Regional Value Chains and Mining Capital Equipment: Exploring Opportunities for Linkages and Upgrading in Southern Africa

Paper prepared for UNCTAD project on "Development policies for sustainable economic growth in Southern Africa"

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1 Introduction

Global value chains (GVCs) underpin most of the world's production and international trade. GVCs encompass the different value-added links, composed of many activities, required to bring a product from conception and design to its delivery to the final consumer and, finally, to its disposal (Kaplinsky and Morris, 2001). Since the 1970s, the pace of geographical dispersion of these value-added links has accelerated, as lead firms have increasingly outsourced and offshored production across the globe. This fragmentation was made possible by technological advances in transport, communication, and production, as well as by trade and investment liberalisation.

Within this context, some developing countries have succeeded in participating and upgrading their roles in GVCs. The developing countries' share of global manufactures trade grew from 10% in 1980 to 45% in 2014. Most African countries however have been left behind and relegated to the bottom of GVCs (UNCTAD, 2016).

The last decade has witnessed important changes to organization and structure of GVCs (Gereffi, 2013). Industry concentration has increased, with many industries dominated by a handful of lead firms. Lead firms are also re-formulating their procurement strategies in favour of fewer larger and highly capable suppliers in large producer countries such as China, India, Brazil and Turkey. This change has increased consolidation on the supply side, with larger suppliers upgrading into pre-production services (design, R&D and purchasing) and post-production services (logistics, marketing, branding) (Appelbaum, 2008; Gereffi, 2013; Sturgeon and Kawakami, 2010). Industry concentration and tougher competition on the supply side make it even harder for African producers to participate in GVCs. More than ever, policy-makers have to design multifaceted strategies to promote industrialisation and job creation. This paper looks at the opportunities offered by regional value chains (RVCs), in particular the RVC for mining capital equipment in Southern Africa.

There are several reasons why policy-makers should consider the opportunities presented by the mining capital equipment industry. Since the late 1990s, FDI in Southern Africa's extractive industries have been significant, creating a large demand for engineering products and services. Several governments have adopted policies aimed at building domestic capacity in these areas. The mining capital equipment industry requires skills and productive supply chains which have the potential to deepen the value-addition and knowledge-intensification processes associated with mining investment. Moreover, these skills and productive capabilities can migrate laterally into other sectors. Finally, the Southern African Development Community (SADC) Industrialization Strategy and Roadmap has prioritised, among others, mining and the mining capital equipment industry. The African Mining Vision also envisages regional strategies to develop upstream linkages to the mining sector. This paper aims to analyse

potential areas for regional cooperation, focusing on four SADC countries, namely Mozambique, Tanzania, South Africa and Zambia.

The paper is organised as follows: Section 2 discusses the reasons why African policy makers should pay attention to RVCs and the mining capital equipment industry. Section 3 presents key features of the global and regional value chain for mining capital equipment. Section 4 analyses productive capabilities, opportunities and challenges in the four countries, while the policy frameworks are discussed in Section 5. Finally, Section 6 concludes by discussing potential areas for regional cooperation.

2 Regional value chains and extractive industries

2.1 Opportunities in regional value chains

Regional value chains are characterised by a combination of intra-regional trade, regional investment and/or regional corporate ownership. RVCs entail two of more countries participating in different links of the value chain, which results in intra-regional trade in intermediate and final goods.

The regional dimension of GVCs is becoming increasingly important. In Asia, RVCs constitute competitive production platforms to supply global markets. For example, in the apparel and electronics GVCs, Taiwanese full-package suppliers to Northern buyers have outsourced labour intensive manufacturing to mainland China (Gereffi, 1999; Sturgeon and Kawakami, 2010). In Europe and America, respectively, Eastern and Central European firms have developed strong linkages to EU buyers, and Mexican firms to US buyers. In some industries, increasing production costs and longer lead times in China, and the need for closer relationship with suppliers, have led EU and US lead firms to favour regional sourcing (Bair, 2006; Ivarsson and Alvstam, 2010; Pickles *et al.*, 2006). Finally, large emerging economies are increasingly focused on supplying regional markets in order to cope with the decline in demand from Northern markets, which had a disproportionately negative impact on producers of intermediate goods (Escaith, Lindenberg and Miroudot, 2010; Ferrantino and Taglioni, 2014; Gereffi, 2013).

RVCs are becoming strategically important for African policy-makers too. Traditional markets are no longer fast-growing, and are supplied by increasingly large, competitive and established suppliers. SSA's manufactured exports to developed economies fell from 5.1% of GDP in 2006 to 2.9% in 2013 (UNCTAD, 2016). Conversely, regional markets are important for value added exports. The bulk of Africa's exports consists of unprocessed commodities: 57% of total exports in 2014 (UNCTAD, 2016). Intra-regional exports however are composed of manufactures (43% of regional exports), and processed

commodities (22%). Even if intra-regional exports are low (20% of total exports in 2014), they accounted for 42% of the manufactured exports growth in 2000-2014.

Regional demand is growing. Africa's urbanisation and high economic growth are underpinning fast-growing demand for value-added goods and services. Africa's middle class is larger, younger, more urbanized, and more embedded in the private sector than even before (Handley, 2015). Africa's urban population growth is the world's highest, at 3.55% in 2010-2015 (World Urbanisation Prospects, 2016). In absolute terms, by 2030, an additional 300 million dwellers will join today's 470 million. Over a quarter of the 100 fastest-growing cities in the world are now in Africa (UN-Habitat, 2014). At the same time, more than 20 African countries have graduated to middle income status in recent years (Resnick, 2015).

The rise of the middle class has a distinctive impact on both demand growth and composition. For example, in Eastern and Southern Africa, a seven-fold increase in consumption of high-value processed foods is likely by 2040 (Tschirley, Haggblade and Reardon, 2013). Indeed, major international consultancies identify supply to the growing middle class as Africa's top investment opportunity for global businesses (The Boston Consulting Group, 2014; Deloitte and Touche, 2013; Euromonitor International, 2016; PricewaterhouseCoopers, 2015). In the SADC region, high growth demand has underpinned the development of RVCs driven by South Africa's apparel retail chains (Morris and Staritz, 2014; Morris, Staritz and Barnes, 2011), supermarkets (das Nair and Chisoro, 2015; Weatherspoon and Reardon, 2003), and agro-processing corporations (Ncube, Roberts and Zengeni, 2016).

For most African countries, domestic markets are too small to support significant industrial upgrading and scale economies. They need to tap into growing regional demand and continue building on existing efforts to integrate regional markets. Africa's RECs have established institutional frameworks for trade and investment liberalization, infrastructure development and regional industrialisation. These provide an important platform to deepen cooperation in industrial policy.[1]

RVCs can be particularly conducive to African firms' upgrading and risk diversification strategies. In GVCs, firms from developing countries have struggled to move into the most knowledge-intensive and

[1] REC-level industrial policies and strategies include the West African Common Industrial Policy, the East Africa Community (EAC) Industrialisation Strategy, the Common Market for Eastern and Southern Africa (COMESA) regional value chain strategies, the Southern African Development Community (SADC) Industrial Development Policy Framework, the Africa Agro-business and Agro-industry Development Initiatives (3ADI) and the Accelerated Industrial Development of Africa (AIDA).

profitable activities such as product design, marketing, branding and distribution (Bair and Gereffi, 2001; Giuliani, Pietrobelli, and Rabellotti, 2005; Humphrey and Schmitz, 2000, 2002). Conversely, regional markets are less demanding and less standard-intensive, they require less sophisticated branding and marketing capabilities, consumer taste tends to be similar to domestic markets, and there are established distribution networks. Information on prices and costs in neighbouring markets is also more easily accessible. Hence, regional markets may be more conducive to firms moving up the value chain. This has been found to be the case in a number of important value chains in Latin America, Asia and Eastern Europe (Bazan and Navas-Alemán, 2003; Navas-Alemán, 2011; Pickles *et al.*, 2006; Sturgeon and Kawakami, 2010). Supplying RVCs is also a risk-diversification strategy for firms affected by slow growth of demand in the EU and US markets. In Eastern and Southern Africa, food producers that traditionally serve the EU supermarket chains have started supplying regional supermarket chains because of less demanding requirements of buyers and lower price volatility (Barrientos *et al.*, 2016).

2.2 Opportunities in the mining capital equipment industry

The potential to industrialise leveraging natural resources is often viewed with scepticism. The Dutch Disease and rent-seeking by political elites have been identified as the main culpable for this *natural resource curse* (Auty 2001; Sachs and Warner 1997). Nevertheless, some resource-rich countries did manage to pursue industrialisation successfully, by progressively diversifying their economic structures but also by developing industries that lie upstream and downstream to their resource sector. Because of globalisation and technological innovations, geographical proximity to resources, which played an important role in the past, is less relevant today. However, history suggests that there are factors which can be pivotal in fostering resource-based industrialisation.

