TRADE & INDUSTRIAL POLICY STRATEGIES

INDUSTRY STUDY

Technological Change in the Capital Goods Industry

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TIPS industry studies aim to provide a comprehensive overview of key trends in leading industries in South Africa. For each industry covered, working papers will be published on basic economic trends, including value added, employment, investment and market structure; trade by major product and country; impact on the environment as well as threats and opportunities arising from the climate crisis; and the implications of emerging technologies. The studies aim to provide background for policymakers and researchers, and to strengthen our understanding of current challenges and opportunities in each industry as a basis for a more strategic response.

This industry study outlines the technological change and processes in the capital goods industry, looking at emerging technologies and their impact. It is the third study focusing on the capital goods industry. The first study mapped out the capital goods value chain, highlighting economic trends and the impact on national outcomes. The second study analysed the industry's international trends, looking global trade and South African trade by country and product.

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ABBREVIATIONS

ADT	Articulated Dump Trucks
AHS	Autonomous Haulage Systems
AI	Artificial Intelligence
AMSA	ArcelorMittal South Africa
CPU	Central Processing Unit
DSI	Department of Science and Innovation
dtic (the)	Department of Trade, Industry and Competition
GHG	Greenhouse Gas
HPE	Hydro Power Equipment
IDC	Industrial Development Corporation
IIoT	Industrial IoT
IoT	Internet of Things
MEMSA`	Mining Equipment Manufacturers of South Africa
MMP	Mandela Mining Precinct
OEMs	Original Equipment Manufacturers
SAMERDI	South African Mining, Extraction, Research, Development, and Innovation (strategy)
SBU	Strategic Business Unit
TMM	Trackless Mobile Machinery

1. INTRODUCION

This industry study outlines the technological change and processes in the capital goods industry, looking at emerging technologies and their impact. The study commences with a discussion of international technological trends including Artificial Intelligence (AI), digital twins, automation, additive manufacturing, and the Internet of Things (IoT). This details the technologies and their impact on the industry. Given that the capital goods industry in South Africa mainly supplies the mining industry, the study connects technological change and processes with their impacts and benefits on the mining sector. The study also shows that digital technologies are transforming capital goods through automation and the IoT. This change in the production process of capital goods has allowed manufacturers to produce products with precision, with sensors embedded in machinery detecting and fixing faults in industrial operations. Digital technologies have reduced downtime, improved uptime, automated manufacturing and industrial processes, and lowered costs for industries.

This is the third industry study on the capital goods industry The first study – Industry Study: Capital Goods in South Africa 2024 – mapped out the capital goods value chain, highlighting economic trends and the impact on national outcomes. It also discussed governance structures and stakeholders and concluded with an analysis of the strengths, weaknesses, opportunities, and threats of the capital goods industry in South Africa.

The second study – Industry Study: International Trends in the Capital Goods Industry 2024 – looked at trends in global trade and South African trade by country and product. The study discussed trends in foreign investment in South Africa, highlighting leading foreign investors and concluded with a discussion on dominant foreign exporters while highlighting their competitive advantages. The capital goods international trends industry study reported that the top five traded products globally included other special-purpose machinery, other general-purpose machinery, pumps, mining machinery, and lifting and handling equipment (Mthembu, 2024). In tandem with these findings, this industry study highlights technological change in pumps, mining machinery, and lifting and handling equipment. Findings show that technological changes in mining machinery and equipment are driven by safety and efficiency improvements while reducing safety risks and costs of production.

This third industry study of the capital goods industry describes technological trends in the industry, the use of technologies in South Africa, and the impact on firms. The study concludes with a discussion on support measures for new technologies.

2. EMERGING TECHNOLOGIES IN THE CAPITAL GOODS INDUSTRY

Emerging technologies in the capital goods industry include AI, digital twins, automation, additive manufacturing (3D printing), and IoT. These technologies are described in Table 1, with their impact on the industry discussed. The development of these technologies is largely owed to digitalisation, as internet connectivity enables the collection and sharing of data. For example, sensors integrated into industrial applications and technologies facilitate industrial processes while monitoring and collecting data. AI analyses the data and assists operators in making decisions, while some technologies can halt or alter the operation when faults are detected.

