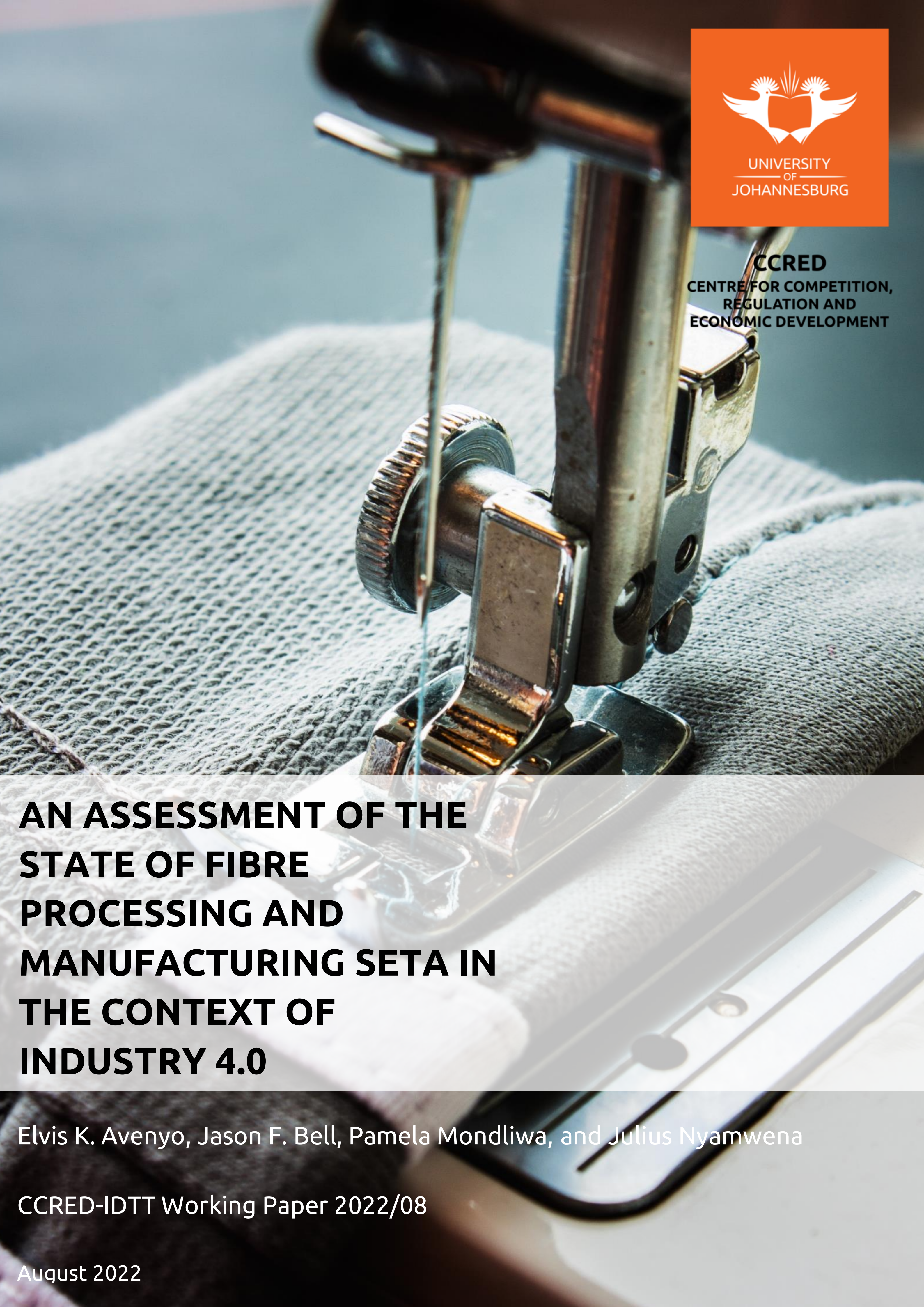

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AN ASSESSMENT OF THE STATE OF FIBRE PROCESSING AND MANUFACTURING SETA IN THE CONTEXT OF INDUSTRY 4.0