In this respect, the experiences of Scandinavian countries, Australia, Scotland and the US provide key lessons for Southern Africa (Andersen 2012; Blomström and Kokko, 2007; David and Wright 1997; Raines, Turok and Brown, 2001; Wright and Czelusta, 2007). All these economies invested in domestic technological capabilities, in particular in engineering and technical education, training, and R&D. Over time, national systems of innovations emerged with strong linkages between research institutes, universities, extractive companies, and supplier firms. In the early stages, inflows of foreign capital and skills enabled technology and knowledge transfer which was made possible by previous investment in domestic capabilities. In Norway, state ownership of natural resources was strategically important to catalyse investment in domestic innovation and production capabilities. With time, these countries developed sophisticated capabilities in capital equipment and specialised services, which have often migrated to other industries or the export market. The opportunities for the development of downstream and upstream industries, which hinge on technological innovation, advancement of skills, and capital

accumulation, are however country- and sector-specific (Andersen 2012; Fessehaie, Rustomjee and Kaziboni, 2015; Morris, Kaplinsky and Kaplan, 2012).

Mining capital equipment covers a broad array of equipment to explore, extract, and process minerals. The industry is important for several reasons. Firstly, although it is a capital-intensive sector, there are significant backward linkages to metal fabrication and component manufacturing which open opportunities for job creation in small and medium sized firms. Significant job creation and value addition also take place downstream, in the aftermarket services sector, as discussed in the next section. Moreover, mining capital equipment is linked to the development of engineering and technical skills and can spur important technological innovation and adaptation capabilities.

Lateral migration of technologies to non-resource sectors can promote further manufacturing growth, job creation and technological advancement. Country experiences suggest there are opportunities for lateral migration, for example, into the agriculture, forestry and transport sectors (Tordo *et al.*, 2013). For example, after the 2008 crisis, copper mining companies cut procurement spending or suspended operations altogether. In response, engineering companies in Zambia diversified away from mining (Table 1). Firms moved into the construction, forestry, and utilities sectors. Government in particular was seen as a low-risk market. Other suppliers targeted Lafarge (cement) and Zambia Sugar, two of the largest non-mining corporations in Zambia, as well as oil marketing companies and breweries.

In South Africa, a company developed composite packs that reduced underground mining fatalities caused by rockfalls and seismic activity and were later used for anti-terrorism policing (Walker and Minnitt, 2006). In South Africa, the Statscan (formerly Lodox) system, a low-radiation full body imaging device initially developed to control theft by workers from diamond mines was later adapted to the medical industry for emergency situation x-rays (Altman, 2007).

Table 1: Market diversification strategies for selected suppliers

Sector	New target markets
Compressors and other capital equipment distribution	Oil marketing companies, industrial sectors
Electric products	Transport, government procurement, corporate and exports
Electric products	Breweries, oil marketing companies

Engineering products	Corporate, farming
Electrical engineering	Corporate
Equipment supplier	Corporate
Fabrication	Agriculture, transport
Gas products	Corporate, households
Hydraulic equipment	Transport, industrial hydraulics, farming
Limestone and hydrated lime	Sugar refinery, households
OEM equipment	Construction, forestry
OEM pumps	Water utilities
Steel fabrication	Utilities, oil marketing companies, government procurement
Steel fabrication	Construction
Wire manufacturing	Corporate

Source. Fessehaie (2012)

3 The value chain for mining capital equipment

3.1 Global dimension

Capital equipment requirements vary by type of mining operation (open cast, underground) and project phase (exploration, development, extraction, material handling, and mineral processing). This research focuses on the demand for capital equipment in the operational phase of a mining project, namely material-handling equipment (load-haul dumps, articulated dump trucks), and mineral-processing equipment (crushers, grinders, pumps, valves, conveyors). The operational phase of a mining project requires a broad range of machineries and services and supports entry by a large number of suppliers at different levels of capital and skills intensity. This offers opportunities for entry by developing countries' firms. Conversely, mining exploration relies heavily on knowledge- and skill-intensive inputs provided by specialised suppliers of geo-chemical and geo-physical services. Mining design, construction and refining plants are usually sub-contracted to specialised project design consultancy firms and large mine construction contractors from a restricted number of countries.

As a general trend, mining corporations have been under pressure to reduce costs and increase productivity. During the 1980s and 1990s, and later after the 2008 economic crisis, this was a response to depressed commodity prices. Supply chain strategies determined the profitability of mining operations. Developing organisational capabilities to manage complex financial and production

networks became even more important in light of increased internationalisation of companies. Just-in-time, total quality management and total cost management are the cost-saving managerial practices used in purchasing and supply chain management. The focus on Total Cost of Ownership (TCO) means that procurement decisions aim to reduce long-term costs inclusive of capital, maintenance and operational expenses. Supplier selection is not only based on the initial purchasing price, but also on product quality and performance, availability of aftermarket services and innovative features (such as energy- or labour-saving technologies).

On the supply side, three important changes have taken place in the last two decades. First, the industry has become highly concentrated, because global Original Equipment Manufacturers (OEMs) have pursued mergers and acquisitions as an avenue to acquire new intellectual property and innovation capabilities, expand their range of products, access regional markets and reduce competition. Few players dominate several product markets at global level. For example, Sandvik, Atlas Copco, and Caterpillar dominate the market for Load Haul Dumps (LHDs), trucks, drills and bolters (RMG and Parker Bay, 2012).[2]

Second, global OEMs are increasingly outsourcing manufacturing operations. Whilst IP-intensive components are still manufactured in-house, OEMs are relying on global supply chains for heavy fabrication work and standard components. Third, OEMs are characterised by a process of *servicification of manufacturing*, which refers to an increasing share of services used as inputs into manufacturing, either produced in-house or bought from third parties, and sold as a bundle with the physical products (National Board of Trade, 2010). Table 2 shows the services acquired and sold by the Swedish OEM Sandvik, a key player in the mining equipment industry. The company sources approximately 40 types of services, either in-house or acquired from third parties, and sells approximately 15 types of services. In 2011, 40% of Atlas Copco's revenues came from the aftermarket and rental/leasing division (National Board of Trade, 2010).

Table 2: Composition of services acquired and offered by Sandvik Tooling

SERVICES ACQUIRED
Legal services; Accounting, book-keeping etc.; Taxation services; Placement of personnel
Computer services; Educational services; Environmental services; Banking services; Insurances

[2] Other important global players in mining and processing equipment are Furukawa (underground and surface drilling equipment), Joy Global (open-pit mining equipment), Komatsu (mining extraction and haulage equipment), Boart Longyear (underground and exploration drilling equipment, rock drilling tools), Metso (grinding mills), Weir Minerals (pumps and liners), Outotec and FLSmidth (grinding mills).

R&D; Design
Advertising; Market research
Services incidental to manufacturing; Maintenance and repair; Energy services
Packaging; Printing; Publishing; Photographic services; Audio-Visual services
Courier services; Logistic services; Postal services; Telecommunications; Hotels and restaurants; Travel agency services; Maritime transport – freight; Inland waterways – freight; Inland waterways – freight; Air transport – freight/passenger; Road transport – freight/passenger; Cargo-handling services; Storage and warehouse services; Freight transport agency services; Feeder services
Rental/Leasing; Security services; Building cleaning services; Medical services; Health related services

SERVICES OFFERED
R&D; Design; Computer services
Rental/leasing; Financial services
Management consulting; Technical testing and analysis services; Services incidental to manufacturing
Maintenance and repair
Environmental services; Logistics; Warehouse services

Source: National Board of Trade, 2010

Two types of services are particularly important: R&D and aftermarket services. OEMs have internationalised their R&D activities across the globe, including in emerging economies, and have formed technology alliances with the mining companies. Equipment manufacturers have become the key source of innovation in the industry, mainly in the form of incremental product innovation. Global OEMs allocate very large budgets to R&D in order to reduce TCO for customers, and deliver improvements in energy efficiency, operational productivity, worker safety and health, and environmental impact. OEMs are also increasingly expected to provide 'full-package solutions', where they manage an entire segment of the supply chain on behalf of their customers.

Aftermarket services have taken on strategic importance. In light of commodity price volatility and significant year-on-year demand fluctuation, the market for spares, repair, and maintenance has become a profitable and stable revenue source. Table 3 provides an illustrative example of the size of the repair and maintenance market for mining and mineral processing equipment. The expenses on repair and maintenance (Stay in Business expenditures) over an average 30 years lifespan of a mine totalled up to 35 times the initial expenditure. Processing plants offer overall the highest aftermarket opportunities in particular for grinding mills, cyclones and pumps (because of large numbers of units installed) and crushing plants. In mining, LHDs and continuous mining machines have the largest aftermarket services. When markets are sufficiently large, OEMs invest in local subsidiaries to capture these

revenue streams. This investment impacts positively on employment and upskilling of the workforce - especially when OEMs invest in training academies and overseas training.