While digital technologies empower workers through informing decision-making, performing repetitive tasks, and reducing risks to hazards, they are however replacing jobs. Automated industrial processes are also changing skills that are required to perform certain tasks. Opportunities for workers include upskilling, reskilling and improving expertise through training and development programmes to utilise digital technologies or transition into new roles in industrial processes. For businesses, digital technologies present opportunities for reduced costs, defective products and downtime. They can

increase output, improve quality control, and through predictive maintenance improve machine performance. Challenges that emerge include an increased complexity in operating machinery and equipment and issues that may arise with remote control of automated processes and production.

Table 1: Emerging technologies in the capital goods industry

TECHNOLOGIES	DESCRIPTION	IMPACT
Artificial Intelligence (AI)	AI reproduces human intelligence processes through machines such as computer systems. Examples of AI include language models and expert systems. AI optimises equipment performance, maintaining its uptime while reducing its downtime. It also provides real-time data to connected devices.	AI allows technologies and processes to be remotely operated and controlled. Reduces downtime and increases uptime. Informs decision-making through analysing collected data. Mining simulation allows for adequate planning for mining operations and determining equipment utilisation rates. Repetitive, complex, time-consuming, and laborious tasks are performed by AI instead of workers. Improves automation and the ability of self-driving trucks to navigate routes.
Digital twin	A digital twin is a digital visualisation of physical objects and processes. It is created from data collected by sensors and devices, which then creates an AI model to forecast the behaviour of objects and processes.	Provides real-time monitoring and predictive maintenance. Optimises processes and improves production. Improves safety and reduces risks. Improves sustainability of the environment by finding ways to optimise the use of resources.
Automation	Automation refers to automatic production and processes, with fewer interventions from workers. Devices, systems and tools including AI are programmed to perform tasks. Automated machinery and technology can perform tedious tasks, while workers perform skilled tasks.	Improves efficiency, with tasks performed at higher speed by automated machinery and equipment. Reduces production errors, therefore increasing the quality of output. Decreases labour costs, making production capital-intensive. Improves safety, with heavy tasks performed by machinery instead of workers. Easily collects and analyses data to improve technology and processes.
Additive manufacturing (3D printing)	Additive manufacturing refers to the digital manufacturing of objects, by adding layers, using Computer-Aided Design (CAD model) or 3D scanners. 3D printing contrasts with subtractive manufacturing, where parts are removed by cutting, drilling, boring, and grinding as an object is manufactured.	Enables efficient and swift design of manufacturing products resulting in reduced turnaround times and increased production output. Opportunities to change 3D design specifications and reprint a 3D piece in a few hours compared to days needed for traditional designs.

TECHNOLOGIES	DESCRIPTION	IMPACT
	Both processes can be used in tandem because of their overlapping applications. AI in additive manufacturing improves quality, innovation, production, and quality control.	AI designs objects and monitors the production process. AI can identify defects that cannot be detected by a human, therefore reducing the output of faulty products. AI can detect potential faults in the 3D scanning process and remedy faults by itself, ensuring quality control.
Internet of Things (IoT) and Industrial IoT (IIoT)	IoT includes connecting electronic devices through the internet. IoT devices are equipped with technologies including sensors, software and internet connectivity to gather and transmit data, enabling these smart devices to communicate. Integrating IoT into equipment allows for remote monitoring and control of machinery and equipment. IIoT refers to IoT in industrial technologies and processes. IIoT examples include smart manufacturing, with IoT embedded in machinery and equipment to automate and optimise industrial operations. IIoT applications include AI, machine learning, and robotics.	IIoT enables predictive maintenance and can lead to reduced maintenance costs. Real-time monitoring and control ensure overseeing and managing production processes in real-time. IoT and 3D printing enable customisation of products, giving manufacturers a competitive advantage. Cybersecurity is a concern for adopting IoT and IIoT. Technologies and processes must be securely connected.

