precursors. Indeed, BloombergNEF (2021) estimates that building a 10,000 metric-ton precursor facility in the DRC could cost $39 million. This is three times cheaper than what it would cost for a similar plant in the US.

Figure 3: Capital cost of a 10,000 metric tons precursor plant, cost components, and aggregate cost comparators



Source: BloombergNEF, 2021.

The DRC produced about 70% of global cobalt supply in 2020. In April 2021, leading battery manufacturer, Contemporary Amperex Technology (CATL) announced it will acquire 25% of CMOC's stake in the Kisanfu mine in the DRC with estimated reserves of about 3.1 million tons of cobalt (Daly, 2021). The company wants to process the ore at the nearby Tenke Fugurume mine. While this is an interesting development, DRC does not produce other two critical minerals – nickel and manganese – needed to produce battery precursors. These critical minerals are however available in neighbouring countries. For example, nickel could be sourced from Madagascar's Ambatovy mine (or South Africa and Zimbabwe where it is a by-product of PGMs); while manganese could be procured from Gabon or South Africa and transported into the DRC. Developing a precursors industry could also untap other critical minerals available in DRC like manganese, which are currently unexploited. Developing of manganese could offer further diversification downstream in the battery value chain, given that manganese is used in the manufacturing of lithium-ion battery cathodes.

Recently, African governments' awareness of the strategic value of critical minerals for domestic and regional industrialisation and production linkages development has been increasing. Governments in the region will have to closely collaborate and partner to create an African battery production industry. Recognizing this, the DRC and Zambia have established a "Joint Battery Council." The two countries form part of the so called "Copper

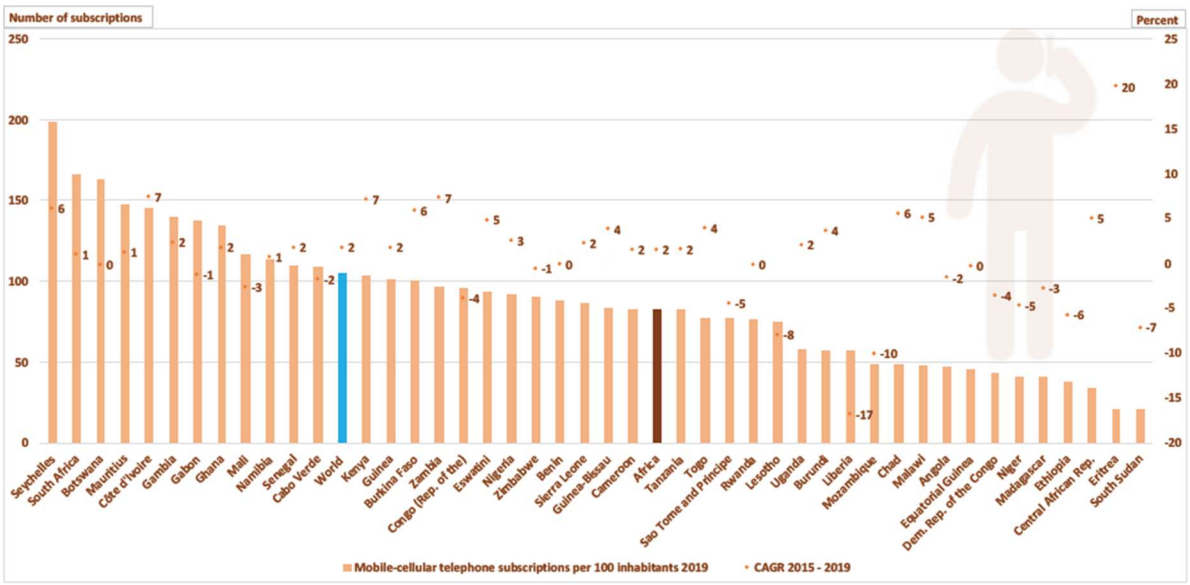
belt" which stretches from the Central African Republic, the DRC and Zambia. This region accounts for the world's largest supply for cobalt, a mineral used in the production of lithium-ion batteries. By locating domestic strategies as part of regional industrial development plans, African countries could also exert more bargaining power and realise greater cluster and scale economies. UNECA has identified several opportunities for regional value chains development cutting across Central Africa into East and Southern Africa for battery-minerals and electric-vehicles; a regional nitrogen, phosphorous and potassium 'super-fertilizer' value chain linking DRC, Ethiopia and Morocco and natural-gas-producing East, West, and Central African countries (Pedro, 2021). In February 2021, in the Africa Business Forum, the establishment of an African Battery Alliance was launched, a regional development model which has been already developed for batteries and hydrogen technologies across Europe.