Table 3: Aftermarket sales for mining and mineral processing machinery

Mining equipment	Initial	Total SIB	Ratio SIB:initial	Processing equipment	Initial	Total SIB	Ratio SIB:initial
Underground loaders (LHDs)	1.9	27.0	14 :1	Grinding mill, rod & ball	5.5	197.6	35 :1
Shovels, hydraulic	15.9	179.3	11 :1	Cone crushers	4.0	65.0	16 :1
Continuous miners, u/ground	3.2	35.9	11 :1	Mobile crushing plants	1.2	17.7	15 :1
Roof bolters	1.4	16.5	11 :1	Gyratory crushers	13.0	170.0	13 :1
Tunnel boring machines	19.0	210.9	11 :1	Grinding mill, SAG	13.5	181.7	13 :1

Source. Virgo, Armstrong and Alftan, 2013

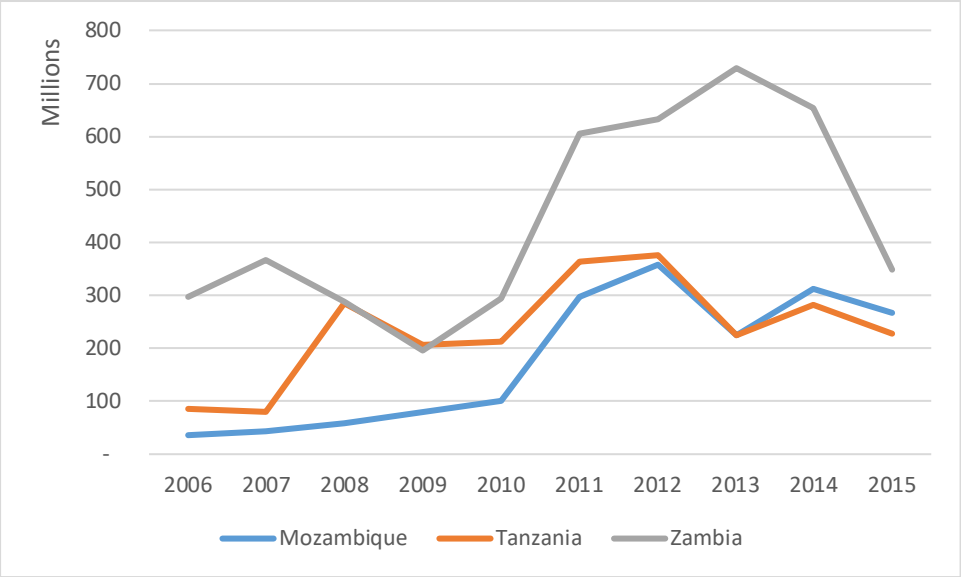
3.2 Regional dimension

In Southern Africa, the market for mining capital equipment is significant both in terms of production capabilities and demand growth. In terms of production capabilities, as discussed in the next section, South Africa has developed a world class manufacturing sector, mainly located in Gauteng. Levels of manufacturing capabilities vary across the rest of the region, with higher capabilities in Zambia than in Mozambique and Tanzania.

Regional demand has grown significantly on the back of FDI in the mining sector, recovering substantially after the 2008 crisis but declining again in 2014 following the closure of Chinese mining operations. Imports of mining capital equipment have been particularly high in Zambia, with more than US$ 600 million worth of imports annually between 2011 and 2014 (Figure 1). Cumulatively, over the

past decade, imports totaled US$ 4.4 billion in Zambia, US$ 2.3 billion in Tanzania, and US$ 1.8 billion in Mozambique.

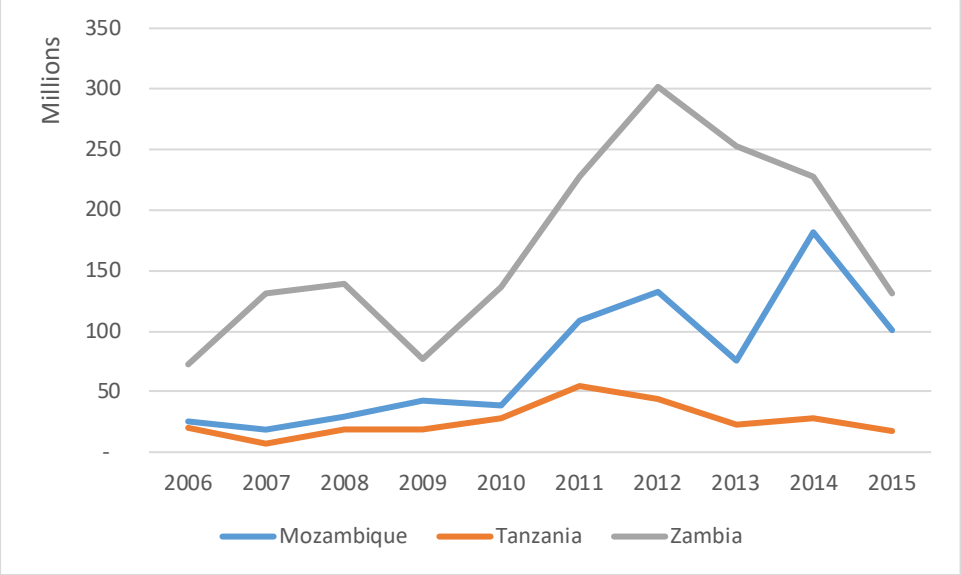
Figure 1: Imports of mining capital equipment



Source: COMTRADE Database, accessed from http://comtrade.un.org/ in June 2017.

In absolute terms, Zambia is a major destination for South African exports of mining capital equipment, peaking at US$ 300 million in 2012. To a lesser extent, so is Mozambique (Figure 2). In Tanzania, imports have been mostly below US$ 50 million per year during the past decade. Table 4 shows South Africa's market share in the three countries. South Africa is the key supplier of mining machinery to Mozambique, and to a lesser extent, Zambia. In both markets, it faces stiff competition from suppliers from the North (EU, US, Australia), Turkey and China, although Chinese imports into Zambia have declined following the closure of the Chinese-owned mines. Tanzania's main sources of mining machinery are China and India, with South Africa's market share relatively small, and in decline.

Figure 2: Imports of mining capital equipment from South Africa



Source: COMTRADE Database, accessed from http://comtrade.un.org/ in June 2017.

Table 4: Top sources of mining capital equipment imports, market shares and import growth 2011-2015

Zambia			**Tanzania**			**Mozambique**		
	Share	Growth		Share	Growth		Share	Growth
World	1	-6	World	100	2	World	100	2
South Africa	36.8	-14	China	50.2	31	South Africa	57.6	3
China	20.5	-14	India	15.9	21	Portugal	9.9	19
UK	4.8	14	South Africa	9.5	-24	China	8.8	44
Australia	4.5	27	Indonesia	5.7	-3	Austria	7.4	23
Canada	4.5	73	France	3.4	14	Turkey	3.3	63
USA	3.6	42	USA	2	-16	India	2	-43
Turkey	3.6	170	Italy	1.7	-21	Italy	2	2
India	3.3	-13	Turkey	1.7	0	Spain	1.7	75
Finland	2.5	-2	UK	1.3	-2	UK	1.7	107
Germany	1.4	31	Germany	1.3	-10	France	1.1	61

Source: Trademap Database, accessed from http://intracen.org/ in June 2017.

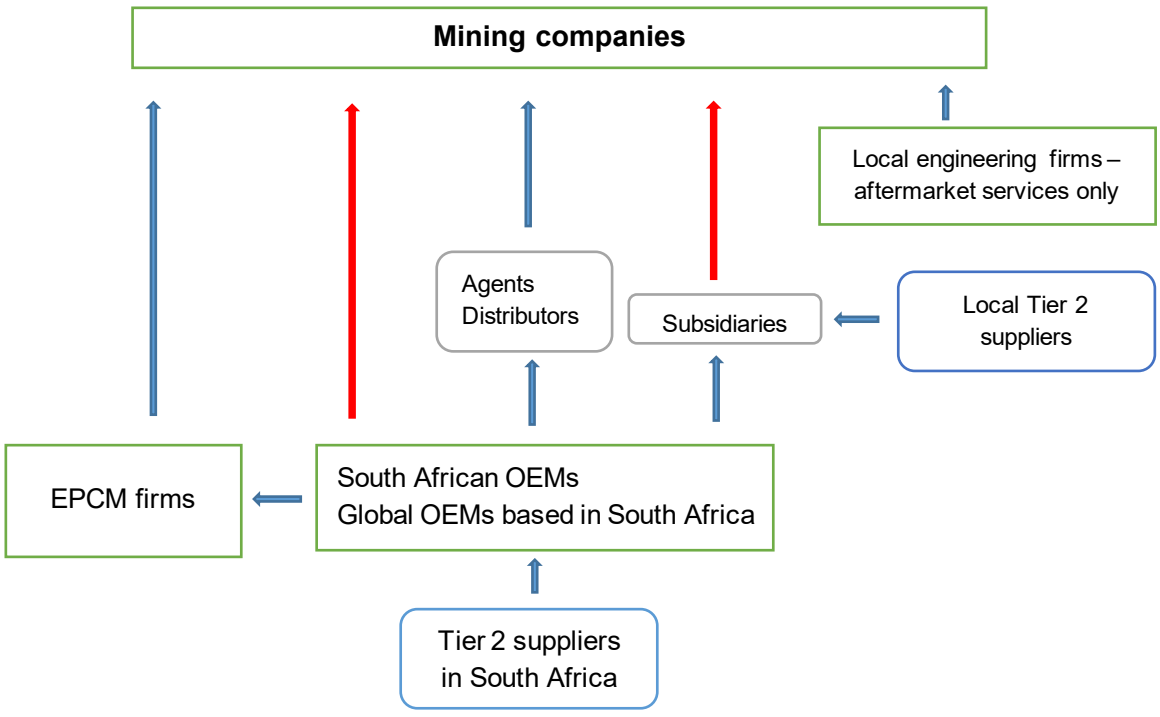
Figure 3 depicts the RVC for mining capital equipment. Mining companies in South Africa, Mozambique, Tanzania and Zambia source capital equipment in two ways: 1) directly from the OEMs or OEM subsidiaries; 2) indirectly from engineering, procurement, construction and management (EPCM) firms, agents and distributors.