Source: Adapted from Siemens, 2023.

3. DRIVERS OF TECHNOLOGICAL CHANGE

While digitalisation is at the forefront of driving technological change and processes, environmental concerns promote the use of clean energy by the capital goods industry. Decarbonisation efforts are mandated through regulations such as carbon taxes to lower greenhouse gas (GHG) emissions. At the same time, technological advancements are driving the development of more environmentally sustainable manufacturing processes.

The manufacture of machinery is an energy-intensive process, with a high carbon footprint thus requiring the industry to find sustainable solutions (Bekker, 2021). The industry has devised solutions to decarbonise industrial processes through power purchase agreements to acquire renewable energy from power producers. Common renewable energies include wind energy and solar photovoltaic. In South Africa, companies that manufacture capital goods, such as Barloworld, Bell Equipment and ELB Equipment, have made investments in solar generation capacity and battery storage systems for some of their branches (Bekker, 2021). On the one hand, the installation of solar generation capacity helps in reducing the use of carbon-intensive electricity, and the other hand this decreases reliance on electricity from Eskom for the South African industry. Evidently, the shift towards decarbonising production processes is influencing technological change.

Consumer preferences are shifting towards buying environmentally friendly products. This change is leading producers to offer low-carbon products. To appeal to environmentally conscious consumers, major manufacturers have implemented initiatives to decrease electricity and water usage. This does not only assist manufacturers in complying with regulations but also cuts costs (Bekker, 2021). Large consumers are also displaying interest in electric vehicles. Mining companies' preferences are shifting

towards acquiring electric trucks from Original Equipment Manufacturers (OEMs) in comparison to diesel-powered trucks, thereby reducing carbon emissions in mining operations. There is a growing trend of manufacturing and selling of electric trucks by OEMs. To demonstrate this momentum, the International Energy Agency (2024) reported that global sales of electric trucks surged by 35% in 2023 compared to 2022. Countries that dominate global sales of electric trucks in 2023 include China at 70%, followed by the United States and Europe. The transition from traditional diesel-powered mining vehicles to electric vehicles is driven by the objectives of reducing the release of diesel fumes into active mine workings, making electric vehicles suitable for areas with strict emissions regulations (Steenkamp, 2023).

The traditional pump systems used for water management in industrial processes often lack advanced technology, making them inefficient and leading to high energy consumption. Technological changes are also being seen in mining operations, where the focus on occupational health and safety regulations are driving innovation and prompted the South African Department of Mineral Resources and Energy to amend the Mine Health and Safety Act No. 29 of 1996 in 2017. The amendment draws on new technologies and requires Trackless Mobile Machinery (TMM) in mining operations to be equipped with tracking technology to prevent collisions (Slater, 2023). As a result, TMMs are fitted with sensors and Collision Avoidance Systems to detect danger.

4. TECHNOLOGICAL CHANGES IN THE CAPITAL GOODS INDUSTRY

4.1 Automation in mining equipment

Dump trucks can have either a manual or automatic transmission and are used to transport materials such as coal. A manual dump truck requires a driver to shift gears using a clutch and gear, giving the driver control over a vehicle. Automatic dump trucks shift gears automatically, freeing the driver of labour that includes shifting gears, enabling them to focus on steering and loading. Driving a truck with either transmission is laborious and often unpredictable as the precision is dependent on the driver.