Elvis K. Avenyo, Jason F. Bell, Pamela Mondliwa, and Julius Nyamwena

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Abstract

The advent of advanced technologies and production methods bring about complex business and operational environment. As new technologies come about, firms adopt new production methods, existing markets expand and new markets are created, and societies evolve. This paper assesses the state of the South African fibre processing and manufacturing-related industries in the context of industry 4.0, to understand the skills landscape within the FP&M SETA and its subsectors. We analysed firm-level data obtained from the FP&M SETA annual reports, sector skills plan, and firm-level data collected as part of the Digital Skills Survey. The analysis revealed that the core strategic challenge facing skills development in the sector is the lack of resources to best support the sub-sectors to achieve inclusive growth. Developing high-level skills and exposure to cutting-edge knowledge, best practices, and trends in plant and machine technology, innovation, and entrepreneurship is key to promoting world-class manufacturing. Insights from the Digital Skills Survey (2020/21) suggest that the current technological infrastructure prevailing in the industry is dominated by manual-and semi-automated technologies and processes and that the lack of adequate human resources is a key obstacle that affects the ability of sampled FP&M firms to engage in advanced technology adoption.

Keywords: Manufacturing, skills, Industry 4.0, Digitalisation

JEL codes: L6; L65; O33

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1. Introduction

The world economy is undergoing structural and technological transformation, sometimes described as the 'Fourth Industrial Revolution' (4IR). The digitalisation and automation of economic activities and its differential impacts across the globe and industrial sectors are at the centre of the transformation. Extracting benefits from Industry 4.0 requires coordinated policy interventions designed to support the diversification of the economy (Bell et al, 2018a). A challenge for a middle-income country like South Africa, however, is to grow capabilities in the more technologically sophisticated segments of value chains, thereby allowing it to break from the 'middle-income trap' (Andreoni & Tregenna, 2020) while simultaneously creating large numbers of jobs, including in related service activities.

For a sustainable upgrade, technologies must be widely diffused and embedded in a way that rapidly builds skills within interdependent domestic industrial ecosystems (Andreoni & Tregenna, 2018). This embedding of technology requires coordinated strategies across skills, investment, and technology to support incremental changes required to realise efficiencies and improve competitiveness and stepwise changes (Barnes, et al., 2019). Indeed, skills upgrading is critical for supporting productivity growth and technology diffusion. Possessing the requisite skills is necessary for escaping the middle-income trap (Sen & Tyce, 2018). However, South Africa has a well-documented mismatch between the skills required by industry and those produced by learning institutions (Beare, et al., 2014, Bell, et al., 2018a; DHET, 2019).

The persistence of this mismatch will continue to cast a shadow on the ability of South Africa to escape the middle-income trap. Therefore, in recognition of this challenge, South African policymakers have been called on to prioritise the development of a digital skills policy as part of a broader set of digital industrial policy priorities (Barnes et al., 2019b). These calls have culminated in the establishment of a priority skills list for essential industrial activities. The Sector Education and Training Authorities (SETAs) have an essential role to play in this regard. There is also a need to link digital skills policy to broader technology policy to provide less-resourced firms with complementary support in training, technology absorption, and associated organisational development (Barnes et al, 2019).

To date, there have been numerous strategies aimed at alleviating these skills issues[1]. However, the record of these strategies is poor with little coherence between technology, skills, and industrial policy. Smaller firms tend to suffer as a result as larger firms are more easily able to internalise and privatise skills training and upgrading. In light of these issues, this paper assesses the state of South Africa fibre processing and manufacturing industry to understand the skills landscape and the adoption of technology in a specific context given the link between Industry 4.0, the changing nature of work within FP&M SETA and its subsectors.

The paper proceeds as follows. Section 2 discusses the methodology. Section 3 discusses the changing nature of skills and work in the context of technological upgrading and Industry

[1]The general skills policy framework for South Africa is in the form of the Skills Development Act of 1998. From a macroeconomic perspective there was the Accelerated Shared Growth Initiative of South Africa (AsgiSA). At a more microeconomic level, policies aimed at skills development took the form of the Joint Initiative on Priority Skills Acquisition, and the Human Resources Development Strategy for South Africa. In the last 10 years, a number of other policy documents have also made skills development their priority. These include the National Skills Accord (2011), the White Paper for Post-School Education and Training (2013), the Third National Skills Development Strategy (2016), and the Professional Development Framework for Digital Learning (2017).

4.0. Following this, Section 4 outlines the performance of the sectors that characterise the FP&M SETA. Section 5 takes a nuanced view of skills in the FP&M SETA. Section 6 reviews the skills training provided in light of 4IR changes and also aims to assess the readiness and preparedness of the FP&M SETA for high-tech and digital skills. Section 7 analyses the readiness and preparedness for high-tech and digital technologies in the FP&M SETA. Section 8 concludes.