1) Direct sourcing from OEMs

Mostly, OEMs are based in South Africa to supply the regional market and include both South African OEMs and global OEMs (EU, US, Australia). Some of the largest OEMs have subsidiaries across the region, sometimes in JVs with local firms. Two of the three global leaders in key mining equipment, Atlas Copco (Sweden) and Sandvik (Sweden), have subsidiaries in South Africa (where they offer the entire range of aftermarket services), Zambia, Tanzania, and Mozambique. Caterpillar uses local dealers, with Barloworld South Africa also serving Mozambique, and Mantrac Group providing services in Tanzania.

Given Zambia's large number of mines, and its proximity to mines in the Democratic Republic of Congo, the number of OEM subsidiaries is particularly high. Mining companies source directly from the OEMs based in South Africa or local subsidiaries (red arrows in Figure 3), through multi-year contracts inclusive of aftermarket services. The network of Tier 2 suppliers, i.e. suppliers of components and materials to OEMs, is relatively well-developed in South Africa, but weak or non-existent across the region.

Figure 3: Regional mining supply chain



Source: Author's fieldwork

2) Indirect sourcing from EPCM firms, agents and distributors

The mining companies can also source equipment indirectly (blue arrows in Figure 3). EPCM firms are sub-contracted by mining companies to develop greenfield and brownfield projects. Under these arrangements they are responsible for the procurement of capital equipment to be integrated into complete systems. Their decisions on system specifications at the plant design stage lock mining companies into long-term contracts with the OEMs. Many EPCM firms have regional offices in South Africa, where they have access to a skilled workforce, a sophisticated physical infrastructure, and specialised suppliers. Procurement from EPCM firms is common across the mining industry, but the degree of local sourcing depends largely on the availability of competent suppliers and existing collaborations with specific technology providers. In Africa, local sourcing from EPCM firms has obviously been lower than in Australia and Russia.

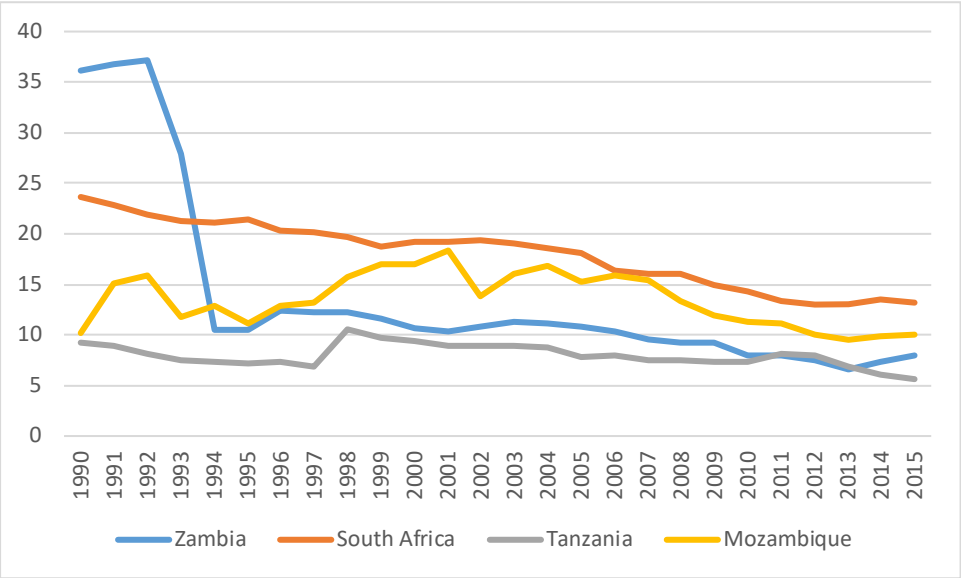
Indirect sourcing also takes place through large networks of local agents and distributors. Some of these firms have exclusive distributorship and/or equity relationships with the OEMs, receive substantial support from them, and engage in value-added services such as repair and maintenance. Other firms are small trading agents, involved in activities requiring minimal skills or knowledge. Political connections may give some of these firms an advantage in securing contracts, but these firms seldom improve the overall value change. In Zambia, there is also a network of long-established local engineering service providers specialised in aftermarket services only. They are fairly competitive because their proximity to the mines ensures short lead times.

4 Capabilities in capital equipment and metal fabrication

4.1 Technological capabilities in capital equipment and metal fabrication

Production and technological capabilities in the mining capital equipment industry vary considerably across the region. However, across all countries, this industry's performance needs to be contextualized within the broader process of de-industrialisation. Manufacturing value added (MVA) contribution to GDP in South Africa and Zambia has been characterised by a consistent decline, particularly in Zambia (from 36.1% in 1990 to 7.9% in 2015) (Figure 4). In Mozambique, MVA contribution to GDP has been stagnant, until the entry of the aluminum smelter MOZAL, which was estimated to contribute up to half MVA in the 2000s (Castel-Branco and Goldin, 2003). MVA contribution to GDP has since the 2000s been in decline. In Tanzania, MVA contribution to GDP rose in the late 1990s and early 2000s but stagnated during the rest of the 2000s. In the past five years, it declined significantly (from 8.1% in 2011 to 5.6% in 2015).

Figure 4: Manufacturing Value Added as % of GDP



Source: World Development Indicators, retrieved from http://databank.worldbank.org/

In Mozambique, Tanzania and Zambia, the machinery and metal fabrication sector has been characterised by declining output and shrinking technological capabilities (Fessehaie, 2012; Msami and Wangwe, 2016; Sousa Cruz *et al.,* 2016). Industrial production is increasingly concentrated in few, large firms, and a multitude of small-scale, informal businesses (Msami and Wangwe, 2016; Sutton, 2014; Sutton and Langmead, 2013; Warren-Rodríguez, 2008b). The three countries share challenges related to lack of management and technical skills; poor access to credit, technology, and business development services; weak national quality assurance systems; uncompetitive upstream industries; and costly and unreliable infrastructure. Stakeholder interviews confirm that costly and unreliable utilities and lack of finance are the most serious constraints to growth in the sector.

In Mozambique and Tanzania, there are further constraints related to burdensome regulatory and administrative environment (ODI, 2016; Wangwe *et al.*, 2014; Warren-Rodríguez, 2008b). Interviews confirm for example that South African OEMs operating in Mozambique struggle with understanding laws, excise and customs regulations (Langa et al., 2017). Moreover, inefficient bureaucratic procedures at the Mozambique-South Africa border increase logistics costs. In Tanzania, port clearance and administration fees and charges amount to 1.6% CIF value of imports, increasing inputs costs for local manufacturers.

There can be dramatic differences in technological capabilities between local manufacturing firms and OEMs. Local manufacturers in Mozambique, Tanzania and Zambia are mostly involved in metal casting and fabrication. Over time, their capabilities and competitiveness have declined. On the other

hand, OEMs have invested to expand their distribution network, with subsidiaries or agreements with dealers. The largest ones employ few hundred workers, a relatively large number compared to local firms. In Zambia and Tanzania, most technical positions are filled by nationals; Mozambique has a higher presence of foreign staff in OEM operations. Workers are semi-skilled and skilled. The subsidiaries or their large distributors, such as Mantrac and Barloworld, invest significantly in-house and external training. For example, OEM subsidiaries in Zambia's Copperbelt invest heavily in training, unlike other types of firms (agents, independent manufacturers) (Table 5). Training is done in-house and in South Africa, less often in the home country of the parent company. Support to local TEVT institutes and universities is not common. Other illustrative examples as far as Tanzania is concerned include Mantrac providing management, technical, product-related, and competency-based training, as well as safety training to its engineers; and Atlas Copco providing mechanical, electromechanical, and mining engineering applied training.