3.2 Diversification route 2 : Mobile phone technologies

The development of precursors for batteries would allow DRC to diversify from minerals downstream into the batter value chain, while establishing regional collaboration. There is, however, another route to diversification, one that starts from other electronic products for which demand in the African market is constantly rising. These are mobile phones. The African mobile market is very diverse. Mobile cellular subscriptions are far in excess of 100 per 100 inhabitants in 12 out of 44 countries, namely Seychelles, South Africa, Botswana, Mauritius, Côte d'Ivoire, Gambia, Gabon, Ghana, Mali, Namibia, Senegal, Cabo Verde and Kenya. Twenty countries have subscription rates per 100 inhabitants below the African average of 82.3, while 12 other countries have less than 50 subscriptions per 100 inhabitants, as shown in figure 4 (ITU, 2021).

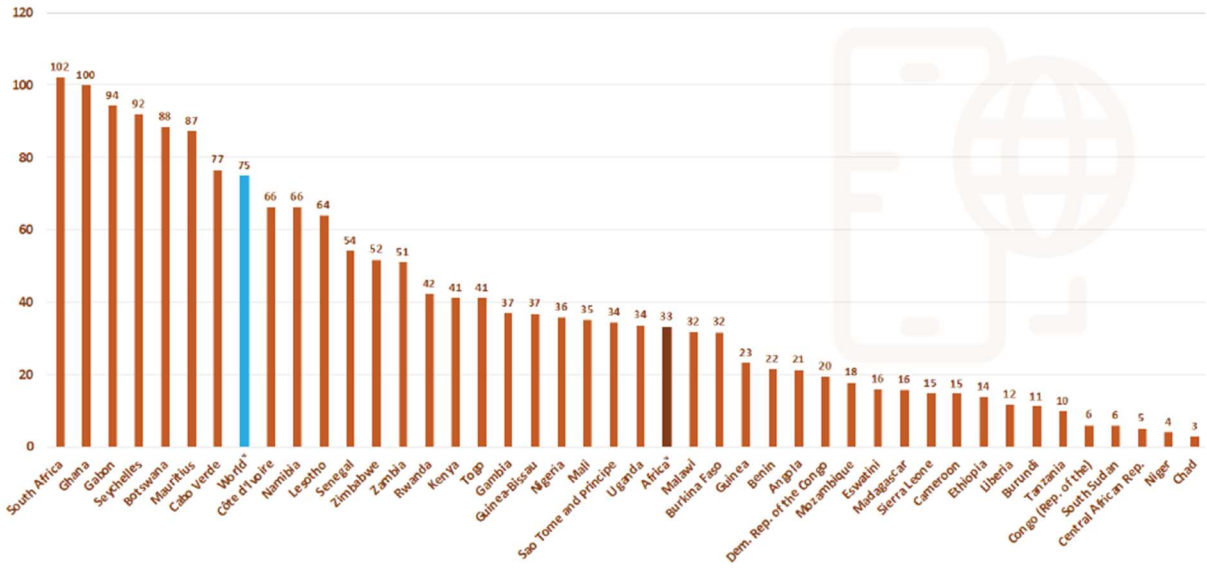
African active mobile broadband subscriptions per 100 inhabitants reached 33.1 in 2019, far below the world average of 75 per 100 inhabitants. However, in six countries in the Africa region, including South Africa, Ghana, Gabon, Seychelles, Botswana, Mauritius and Cabo Verde, figure 5 below shows that active mobile broadband subscription rates per 100 inhabitants are above the world average.