Komatsu commercially introduced Autonomous Haulage Systems (AHS) in 2008, a system that operates autonomous dump trucks including loading, hauling, and dumping. The driverless trucks have improved the safety, operational efficiency, and profits of mining companies. Rio Tinto's Pilbara iron ore mine in Australia received 80 driverless Komatsu trucks in 2008, followed by BHP Billiton and Suncor. The trucks were mostly purchased from Caterpillar, Sandvik, Komatsu, and Atlas Copco (World Sensing, n.d.). AHS technology transformed mining technology, from manual and semi-autonomous machinery to autonomous machinery. The revolution of mining equipment is headed towards fully autonomous mining operations, moving away from just autonomous mining vehicles. In 2019, the Syama Gold Mine in Mali became the first fully automated mine, owing to a partnership with Sandvik. Sandvik supplied Syama with a complete set of autonomous equipment and digital solutions, including a fleet of Sandvik TH663i trucks, autonomous drills, and fully autonomous loaders (Cuffari, 2019).

The IoT advances mining machinery through sensor technologies, various connectivity networks, and edge computing (Matellio, 2023). Sensors in mining machinery have enhanced safety measures by monitoring conditions. For instance, the safety of miners and mining machinery is secured by monitoring ventilation and toxicity in underground mines, facilitating fast and efficient evacuations (Ramesh, n.d.).

4.2 IoT in Pumps

An IoT-based pump monitoring system is a network of connected devices that analyse and monitor pumps in real-time. It collects data from pump sensors and sends it to a centralised system for fault

identification, performance forecasting, and optimisation (Rupareliya, 2023). The IoT technology attached to pumps allows for instant data collection, analysis and remote monitoring. Figure 1 shows key applications of an IoT-based pump monitoring system. Pump sensors measure pressure and flow rate, sending data to a Central Processing Unit (CPU). The CPU processes and analyses data collected from sensors, running an algorithm and identifying variability in the pump performance, thus setting off alerts when faults occur. A wired or wireless communication network transfers data between sensors, CPU and other devices connected to the pump system. Collected data is often stored on cloud storage because of size, allowing for remote access by operators, while the user interface is an online dashboard (web or mobile application) that triggers alerts and shows visuals of the pump performance. The alert system can trigger alerts, notifying control operators through push notifications, emails, or SMSs (Rupareliya, 2023).

Smart pumping stations are remotely monitored and controlled by operators, producing instant data such as water levels and pumping frequency which is measured by sensors. Smart pumping stations are fitted with automatic alert systems that alert operators of issues that may occur, informing instant decision-making to solve problems in pumping stations. Such alerts can indicate leaks, informing operators.

Taking climate change concerns into consideration, stormwater management systems use pumps to reduce the runoff of rainwater and to improve water quality. A submersible pump is planted underground to pump water into a pump station. Water is therefore prevented from ponding on surfaces in public and industrial areas, avoiding hazards such as floods and pollution. Stormwater management systems also infiltrate, treat and store water.

The mining industry uses pumps to remove underground water, transport slurry, and pump water for processing, with the IoT technology in pumps optimising these processes (Rupareliya, 2023). This also reduces harmful substances that can be released into the environment.

4.3 IoT in lifting and handling equipment

The use of IoT technology in lifting and handling equipment has become increasingly common, allowing for advanced applications in industrial processes. The integration of IoT in equipment enables remote monitoring and control of overhead equipment, simplifying the operation of such equipment. IoT sensors are linked through a local network, wirelessly transmitting data via a cloud computing system to operators and OEMs in real-time (MHI Overhead Lifting, 2022). IoT-based sensors in cranes provide instant data about their operation.

In the past, data from lifting and handling equipment was available but required a technician to physically connect a laptop or tablet to a crane to retrieve the data for a batch download (MHI Overhead Lifting, 2022). Cranes fitted with IoT technology now allow the information to be instantly accessible through a secure, web-based dashboard or mobile app. While most of the new cranes are often fitted with IoT technology, opportunities exist for older cranes to be fitted with new technology. In addition to remote monitoring, software updates of the sensors can also be updated remotely by OEMs, phasing out the need for technicians to visit sites to solve operational issues.