Table 5: Supply firms investment in skills development in Zambia, 2014

	Invest in skills development	In-house	In South Africa	Abroad	Support to local institutes
OEM Subsidiaries	100%	100%	100%	50%	17%
Others	17%	17%	0%	0%	0%

N= 34 firms. *Source. Fessehaie, 2015*

Though OEM subsidiaries do not assemble locally, some, such as Mantrac Tanzania and Sandvik Zambia, are involved in machine re-conditioning. A large segment of OEM business is repair and maintenance, which is often provided under warranty. This area has generated significant employment and skills development opportunities. According to interviews, contracts with two mega-projects in Mozambique allowed one large foreign firms to diversify into parts manufacturing, which now represents 40% of the turnover (Langa et al., 2017). OEMs rely on engineers and technicians from abroad for the most complex repair tasks. This is especially the case in Mozambique and Zambia, where proximity to South Africa may have discouraged additional investment in skills and equipment to provide all repair services from local resources.

Local sub-contracting is very limited across Tanzania, Mozambique and Zambia. Most parts and components are procured by the head office through a global network of suppliers. For example, one of the OEMs interviewed reported that parts and components are purchased by suppliers across 32 countries. Only in South Africa are local manufacturers competitive in supplying OEMs with specialized, higher-tech components which are less price-sensitive. According to the interviews, key

bottlenecks in local supplier capabilities relate to price competitiveness, product design, and certification.

4.2 Contextualizing capabilities within broader developments in the mining sector

The structure of the mining capital equipment industry in the four countries stems from the history of their mining sectors. In South Africa and Zambia, large-scale mining dates back at least a century: gold, diamond, coal, chrome, and platinum mining in South Africa, and copper mining in Zambia. Protectionist policies in apartheid-era South Africa and post-independence in Zambia leveraged the mining sector to develop local engineering manufacturing industries. These policies were accompanied by significant investment in education and, in South Africa, R&D.

South Africa's innovation efforts were driven by the private sector-funded Chamber of Mines Research Organisation (COMRO) and supported by a very dynamic national system of linkages between mining companies, suppliers, research centres, universities and technical and artisanal schools. Over time, the capital equipment industry became particularly innovative in the areas of mineral processing and deep mining (Walker and Minnitt, 2006). However, since the 1990s, a combination of lower funding from the private and public sectors to domestic R&D, internationalisation of mining and supplier companies, and reduced investment in skills development, has led to a considerable reduction in innovation capabilities and a shift from long-term, 'blue sky' R&D to short-term product development (Walker and Minnitt, 2006). While South Africa retains a comparative advantage in mining-related innovation, the decline of its national system of innovation is eroding its capacity to sustain such competitiveness in the future (Kaplan, 2012). The industry has also witnessed increased levels of import penetration, because global OEMs have established subsidiaries to serve the region, but with little investment in R&D or manufacturing, and because standard components are increasingly imported from low cost countries.

In Zambia, government support for a domestic capital equipment industry in the 1970s and 1980s never led to the level of competitiveness achieved by South Africa. However, it did create a relatively large and diversified manufacturing basis, with access to skilled workforce (Fessehaie, 2012). The trade liberalization and privatization process in the 1990s largely coincided with the erosion of manufacturing capabilities in Lusaka and the Copperbelt. In terms of capital equipment, most OEMs re-organised their value chains by moving away from manufacturing and investing in marketing, distribution, and aftermarket services. This was done either by establishing subsidiaries in Zambia, or in South Africa to serve Zambia; or through a large network of agents and distributors. Engineering capabilities can be found in the local fabrication, repair, and maintenance services. There are also manufacturing firms supplying fabrication work, components, and mill balls.

The trajectory of the mining capital equipment industry has been very different in Mozambique and Tanzania. In both countries, large-scale mining is relatively new. In Tanzania, before the late 1990s the sector was dominated by small-scale gold mining, which does not offer the same opportunities for upstream industry linkages, R&D, and skills development as large-scale mining. Since the late 1990s, large mining conglomerates invested in Tanzania's gold, diamond, nickel, uranium, coal, iron, and natural gas sectors. In Mozambique, large investment in mega-projects since the late 1990s included MOZAL (aluminum smelting), SASOL (gas deposits), and Companhia Vale do Rio Doce (coal deposits).[3] Future investments in liquefied natural gas are expected to turn the country into one of the world's largest producers.

In Tanzania, there has been a recent revival of the metal fabrication industry (Gray and McMillan, 2016). Output growth has been significant for machinery and equipment (60% in 2010-2012), basic metals (47% in 2010-2012), and fabricated metals (32% in 2010-2012) (Wangwe *et al.*, 2014). Metal fabrication is dominated by six large domestic firms and a large number of SMEs (Gray and McMillan, 2016). Their main activities include steel/aluminum making from scrap; fabrication and body building and; making wires, structures, and other inputs into the construction industry. However, the industry is relying mostly on imported intermediate products (Wangwe *et al.*, 2014). It has also established the Steel Manufacturers Association of Tanzania.[4]

Linkages between the industry and the mining sector are very weak (Gray and McMillan, 2016; Mjimba, 2011; Perkins and Robbins, 2011). This is due to low supplier capabilities but also the geographical remoteness of the mining companies, which increases cost of supply, and reduces agglomeration economies (Perkins and Robbins, 2011). The mining companies import machinery directly or indirectly through OEM subsidiaries (Mjimba, 2011). South Africa is a key supplier of mineral processing machinery and systems.

Mozambique's manufacturing performance after the late 1980s reforms has improved compared to the previous period of centralized economic planning. However, this improvement has coincided greater concentration of manufacturing into a small number of firms and industries without generating

[3] MOZAL is owned by BHP-Billiton (66%), the South African Industrial Development Corporation (20%), Mitsubishi and the Government of Mozambique. Apart from the aluminum smelter, the project also invested in infrastructure development (roads, telecommunications, electricity, water and sewers, and harbours).

[4] Whilst the Morogoro Engineering Cluster was established in 2005 with 60 registered metal companies, stakeholder interviews revealed very little knowledge of this initiative.

significant employment (Sousa Cruz *et al.,* 2016; Warren-Rodríguez, 2008b). While growing rapidly since 2000s, total industrial production has been driven by mega-projects in the aluminum processing, extractive industries, and agro-processing (sugar, forestry) (CCRED, 2017). The metalworking industry generates the largest contribution to manufacturing value added (43%) but has been in decline since the late 1970s (Sousa Cruz *et al.,* 2016; Warren-Rodríguez, 2008b). Currently a small number of metal fabricators mostly based in Maputo province supply metal parts, galvanized steel, and repair and maintenance services (Warren-Rodríguez, 2008b). Overall, the decades after privatization have been characterised by a loss of technological capabilities. New entrants, mostly foreign-owned, have engaged in packaging and assembly of imported intermediate products, while long established firms have moved away from manufacturing into more remunerative specialized engineering services for large clients such as MOZAL (Warren-Rodríguez, 2008b).

Linkages between the local manufacturing engineering sector and mega-projects have been very weak. The most significant linkages built around very large projects have been the result of the MOZAL programme for SMEs undertaken by Centro de Promoção de Investimentos (CPI), under the Ministry of Planning and Development. In 2005, the programme resulted in the establishment of the 660-hectare Beluluane Industrial Park adjacent to the MOZAL smelter. Overall, the programme resulted in firm upgrading and linkage development (Krause and Kaufmann, 2011). In the metalworking (metallurgical) sector, subcontracting to MOZAL resulted in skills and technological upgrading of the SMEs, and a number of joint ventures with specialised foreign suppliers, which contributed to further technological learning, and for three firms even opened access to new markets (Robbins, Lebani and Rogans, 2008; Warren-Rodriguez, 2008a). Nevertheless, recent research shows that the impact of MOZAL on broader industrial development has been limited (Castel-Branco, 2004; Langa and Mandlate, 2015; Robbins et al., 2008). First, linkages have been very limited in scope and number of firms involved because suppliers lack the scale and capabilities required, face high entry barriers, and operate in a difficult business environment. Companies involved in the engineering sector are positioned in low value-added lines of business (supply of simple products, welding, maintenance). MOZAL and its suppliers also failed to invest the resources required to build more complex technological capabilities. Instead, firms diversified into services with low barriers to entry, minimal risks, and/or speculative/rent activities. The sustainability of linkages has also been questioned (Langa and Mandlate, 2015). Local firms that undertook large investment to meet buyer's requirements on quality, management and safety, have struggled to deploy their new capabilities into traditional markets or with other mega-projects.