Figure 4: Mobile cellular subscriptions, African countries, 2019 and Compound Annual Growth Rate (%) between 2015-2019



Source: Based on the ITU WTI Database, December 2020 edition

Figure 5: Active mobile broadband subscriptions for 100 inhabitants, 42 African countries, 2019



Source: Based on the ITU WTI Database, 2020 estimates

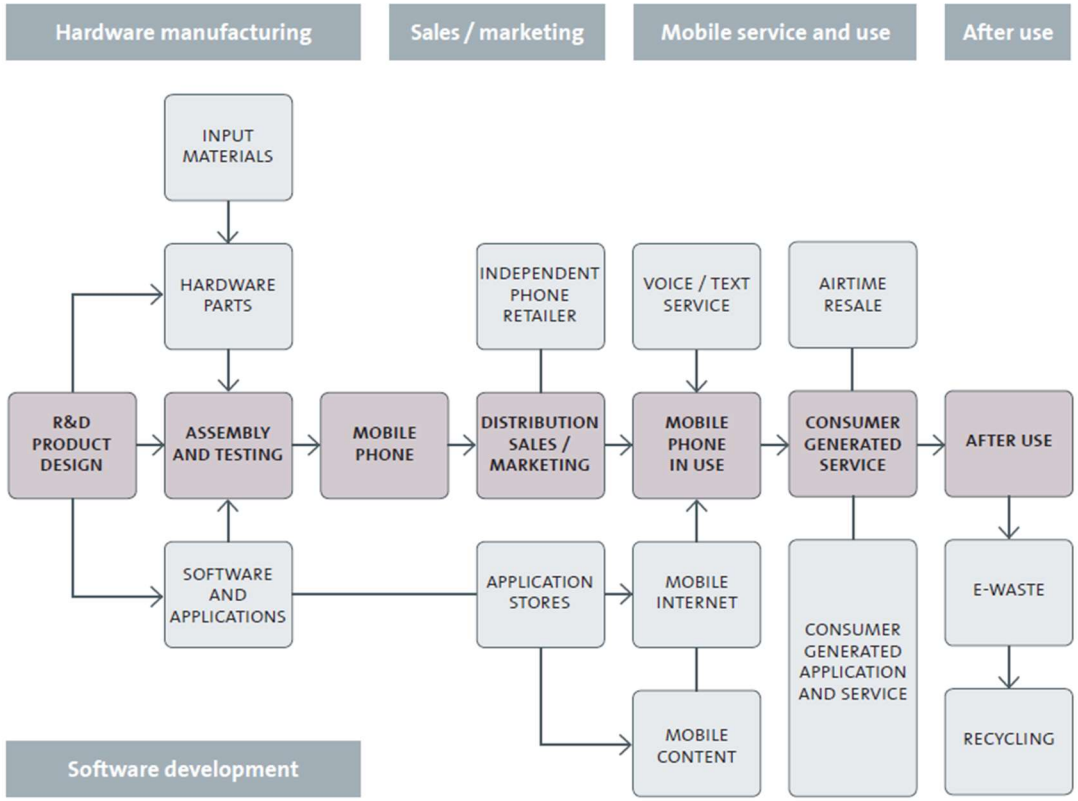
Demand for affordable and reliable smartphones has increased significantly, hence manufacturers are now competing for the middle range smart phone and budget phone brackets. The leading company is called Transsion, a Chinese led group that started in Africa in 2006 and focuses on emerging markets outside of China. Since 2011, every phone it sells in Africa has been assembled in Ethiopia and the company claims to have over 10,000 local employees. Its well-known branded phones TECNO is the single biggest smartphone seller on the continent (Dahir, 2018). TECNO has focused on developing product and service solutions targeted to the African consumer and context, specifically challenges with access to electricity. While domestic solar panels and kiosks are improving access, customers need long life battery. The company developed a technology that provides 72-hour battery life and up to six days in standby mode. Furthermore, the company developed enhanced camera phones that are optimised for darker skin tones. Finally, it introduced phones with dual SIM cards in recognition of the fact that consumers use multiple sims to reduce costs.