5. TECHNOLOGICAL TRENDS IN SOUTH AFRICA

South African OEMs are being affected by increasingly prevalent global emissions regulations, leading to growing market demand for electrical and hybrid-electrical equipment. Electrical machinery is expensive and can operate for about eight hours without recharging, but the shift to non-emitting heavy machinery and equipment can ensure the competitiveness and sustainability of companies

(Bekker, 2021). With the growing trend of electric trucks in response to environmental concerns, South African mining companies have expressed interest in these technological advancements, aligning with their carbon-neutral goals. Anglo American for example set a target in 2018 to reduce GHG emissions by 30% by 2030 and to have carbon-neutral operations by 2040 (Anglo American, 2022). This section discusses technological changes and processes in the capital goods value chain in South Africa.

5.1 Technological changes in the capital goods value chain

Bell Equipment reported in March 2023 that its autonomous Articulated Dump Truck (ADT) had reached the adoption stage after four years of extensive testing. Bell partnered with two service providers, giving customers a choice between the two. The service providers are Xtonomy in Europe and Pronto AI in the United States, both offering different AHS and terms of service.

Xtonomy provides a radar-based system with minimal impact from the weather but requires higher upfront fees and relies on the loading tool operator to manage the operation. The system offers continuous site and object mapping with limited manual interaction, making it suitable for multiple load and dump sites. The advanced in-cab display and supervision screens can be easily integrated with other equipment on-site to provide a fully autonomous system (Bell Equipment, 2023). In comparison, Pronto AI offers quick deployment with a simpler, integrated system that features subscription-based pricing with minimal upfront costs. It is a camera system, with the non-dynamic site and object detection manually controlled. Pronto AI's camera system is controlled through a user-friendly mobile app, and routes can be changed through manual driving. In addition, the system can be operated through a private LTE network[1] (Bell Equipment, 2023).

An autonomous system comprises three components including machines that can be operated remotely, external sensors which act as the eyes and ears of the machine, and advanced site control software that manages operations by communicating with these two components (Bell Equipment, 2022). The ADTs manufactured by Bell are standard without hardware. The area allocated for the sensor and control system can be reconfigured to accommodate a new system for another site or used for manual operation (Bell Equipment, 2023).

The Mogalakwena Platinum Mine in Mokopane, Limpopo, owned by Anglo American, was presented with a P&H 4800XPC rope shovel from Komatsu in April 2024. This mining electric rope shovel is the largest in the world, with a 135-ton payload. It is also the second one in the world, with GHG emissions of 90g of CO_2 for every ton moved, compared to 273g of CO_2 for a diesel power hydraulic excavator and 136g for an electric hydraulic excavator (Moore, 2024). In addition, the mine received the first Komatsu 930E 290-ton truck, which was converted to a hybrid hydrogen fuel cell and battery by First Mode (Moore, 2024).

Marula Mining[2] owns the Blesberg mine in the Northern Cape through its South African subsidiary, South African Lithium and Tantalum Mining. In August 2023, the company announced that it was in the process of purchasing[3] two sensor-based XRF ore sorting plants for R40.6 million from Rados International Technologies in Malta (Marula Mining, 2023). Marula Mining finalised the commissioning of a Rados SRF100-8 X-ray fluorescence ore sorter in the Blesberg lithium and tantalum mine, intending to advance its ore processing capacity and increase production (Parker, 2024).

[1] Long Term Evolution network. A type of wireless data transmission.
[2] Marula Mining is an African-focused mining investment company, listed on the London Stock Exchange.
[3] In addition to the Rados SRF 100-8 worth R23 million, Marula Mining purchased a Tomra COM 1200 ore sorter for R17.6 million from Q Global Mining. The latter is yet to be commissioned.

The sensors in the ore sorting equipment identify and separate concentrate from waste. During the sorting process, the X-ray generator exposes the material to rays, with the signal being reflected to the sensor. The sensor then communicates with the control panel to direct the sorting of the material. The Rados ore sorter is equipped with AI capabilities, and its ore sorting algorithm improved spodumene recoveries to 89% during commissioning and bulk testing (Parker, 2024). Although the recovery rate was reported about 14 days after commissioning, the mining company expects the AI algorithms to continue to enhance spodumene recovery.