5 Policy frameworks in Southern Africa

5.1 National policy frameworks

In the 1990s, as part of their structural adjustment programmes, Zambia and Tanzania adopted policies to privatize mining assets and incentivize FDI in the mining sector.[5] These were successful in restructuring the industry by promoting the entry of large mining conglomerates which invested significant resources to re-capitalise the mines or undertake greenfield projects. Since the 2000s, governments have been under pressure to deal with the tax regime and labour conditions prevalent, and increasingly, to open procurement opportunities for local businesses. In both countries, this led to a revision of mining policy frameworks, with new legislation adopted in the late 2000s.[6] Among other provisions, these policies encourage mining companies to increase local sourcing, but do not establish mandatory obligations, specific targets, or monitoring mechanisms. Overall, there has been very limited impact on local machinery and metal fabrication industries (Fessehaie, 2012; Hansen *et al.*, 2014; Mjimba, 2011).

Local content policy in Tanzania is controversial (Kinyondo and Villanger, 2017). The experience with mining has shaped the approach of local content in the oil and gas industry. The 2017 Mining Act and 2015 Petroleum Act include local content provisions. The mining local content (40% local content target) provisions refers to local procurement rather than local ownership or local value addition (Lange and Kinyondo, 2016). Respondents highlighted that the mining local content policy had increased opportunities for the private sector, but not necessarily for manufacturers. Conversely, the 2015 Petroleum Act, and recently approved local content legislation (July 2017), define obligations in terms of ownership and use of domestic human and material resources and services.[7] Government is in the process of finalizing regulations which will set concrete targets, as well as implementing and monitoring mechanisms.

From the mid-1990s, Tanzania's government brought industrial development back onto its agenda with the 25-year Sustainable Industrial Development Policy (SIDP2020) which seeks to promote economic transformation (Wangwe *et al.,* 2014). Similar to the mining legislation, the industrial policy reflects

[5] In Zambia, this was done through the 1995 Mines and Minerals Development Act; in Tanzania through the 1997 Mining Act and the 1998 Mineral Policy.

[6] Zambia 2008 Mines and Minerals Development Act; Tanzania 2010 Mining Act and 2009 Mineral Policy.

[7] Under the Petroleum Act, the National Oil Company and the newly established, Petroleum Upstream Regulatory Authority (PURA), have the mandate to promote local content (Kinyondo and Villanger, 2017). The licensee's procurement plans and local content plans should be submitted to PURA, along with a detailed local supplier development program.

the objective of increasing upstream linkages to the resource sector.[8] The planned interventions include the development of the Mtwara special economic zone (SEZ), an oil and gas corridor. Metal fabrication has been encouraged by measures such as an export ban on scrap metal and import protection on metal bars (Gray and McMillan, 2016). Government is also engaging with foreign investors in practical ways: foreign investors are encouraged to share information on the standards of procured inputs with Tanzania Bureau of Standards, the Engineering Board and potential local suppliers. However, there are concerns over inadequate leadership, resources and institutional capabilities to address structural competitiveness bottlenecks and ensure policy implementation (ODI, 2016; Wangwe *et al.,* 2014).

In Zambia, the link between industrial policy and local content has been weaker than Tanzania. Recent industrial policies, such as the 2012 Strategy for Industrialisation and Job Creation, and the 2012 Engineering Products Industrial Strategy, do not explicitly target the development of engineering manufacturing capabilities to supply the mining sector. However, in 2013, the private sector took a leadership role, as the Chamber of Mines of Zambia and the Zambia Association of Manufacturers, working closely with government, mining companies, and other key stakeholders, established the Zambian Mining Local Content Initiative (ZMLCI). The ZMLCI mainly focuses on a business-to-business platform and providing technical support to local firms.

In Mozambique, investment and industrial policies have no local content provisions (Robbins, Legani and Rogan, 2008). The MOZAL linkage development programme was successful because it was supported by large corporations and international financial institutions. However, less well-defined interventions tend to be poorly implemented (Castel-Branco, 2004). Mozambique's experience with MOZAL has resulted in a certain degree of institutional capacity building in SME development. This has been enshrined in the 2007 Strategy for the Development of SMEs in Mozambique and a state-owned SME institute, the Instituto para a Promoção das Pequenas e Médias Empresas (IPEME), founded in 2008 to implement the strategy.

Mozambique's overall industrial policy remains weak (Robbins *et al*., 2008; Warren-Rodriguez, 2008a). Except for MOZAL, Mozambique does not have a clear strategy to develop linkages to mega-projects (Krause and Kaufmann, 2011). Since its structural adjustment programme in the late 1980s, industrial policy has focused on horizontal measures such as general FDI promotion and business environment reforms (Krause and Kaufmann, 2011). There has been no selective policy to foster

[8] Both Tanzania's Five Year Development Plan (FYDP) and Integrated Industrial Development Strategy (IIDS) 2025 target the iron and steel industry. One of the key policy issues identified by the IIDS under resource-based industrialization is to link the mining sector development with the rest of the economy, and increase participation by local businesses and citizens.

specific technological capabilities or to create agglomeration economies (Krause and Kaufmann, 2011; Warren-Rodríguez, 2008b). The 2007 Industrial Policy and Strategy focuses on improving the business environment, SME promotion and FDI promotion (Sousa Cruz *et al.,* 2016). Poor policy implementation, low resources, and lack of coordination between interventions of various institutions and NGOs are a problem (Warren-Rodríguez, 2008b).

South Africa's key local content provisions are found in the Mining Charter. The 2002 Minerals and Petroleum Resources Development Act (MPRDA) provided for a Mining Charter to be developed by government and industry stakeholders with the objective of addressing past inequalities in terms of ownership, employment, and business opportunities. The first Mining Charter (2004) required the mining companies to increase opportunities for Historically Disadvantaged South Africans' (HDSA) suppliers. Implementation however was unsatisfactory, and a new Charter was established in 2010, the Broad-based Socio-Economic Empowerment Charter for the South African Mining and Minerals Industry. This Charter sets specific targets in terms of local procurement from Broad-Based Black Economic Empowerment (BBBEE) companies, which for capital goods was 40% of total procurement by 2014.

The 2015 review of the Mining Charter found significant progress,[9] however this has not resulted in increased levels of local value addition. Global OEMs and large suppliers have been able to meet the Mining Charter requirements mostly by supplying via BBBEE importing agents, rather than local manufacturers. Recently, the government has initiated a consultation process with stakeholders to address the impact of mining procurement practices on the local industry, and there is a growing consensus on the need to increase sourcing from and cooperation with the local equipment manufacturing industry. Government is also targeting the mining equipment sector with national and local initiatives such as cluster development, development finance and export promotion.

5.2 Cross-cutting themes

The analysis of policy frameworks in the region highlights some cross-cutting themes.

Policy inconsistency

Across countries, there is a level of internal policy inconsistency. All governments granted the mining companies tax incentives on capital equipment imports. For example, Zambia grants investors duty-free import and value-added tax (VAT) deferment for five years for machinery and equipment. Because

[9] 81.6% of mining right holders met the 2014 target of spending 40% for capital goods (Department of Mineral Resources, 2015). Mining right holders have been weighted by mine size, using employment figures.

these exemptions do not apply to supply firms, the mining companies are discouraged from procuring locally. In theory, the policy permits withdrawal of duty-free incentives once there is local production, however this is seldom implemented (Fessehaie, Rustomjee and Kaziboni, 2015). Moreover, importers pay duties on shipments of spares and components attract. This tariff structure discourages investment in local assembly operations and is an issue of concern for the industry. Similarly, in Tanzania, the mining companies receive a VAT refund on imported equipment, and they report that apply for the same incentive for domestic purchases is more time-consuming (Lange and Kinyondo, 2016). Moreover, import of machinery and spares is duty-free, but import duties apply to inputs into fabrication (Gray and McMillan, 2016). In Mozambique, some firms face duties for inputs when the import tariff for the fully assembled equipment is zero-rated, which makes local assembly less profitable.

Across the region, government pressure to increase local content has often, explicitly or implicitly, been framed in terms of local ownership or local registration. In South Africa, this has been framed in terms of Broad Based Black Economic Empowerment (BBBEE) aimed at redressing past racially discriminatory practices of the apartheid era. In 2010, the amendment of the Broad-based Socio-Economic Empowerment Charter for the South African Mining and Minerals Industry set the following targets in terms of mining procurement from previously disadvantaged groups:

- Procure a minimum of 40% of capital goods from BBEEE entities by 2014
- Ensure that multinational suppliers of capital goods annually contribute a minimum of 0.5% of annual income generated from local mining companies towards socio-economic development of local communities into a social development fund from 2010
- Procure 70% of services and 50% of consumer goods from BBBEE entities by 2014

The 2015 review of the Mining Charter found that the large mining companies were meeting their BBBEE targets, especially for procurement of services. However, the impact of the preferential procurement scheme on industrialisation has been cause for concern. The Mining Charter procurement rules are developed around BEE ownership, defined as 25%+1 BEE. To comply, the mining companies' procurement strategies have focused on the ownership profile of their suppliers rather than job creation and local value addition (Hansen et al., 2014; Fessehaie, Rustomjee and Kaziboni, 2015). In fact, they are incentivised to switch from direct imports to indirect imports through BBBEE-compliant agents. Relying on agents also has the advantage of saving buyers the time and costs involved in complying with import procedures. Agents and distributors are not obliged to disclose their local content. Since 2016, government and manufacturers associations have engaged the mining companies to re-focus their procurement strategies towards local technology development and manufacturing, with some success.