Several African companies have also emerged in the market over the last decade, however most of them are mainly focused on assembling of components imported from abroad (mainly China). For example, In South Africa, Onyx was launched in 2017 as a start-up. Onyx imports its components from overseas and builds its smartphones from the circuit board up in South Africa. More recently, in 2018, Mara Group—a pan-African multi-sector business services company—recently opened a smartphone factory in Rwanda. The factory will be producing two Maraphone models, the Mara X and the Mara Z. Mara brags that its smartphones are entirely home-made—produced and packaged in DRC's neighbour Rwanda (Uwiringiyimana, 2019).

In 2021, Africell and Industry Five launched a pilot project to develop assembling facilities for mobile phones in the Democratic Republic of Congo (DRC) for the first time. Industry Five's factory in Kinshasa has been equipped with modular and mobile workstations, and workers have been trained to reach quality standards and handle Africell's proprietary featurephone handsets. Workers are assisted by state-of-the art collaborative robots. Performance testing and quality checks will also occur at the facility (Barton, 2021).

As shown in the figure 6 below, the mobile phone global value chain (GVC) – from product conception to after-use – includes the following major segments: input materials; hardware manufacturing; software development; sales and marketing; mobile service and use; and after-use (Lee, Gereffi and Nathan, 2013). It is a truly global value chain, involving African minerals like cobalt and coltan, assembly workers in China and software developers in India.