Morris Material Holding is a crane company operating in Southern Africa. Morris supplies and manufactures industrial application equipment, including Electric Overhead Travelling cranes, wire rope hoists, jib cranes, chain hoists, and accessories. Morris was awarded a tender to design, manufacture, and install a 100 ton crane for ArcelorMittal South Africa (AMSA) (Morris Material Handling, 2023). The crane was built in-house at the Morris head office in Benoni, with the manufacturer using the latest technologies and the highest quality components. (Business Excellence Magazine, 2024). The crane was installed at AMSA's operations at the Vanderbijlpark Works: a 37 metre double girder, heavy-duty slab handling crane, aimed at handling and supplying slabs to the Hot Mill, with a capacity of up to 100 tons. To meet production requirements, the crane hoists at 9 metres per minute, with a cross travel speed of 70 metre per minute and a long travel speed of 100 metre per minute. It is controlled from the bridge mounted cabin (Morris Material Handling, 2023). The crane is important for the continued production of AMSA's mill.

RGM Cranes manufactures overhead cranes, hoists, and lifting equipment. RGM manufactured 25 overhead cranes for Komatsu's Mining and Construction equipment remanufacturing centre, on its campus in Tunney Industrial Estate, Edenvale. Komatsu had specific requirements for the remanufacturing centre that RGM had to adhere to, thus RGM collaborated with the overhead Turkish based crane OEM, Güralp. The scope of the project was based on tonnage requirements, workflow aspects and engineering requirements. For wall travelling jib cranes, cranage that could handle higher capacity and seamlessly slide back and forth above workstations without interfering or obstructing the work area was required. The Güralp hoist monitoring system embedded in overhead cranes will allow Komatsu to track various parameters on the cranes such as operating hours, service intervals, and the number of maximum lifts per single shift. Including improving Komatsu's competitiveness, the system is expected to improve productivity, efficiency, and worker safety (RGM Cranes, n.d.). information collected from the hoist monitoring system can also inform expansion plans, reduce downtime and repair costs, as well as improve crane operator accountability.

Multotec supplies hydrocyclones to domestic and global markets. These cyclones are used in industries such as mineral processing, food processing, wastewater treatment, and manufacturing. In mineral processing, cyclones are used to separate particles by size and density. They have various applications in mining, including separating ore from waste, removing heavy minerals from slurry, and dewatering tailings (Multotec, 2023a). The cyclones are manufactured in a factory located in Spartan, Kempton Park. Previously, Multotec's cyclones were fitted with an instrumented pressure gauge and connected to the Supervisory Control and Data Acquisition plant (Multotec, 2023b). This system was used to monitor and control the operation of the cyclone. Driven by market demand for more intelligent and advanced products, Multotec has integrated sensors into its cyclones to monitor operational conditions (Multotec, 2020). These sensors are equipped with AI, enabling them to identify operational irregularities such as choking or tramp metal, thereby alerting operators of any anomalies. Multotec has reported that this digital transformation has improved its sustainability, competitiveness in value-adding products, speed to market, and costs (Multotec, 2020).

Agrico, a supplier of irrigation systems, developed a remote irrigation management system called Agrico Web Control. This system allows for the monitoring and adjustment of centre pivots and pumps through a dedicated application. It includes a GPS function and is designed to save time and electricity (Conradie, 2023).