Lead firms

Lead firms can play an important role in promoting local manufacturing upgrading. As far as the mining companies are concerned, the experience with mining supplier development programmes varied. In Tanzania, they have been rare and discontinued quickly (Lange and Kinyondo, 2016). In Zambia, five large mining companies undertook a joint programme, and some have individual supplier development plans, but these have been limited in duration and scope (Fessehaie, 2012). In Mozambique, this experience has been limited to a MOZAL linkage development programme, which has had a positive impact on local technological upgrading, but only on a few firms. The mining companies in South Africa have been relatively more ambitious and consistent in terms of supplier development programmes, facilitated by higher supplier capabilities. For example, an Anglo American enterprise development initiative, Zimele, provided funding to 2300 businesses as of 2017 and established 23 business development centres around the country (Anglo American, 2017). However, such efforts do not necessarily engage local manufacturing or innovative firms, or contribute to re-building the national system of innovation that worked well in the past.

The role of private-sector associations will be critical in designing and implementing industrial policies for the capital equipment sector. In South Africa, the South African Capital Equipment Council is a well-established export promotion body for the industry, which has recently been involved in cluster-type initiatives in the areas of technological upgrading, skills development, and engagement with policy-makers and mining companies, among others. In Mozambique, the Confederação das Associações Económicas de Moçambique (CTA) is the private sector's principal and almost 'official' government interlocutor, with good technical and organisational capacity (Krause and Kaufmann, 2011). In Tanzania, the Tanzania Private Sector Foundation and Confederation of Tanzanian Industries represent the private sector, but more recently the Association of Tanzanian Steel Manufacturers has been established and will represent a key interlocutor in terms of capital equipment value chain development. In Zambia, the Zambia Association of Manufacturers is playing a critical role in promoting local content and is championing a local content policy geared towards local manufacturers rather than trading companies. Across the region, the Chambers of Mines tend to be well organised, and in South Africa, well-resourced as well.

Human capital

Human capital investment is critical to support local capabilities in the capital equipment value chain because it provides skills for productivity growth, technological adoption, and R&D capabilities. South Africa has a well-established tertiary education system in the engineering field, though the South African Chamber of Mines reports shortages of mechanical and electrical engineers (Fessehaie *et al.*, 2015). Similarly, the University of Dar es Salaam has received financial and technical support from the

mining companies for mining engineering courses, but not for mechanical or industrial engineering. There has been no support from the OEMs. As a result, the skills required to support competitive manufacturing sectors are lacking. Across the Southern African region, engineering education at the tertiary level suffers because resources are lacking for infrastructure, apprenticeship programmes, and teaching and academic staff. Declining investment Science, Technology, Engineering, and Math (STEM) education at secondary level also pulls down the overall skill level of the workforce.[10] Respondents have consistently highlighted the weakness of practical skills of students entering the job market, due to weak relationships between training institutes and business, and poor facilities to train engineers and technicians. In Zambia and Tanzania, the weakness of STEM at the secondary level hurts the quality of students entering into tertiary education.

The SADC tertiary education systems struggle to produce the quality and quantity of graduates required by the economy. Table 6 shows mobility rates for in the four countries in 2011. Although not specific to engineering, the table shows that a relatively large proportion of students from Zambia (14.7%), Mozambique (10.6%), and Tanzania (9.1%) study outside their home country. The interview with University of Dar es Salaam confirms that fewer than 10% of engineers are trained outside the country. South Africa is a major destination country for Zambian students, the second most important in Mozambique, but only a marginal one for Tanzania. Consistently with trade patterns, the table shows that Tanzania is not as integrated as Zambia and Mozambique in the Southern Africa RVC. Many Zambian students tend to remain in South Africa and contribute to its private-sector growth in the domestic and regional market, as well as to that country's teaching and research institutes. On the contrary, in Tanzania the 'brain drain' is reversing, according to interviews. Tanzanian engineers used to work in Botswana, Namibia, Swaziland and South Africa. However, many are returning back to Tanzania thanks to good job prospects.

Table 6: Intra-SADC student flow

Country	Students from a given country studying abroad		Top five destinations for outbound mobile students	Number of students from abroad studying in
	Total	Outbound mobility rate (%)		

[10] These include the College of Engineering and Technology, University of Dar es Salaam (UDSM); schools of mines and engineering from the University of Zambia (UNZA) and the Copperbelt University (CBU)

				given country
Mozambique	2366	10.6	Portugal (1,066), South Africa (815), USA (93), UK (71), Australia (67)	n/a
South Africa	5619	0.8	USA (1,971), UK (1408), Australia (643), Cuba (340), Germany (196)	49979
Tanzania	3907	9.1	USA (1,471), UK (1,053), South Africa (283), Australia (119), Germany (115)	275
Zambia	3610	14.7	South Africa (1,363), USA (859), UK (541), Australia (317), Namibia (228)	n/a

Source: CREST (2011)

Technical and vocational skills are a challenge across the region, including South Africa. In South Africa, the mining houses have their own, long-established individual training centres, which are well-equipped and able to offer accredited certifications. Industry however suffers from skills shortages; capital equipment manufacturers report skills gaps for machinists and artisans (electricians, fitters, boilermakers and technical instrumentation). In the rest of the region, skills bottlenecks are even more severe. In Zambia and Tanzania, structured collaborative processes are currently underway between the technical and vocational authorities and the mining companies. In Zambia, the authority, the Chamber of Mines, and individual mining firms are integrating company-specific qualifications into a national qualification framework. The programme seeks to recognize, retrospectively, prior company-specific training, with an initial focus on entry-level skills (heavy equipment operators, crane operators, excavator operators, smelter process controllers, locomotive operators, etc.). In Tanzania, two large gold mining companies have collaborated with the Tanzanian Chamber of Minerals and Energy (TCME) and the authority (the Chamber of Mines) to establish the Integrated Mining Technical Training (IMTT), specifically designed to train artisans (tradesmen). Some respondents reported that the initiative was useful but was too limited to low skill levels (certificate holders and undergraduate trainees). Most respondents however were not aware of this initiative, which suggests that it has had a limited impact so far.

6 Regional cooperation

Deepening regional value chains will require the development of integrated productive capabilities across the region, which will help spark growth in intra-regional flows of intermediate goods, skills, knowledge, capital and services. Cooperation should aim at enhancing capabilities to participate and

upgrade in the mining capital equipment regional value chain both in South Africa, where deepest technological capabilities and knowledge are found, and in Mozambique, Tanzania and Zambia, where capabilities are low. In other words, this process has to result in a win-win outcome, rather than reinforcing existing patterns of development. Before discussing potential areas for cooperation to develop and deepen the regional value chain, we consider the opportunities and the challenges ahead for regional cooperation.

6.1 Opportunities

1) Significant demand

The world market for mining capital equipment was worth US$100 billion in 2016 and estimate suggest it will grow to US$107.3 billion by the end of 2017 (Research and Markets, 2017). The market will grow by a Compound Annual Growth Rate (CAGR) of 7.9% between 2017 and 2022, totaling US$150 billion in 2022. The greatest share of this market is accounted for by surface mining machinery, followed by parts and components, and underground mining machinery. Africa, in particular Southern Africa, is one of the most dynamic markets for machineries required for metals, coal, and minerals mining.

Cumulatively, during the decade 2006-2015, Mozambique has imported US$ 1.8 billion worth of mining capital equipment, Tanzania US$ 2.3 billion, and Zambia US$ 4.4 billion. Though commodity price fluctuations have caused some projects to be temporarily or permanently suspended, the market tends to pick up shortly after economic downturns. Moreover, aftermarket opportunities remain very large (see Table 7).

Table 7: Equipment with large markets for repair and maintenance services and spares

	Equipment with large aftermarket services
Mining equipment	Underground loaders (LHDs) Shovels, hydraulic Continuous miners, u/ground Roof bolters Tunnel boring machines Rotary blasthole drill rigs Continuous miners, surface Backhoes, hydraulic Bucketwheel excavators

	Wheel loaders Shovels, cable Underground ore & coal haulers
Processing equipment	Grinding mill, rod & ball Cone crushers Mobile crushing plants Gyratory crushers Grinding mill, SAG Stackers, conveyor Mill drives, gearless Cyclones Slurry pumps Electric motors Screens

2) Scale of aftermarket services opportunities

Aftermarket services are strategically important for a number of reasons. First, they are a sizeable market, with expenditures on spares, maintenance and repair totaling up to 35 times the initial expense, depending on the machinery. Second, they are a relatively stable source of revenues, because even during economic downturns, mining companies tend to invest to optimize installed equipment utilization. Third, because of aftermarket services, global OEMs tend to invest in facilities in close proximity to the mining companies, and invest in skills development. Governments should leverage this opportunity to attract FDI in local engineering and technical capabilities.