2. Methodology and Data

The current research seeks to understand the skills landscape within the FP&M SETA and its subsectors. To do this, we analysed firm-level data that was obtained from the FP&M SETA that profiled employee's information such as age, occupations and educational qualifications. We supplemented our analysis with Quantec data and data gathered from the Department of Higher Education and Training (DHET) that focused on output, employment, labour productivity and value addition. This allowed for the analysis of possible links between SETA interventions and subsector performance at the sub-sector level. In addition, the research also used publicly available FP&M annual reports, Annual training reports (ATR), and Workplace skills plan (WSP) documents. These complemented the missing gaps in the data, particularly around the analysis of the sector skills, training and education, employee's age distribution, and occupation profiles in section 5 of this current research. In addition, the analysis also drew from the Digital Skills Survey that was designed to capture both the current status quo and the firm's ambition regarding their technological upgrading. Moreover, the survey also tried to understand, from a firm level, which skills are crucial to the firms' operations in these various SETAs, including FP&M in the context of differing technological adoption rates.

3. Industry 4.0 and the Changing Nature of Skills and Technological Upgrading in South Africa

Numerous factors are impacting the manufacturing environment, which in turn are driving demand for a different skillset in the industry (Chenoy, et al., 2019). The emergence of advanced technologies and production methods are driving new production processes. As new technologies come about, firms adopt new production methods, existing markets expand and new markets are created, and societies evolve (World Bank, 2019). Firms increasingly rely on technological upgrading to assist them in achieving gains in productivity using new or existing capital stocks, overcoming information bottlenecks, and innovating.

A key idea within the field of technological upgrading is dynamic efficiency. Dynamic efficiency is the ability to adapt, improve, and innovate upon existing technologies (Mclaughlin, 2017). This carries with it strong links to the thinking around technological capabilities. Yet, technological capabilities extend far beyond possessing necessary skills. It is also determined by the level of knowledge, experience, institutional structures, and linkages inherent to a firm or industry. These can be accumulated and developed by the firm, either internally or through external institutional relationships (Bell & Pavitt, 1995). For purposes of this paper, we place a particular focus on skills and how these relate to technological upgrading and competitiveness. To achieve any form of technological upgrading requires a high level of skill and capability. Furthermore, it also necessitates knowledge about the dynamics of skill accumulation and how this links with literature on capabilities (Hechman & Corbin, 2016), and thus dynamic capabilities (see Teece, et al., 1997).

Industry 4.0 is ushering in a new era in manufacturing that can potentially help firms and industries realise significant returns and massive advantages over their local and international competitors. Industry 4.0 will affect the various FP&M sectors differently due to their relatively different levels of labour and capital intensities. For example, in the clothing and textile sectors, digital technologies and methods of Industry 4.0 are both transforming the manufacturing side in terms of products while also changing the downstream end-user market in driving changes in consumer behaviour (Stewart, 2018). Some of these technologies include the Internet of Things (IoT), the use of big data analytics, artificial intelligence (AI) and machine learning, and additive manufacturing and robotics (Stewart, 2018). These advanced technologies will have differing impacts on different sectors. These technologies can potentially change how the activities in the value chain are performed (Table 1). For instance, advancement in technologies is reshaping the market intelligence function in firms by helping businesses analyse data and market trends through the use of AI.

Table 1: Potential application and use of digital technologies in FP&M SETA firms

Activities in the value chain	Use
Market Intelligence	• Help brands analyse and understand millions of data points about current market trends (AI). • Enable brands to pick out micro trends in what is being purchased and where (AI). • Allow a brand to analyse data from RFID tags and sensors sewn into governments to learn about actual consumer use and materials' properties (RFID, sensors, AI).
Design	• Help designer's forecasts projected demand for new products (AI). • Allow designers and consumers to see how designs will look in real-life situations (AVR). • Help designers classify and better pick colours and avoid mistakes (new software). • Assist producers in tailor-making designs to individual body sizes and shapes using software that detects contours and body shapes (new software).
Materials	• Help manufacturers predict the mechanical properties of a garment (RFID, sensors). • Assist in classifying and grading garments and in identifying and analysing faults (AVR, new software). • Help manufacturers with future decisions on the best raw materials and fabrics to use (AI).