5.2 Institutional support

The Mandela Mining Precinct (MMP) is a Public-Private Partnership between the Department of Science and Innovation (DSI) and the Minerals Council of South Africa. The collaboration aims to revitalise mining research, development and innovation in South Africa to promote industry sustainability. MMP has partnered with multiple government departments and institutions over the years. The MMP was established to implement the South African Mining, Extraction, Research, Development, and Innovation (SAMERDI) strategy, as set out in DSI's White Paper on Science, Technology, and Innovation. The SAMERDI strategy aims to advance technological developments to promote safety, productivity, reduce costs, and extend the life of mines; revitalise mining research and innovation; and support the capacity of the mining supply chain (MMP, 2023). The MMP, Minerals Council, DSI, and Mining Equipment Manufacturers of South Africa[4] (MEMSA) created R&D programmes that are implemented by the Council for Scientific and Industrial Research (CSIR) and the universities of Johannesburg, Pretoria, and Witwatersrand.

A highlight of MMP was the Isidingo Drill Design Challenge that commenced in 2018, seeking companies to develop a rock drill that would offer safety in South African mines. MMP announced two local OEMs, Hydro Power Equipment (HPE) and Novatek, as winners of the innovation challenge in March 2022. The rock drill underwent several weeks of underground training at Impala Platinum in Rustenburg, demonstrating its ability to be used in harsh underground conditions. OEMs successfully addressed occupational health and safety challenges, such as operator fatigue due to the time needed to assemble and disassemble heavy rock drills, as well as loud noise close to the drilled rock. The success of HPE and Novatek in independently designing, prototyping, and testing a rock drill that meets production and safety requirements demonstrates opportunities for local OEMs to produce equipment for the mining value chain (MMP, 2022).

5.2.1. Government support

The Department of Trade, Industry and Competition (the dtic) supports technological innovation through the Support Programme for Industrial Innovation. The incentive provides financial assistance for commercially viable, innovative products and/or processes and facilitates the commercialisation of such technologies. The Industrial Development Corporation's Machinery, Equipment and Electronics Strategic Business Unit (IDC Machinery and Equipment SBU) supports the manufacturing of machinery, capital equipment, electronics, and robotics innovations. The IDC Machinery and Equipment SBU provides financing for capacity expansion projects, enhances competitiveness, and facilitates market access for the industry (IDC, 2022).

Other support measures and programmes include the Manufacturing Competitiveness Enhancement Programme, the South African Automotive Masterplan for manufacturers of vehicles and components, Export Marketing and Investment Assistance, the Black Industrialist Scheme, and the Downstream Steel Competitiveness Industry Competitiveness Fund for steel manufacturers, including machinery producers.

[4] MMP and MEMSA launched the Technology Availability and Readiness Atlas (Mining TARA), an online portal that shows mining equipment, software and systems developed and manufactured in South Africa.

6. CONCLUSION

The capital goods industry study outlined technological changes and processes in the industry. It indicated emerging technologies in the capital goods industry, including artificial intelligence, digital twins, automation, additive manufacturing (3D printing), and the IoT. The study finds that digitalisation is driving technological change, allowing machinery and equipment to be connected to devices through internet connectivity. At the same time, environmental concerns enforced through emissions regulations are encouraging the industry to reduce its carbon footprint. OEMs have installed renewable energy in their facilities and mining companies have purchased electric trucks to meet their carbon-neutral goals. Improving safety in the mining sector and operational efficiencies have also been an important driver of technological change.

This industry study examined technological changes in three capital goods products. International trends suggest that the mining industry is shifting toward fully automated mines. This automation has commenced with the introduction of driverless trucks, which have enhanced the safety and operational efficiency of mining processes. Furthermore, pumps and cranes have been equipped with IoT sensors, allowing for remote monitoring and control, as well as the capability to detect operational faults, thereby improving operational efficiency.

Mining companies in South Africa have started using sensors in ore sorting equipment to enhance recovery rates. Other mines have invested in electric hydraulic excavators with lower emissions compared to previous models. OEMs are in the adoption process of autonomous ADTs. Crane manufacturers have added IoT sensors to their cranes while providing services to install IoT sensors on older cranes.

The Mandela Mining Precinct promotes technological development in the mining industry to ensure its sustainability. The dtic offers an incentive to support technological development in the capital goods industry, while the IDC's Machinery and Equipment SBU supports the industry through financing.

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