3) Locational advantages

Suppliers located in proximity to the mining companies have several advantages: they can offer short lead times, cooperate closely with customers to address technical problems, and benefit from intense knowledge flows and agglomeration effects. The mining companies have increasingly shifted to the two-fold strategy of outsourcing and *nearsourcing*, preferring to procure from local suppliers a vast range of goods and services, *if supplier capabilities are sufficiently high.*

4) Existing capabilities

South Africa has well established manufacturing and services competences in the mining capital equipment industry. Zambia has lost considerable manufacturing capabilities over the last three decades, but some engineering companies are successfully supplying goods and services to the mining sector. Mozambique and Tanzania have low capabilities. However, in Tanzania there has been investment in skills development and there is a revival of the metal sector. Mozambique has a few firms which have upgraded and provide a range of products and services to MOZAL.

5) Renewed government interest in industrial policy and local content

Industrial policy is back on the development agenda, and governments across the region are increasingly looking at different approaches to local content policies. In Tanzania, Zambia and Mozambique, the approach to local content has been on a voluntary basis, and in the latter two cases, governments nudged mining companies to undertake supplier development programme or favour local SMEs. In Tanzania, however, more recent policy and legislative developments suggest a mandatory approach, complemented by stricter licensing and monitoring provisions.

6) SADC Industrialisation Strategy and Roadmap

SADC provides the regional economic integration framework which enables intra-regional trade and investment, cooperation on trade facilitation, harmonized standards setting and compliance procedures, and so forth. More recently, SADC has also embarked on a regional Industrialisation Strategy and Roadmap which provides an important forum to discuss potential programmes to develop upstream linkages in the mining sector. Moreover, the Africa Mining Vision envisages cooperation in this area.

6.2 Challenges

1) High barriers to market entry

Barriers to entry. These include experience, economies of scale, capital requirements, R&D capabilities, access to distribution channels and global supply chains, international standards compliance, and adoption of world-class manufacturing practices. Local firms across the region struggle to overcome these barriers.

2) Very different levels of capabilities across the region

The region is characterised by a significant disparity in capabilities and competitiveness between South Africa on the one hand, and Mozambique, Tanzania, and Zambia on the other. This dilemma calls for interventions that are jointly designed and developed after extensive stakeholder consultations to deal with potential mistrust. Well-designed and properly resourced interventions should ensure shared benefits from regional cooperation.

3) Capability migration to the gas industry

Mozambique and Tanzania are increasingly looking at local content in the gas industry. Gas and oil however utilize different machinery than the mining industry. This strategy will require bilateral cooperation in particular between these two countries given their shared interest in developing capabilities in this area. The potential for South Africa to migrate some its competencies to gas is also worth exploring.

4) Price volatility

All countries are heavily exposed to commodity price volatility, which in the past few years in particular has hurt mining companies' operations and investment, as well as their suppliers. In Mozambique, a combination of falling commodity prices and macroeconomic crisis are leading many foreign and domestic firms to suspend or close down operations. Others are shrinking (Langa et al., 2017). Firms supplying repair and maintenance functions to mega-projects had to retrench 50 to 80% of their workforce.

5) Internal and regional inconsistency of local content policies

In some countries, there is inconsistency between local content, investment and industrial policies. For example, local content policies may focus on local ownership and not on value addition. Investment incentives may discourage local assembly and local sourcing, while industrial policies are not leveraging the buying power of the extractive industries.

Moreover, each country has framed its local content policy at domestic level, with no consideration for the potential to tap into regional value chains and regional cooperation. Yet, Zambia and Mozambique, for example, there are very clear regional dynamics with South Africa that could potentially be leveraged to support value addition and knowledge transfer processes.

6.3 Potential areas for cooperation

Stakeholders highlight that the most binding constraints to the development of manufacturing capabilities relate to domestic policies. These include competitive access to infrastructure, development finance, skills, and inputs. There is general agreement that stakeholder cooperation needs to be strengthened and that the local content policies, in principle, offer an important opportunity for local manufacturers. However, specific recommendations on other areas vary. Some advocate for protectionist policies, others for better integration into global supply chains of the OEMs.

In light of the opportunities and challenges discussed in the previous section, however, it is clear that there is a role for regional cooperation and potential for win-win outcomes. In the short-term, it is unlikely that global or South African OEMs could sub-contract component manufacturing across the region to a significant scale. Equally, the ability of each individual country, except for South Africa, to develop internationally competitive mining R&D capabilities will require long-term investment. Aftermarket services and locational advantages are important opportunities to localize engineering capabilities which nevertheless require additional investment in skills development.

Policy recommendations

Recommendation	Description	Objectives
Support South African firms in investing in subsidiaries across the continent	South African firms, especially OEMs and engineering firms, should be encouraged and supported in investing in subsidiaries in Africa. Such support should include market intelligence, investment facilitation, and access to capital. Trade Invest Africa (South African Dept. Trade and Industry) has a specific mandate in this regard, and should cooperate with Tanzania, Mozambique and Zambia in order to target the mining capital equipment industry. In order to maximise impact on local value addition, the OEM subsidiaries should invest in capabilities to provide aftermarket services. This approach could be a stepping stone towards re-machining and assembly operations. Aftermarket services are skills-intensive, hence there is need for coordination and strategic partnerships.	In Tanzania, Mozambique, and Zambia, OEM subsidiaries contribute to job creation and skills development. In South Africa, OEMs and engineering firms need to expand into Africa for growth and risk diversification

Prioritize the internal processes required to accede to the Washington, Sydney, and Dublin Accords	Accession to these Accords will require improvement of the quality of tertiary and vocational training systems and the associated national accreditation and quality management systems. This process will also contribute towards the SADC Regional Qualification Framework.	Skills development for manufacturing competitiveness
Develop bilateral, multi-stakeholder initiatives for skills development	Bilateral, multi-stakeholder initiatives focused on skills development should leverage the investments of South African firms in Tanzania, Mozambique and Zambia. In each country, South African OEM subsidiaries, TVET authorities, and local TVET institutes in the Copperbelt and Northwest Provinces (Zambia), Tete Province (Mozambique) and Shinyanga region (Tanzania) should cooperate in the area of curriculum development, training, and apprenticeship.	Skills development for manufacturing competitiveness
Finalise the SADC RQF and prioritise TVET and Engineering qualifications	Progress on the SADC RQF hinders Member States from finalising the establishment of NQFs and NQAs. Recognition and development of minimum standards in TVET and engineering -related qualifications should be a priority.	Facilitate regional flows of skills which are critical for manufacturing. Allow skilled workers to gain experience across the region. Upgrade the NQF in each country.

Promote standards compliance through SADC	SADC has a well-established Standardisation, Quality Assurance, Accreditation, and Metrology Programme, with specialised institutions such as SADCAS. SADC should develop a programme on standard compliance targeting metal fabricators, engineering manufacturers, and service providers in the region. This should be a component of the broader industrial upgrading programme suggested below, because most firms will have to make significant investment in process and product upgrading.	Upgrade productive capabilities in the region
Develop a knowledge sharing platform on local content policies under the SADC Industrialisation Strategy and RoadMap	Setting up regular dialogues to facilitate knowledge-sharing on local content policies, under the umbrella of activities undertaken by SADC. Activity II.2.1. "Creation of a business-friendly and conducive environment for competitiveness" of the Costed Action Plan for SADC Industrialisation Strategy and RoadMap foresees activities related to knowledge sharing. Local content policies are currently being designed or implemented in the mining, oil, gas, and engineering services sectors, and, in South Africa, some manufacturing sub-sectors. Policy-makers need to learn from each other's successes and mistakes in a neutral platform with countries at similar levels of development.	Enhance institutional capabilities in designing, implementing and monitoring local content policies

Promote sub-contracting from OEMs	Mapping local supplier capabilities for parts and components in Zambia, Tanzania and Mozambique, with the objective of developing a supplier upgrading programme. It is important to stress that manufacturing firms need to access the entire SADC market to achieve scale. Products with high potential for local sourcing include electrical cables, electrical panels, fixtures and metal fabricated products, bearings, and tires.	Enhance linkages to local manufacturers
Expand cooperation between universities on training and R&D	MoUs between faculties of engineering in South Africa, Tanzania, Mozambique, and Zambia should encourage, among others, post-graduate training opportunities, research fellowships, and R&D projects. This programme should prioritise training. However, there may be specific opportunities for joint R&D projects, including with Mintek or OEMs.	Enhance human capital and research capacity within universities

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