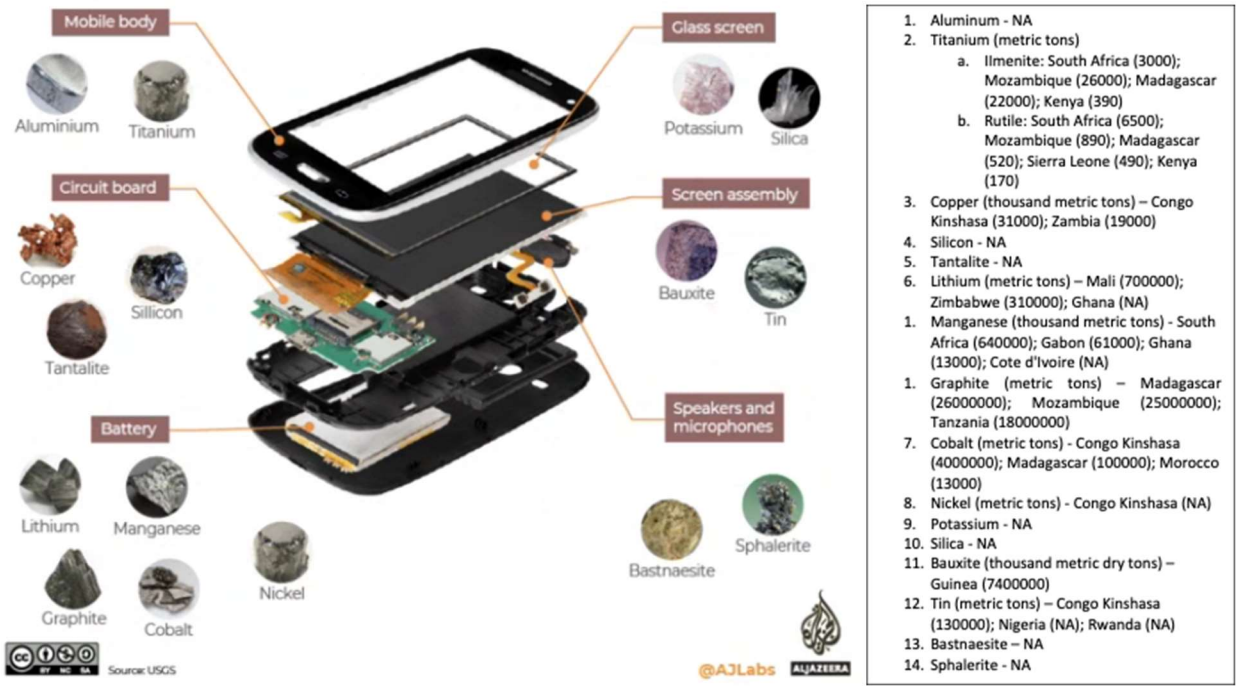
Figure 6: The mobile phone value chain



Source: Lee, Gereffi and Nathan, 2013

Upstream in the supply chain is the raw materials extraction to make the basic components of a phone (figure 7). The composition of phones varies depending on the brand, but an average materials list for a smartphone is: 25% silicon, 23% plastic, 20% iron, 14%, aluminium, 7% copper, 6% lead, 2% zinc, 1% tin, 1% nickel and 0.03% barium. The next few steps in the supply chain require manufacturers to transform the raw material into a usable material or component. The end product is made up of many different components each with its own supply chain. Component suppliers are numerous and will often specialise in particular parts and components which may be used by many different brands. These include circuit board containing the brains of the phone; antenna; liquid crystal display (LCD); microphone; speaker; battery; and camera.

Figure 7: Africa's critical minerals in different components of a mobile phone



Source: Adapted from USGS and data compiled by authors
Note: NA - no data available for African countries

The five main raw materials used in the current lithium-ion batteries are lithium, cobalt, nickel, manganese and graphite. Other materials include copper, aluminium and iron. The feedstocks used in the production of lithium-ion batteries are in the form of metal salts, predominantly sulphates. The sulphates for cobalt, nickel and manganese are combined in various ratios depending on the chemistry type to form the precursor cathode active material (precursors). If DRC was moving towards precursors development, as discussed above, companies who are developing mobile phone capacities in DRC such as Africell and Industry Five could develop further stages upstream in the chain and develop a vertical for electronics. There are already some positive signs. In 2021, Africell undertook a record-breaking network expansion in DRC, extending infrastructure and launching telecommunications services in several new provinces. Meanwhile, Industry Five's facilities in DRC are diversifying towards tablets, laptops, high performance servers, and data storage solutions. The company expects to generate up to five thousand skilled technical jobs in DRC within five years.[1]

[1] Mobile phones to be assembled in DRC for first time - Developing Telecoms

4. Concluding remarks and policy direction

The Democratic Republic of Congo (DRC) is a vast country well-endowed with critical minerals such as cobalt, copper, diamond, gold, tantalum, and tin. These critical mineral resources are pivotal to clean energy manufacturing and the green transition agenda and offer a new window of opportunity for structural transformation of the DRC. However, the prospect of a critical mineral-led development in the DRC is threatened by continuous conflicts and political instability over the last decades.

To reverse the country's development trajectory and tap into the green windows of opportunity, this paper develops a framework that maps the global mobile phone technologies value chain and analyses how the DRC can potentially leverage its mineral resources to localise and capture value within mobile phone technologies technologies, including leading the building of regional value chains in Africa. In doing this, we develop an in-depth country case study and highlights DRC's specific routes to diversification and technological deepening, including opportunities for regional coordination and industrial development.

The case study discussed in the paper highlights two main diversification routes for the DRC and route precursors for industry development and diversification into the production of electronic products and mobile phone technologies. However, the paper also identified several challenges that require active and effective industrial policy to tap into the green windows of opportunity. For one, the case study emphasised the need for DRC to implement sector-specific policies that position the country to leverage their unique strengths towards playing lead roles in the development of the mobile technologies regional value chains in Africa. The DRC can leverage its vast reserves of cobalt, a critical mineral for mobile phone batteries, to promote local assembly and manufacturing of mobile phones by effectively creating special economic zones and offering tax breaks, for instance. However, these approaches can only go so far given that the DRC has technological disadvantage. To take advantage of its natural capital, there is need for the Government to work closely with regional partners to create, develop and reinforce robust regional value chains. Recognizing the strategic value of critical minerals for domestic and regional production linkages development, the DRC and Zambia, for instance, have established a "Joint Battery Council" based on their vibrant mining sectors to closely collaborate and partner to create an African battery production industry. Both countries form part of the so called "Copper belt" and accounts for the world's largest supply for cobalt, a mineral used in the production of lithium-ion batteries. The "Joint Battery Council" can help to leverage the opportunities the natural capital offers for industrial development of both countries.

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