Suppliers and logistics	• Assist brands and manufacturers in better supply chain management and just in time production (RFID, sensors, Internet of Things, AI, blockchains). • Improve logistics management, reduce delays in production and overcapacity. • Help buyers and suppliers to make an account for payments.
Production	• Assist manufacturers in production planning and control and online monitoring. • Help manufacturers optimise spreading, cutting, bundling, sewing, pressing and packaging, and other processes. • Assist brands and buyers in monitoring working conditions (hours and overtime), occupational safety, and health. •
Marketing	• Assist brands in better targeting specific consumer categories and groups. • Allow brands to use social media better to engage and interact with customers • Allow brands and retailers to influence the buying behaviour of consumers.
Retail	• Help a brand understand how consumers shop, when and through which channels. • Allow a brand to understand better how consumers interact with customers. • Help retailers sell additional items through personalised offers based on items already purchased.
Customer service	• Respond to enquiries immediately using chatbots • Improving the shopping experience through AI shopping assistants that offer conversation products and services. • Provide customers with suggestions to their recorded needs or their recent products searches.

Source: ILO, (2019)

The descriptions of the activities that will be changed suggest that there will be increased ICT skills in how ordinary production and marketing tasks are performed. The employment of Industry 4.0 technologies will require a changing nature of skills to complement these new advancements. Thus, the new technology era necessitates qualifications, an acceptance of technology, and digitally-minded workers. In Table 2, below, we look at the key technology areas and changing nature of skills.

Table 2: Key Technologies and the Changing Nature of Skills in the FP&M SETA Industries

Key Technology Areas	Changing Nature of Skills
Additive manufacturing	Process engineer; additive manufacturing engineer; materials researcher; metallurgist; manufacturing technical leader; operations engineer; material development specialist; injection moulding specialist
Internet of Things	Data scientist; IP network engineer; digital systems developer (specialising in hardware interfacing); mobile application developer; information security specialist; cybersecurity specialist
Big data analytics	Big data specialist/developer/engineer; data scientist; big data team manager
Artificial intelligence and machine learning	Applications developer; AI developer; intelligence analyst; user interface/user experience (UI/UX) designer; robotic process automation and AI transformation specialist; AI and game theory research scientist; machine learning engineer; Machine learning engineer; computer vision and machine learning scientist; manufacturing engineer/ programmer
Robotics	Robotics engineer; applied robotics scientist; research scientist AI and machine learning; robotic process automation (RPA) developer

Source: Authors adaptation of Stewart (2018) and Abrahams (2018)

These key technologies are resulting in a decentralisation of the workplace. For example, a firm could produce components in one location, assemble them in another, and sell them from a third (World Bank, 2019). This constant evolution is forcing workers, firms, and governments to seek comparative and competitive advantages in new areas, many of which are not yet conceived. This search for a new advantage requires a coordinated effort from all stakeholders, from workers and firms to associations and the state. The required evolution in skills is attributed to the increased adoption of new technologies which has implications on skill adoption, education and training for workers. For example, traditional ICT skills are essential in adapting the technologies responsible for driving change in manufacturing. However, research has noted that critical ICT-related skills such as software developers, computer network and systems engineers, ICT systems analysts, programmer analysts, ICT security specialists, business analysts, database designers and administrators, and telecommunications network engineers are difficult to fill in South Africa (Stewart, 2018).

Therefore, this paper begins the process of attempting to assess the existing skills gaps and skills development programmes of the FP&M SETA and as well as the readiness for high-tech and digital skills. Understanding this has vital implications for the growth and competitiveness of the industry and aids in providing a necessary precursor for the advancement of the industry in a new manufacturing era.

4. Overview of the Fibre Processing and Manufacturing SETA

Within manufacturing, the majority of the FP&M sectors are classified at the 2-digit QSIC level: Textiles, clothing and leather goods (QSIC 31), wood and paper, publishing and printing (QSIC 32), and furniture and other manufacturing (QSIC 39) represent 18% of total manufacturing output in 2020 (Figure 1). Once combined, the FP&M sectors account as the fourth largest manufacturing subsector. Additionally, Forestry (QSIC 12) accounts for only around 3% of the output for the primary sector. The FP&M sectors are vital for the larger South African economy due to their strong labour intensity in most of its subsectors.

Figure 1: Manufacturing Sectors Share of Total Manufacturing Output and Employment, 2020

Source: Quantec

Within FP&M, its various subsectors contribute differently in terms of key performance metrics (Table 3). For example, in terms of output, the most significant contributor to the FP&M SETA is paper and paper products (QSIC 323), accounting for 30% in 2020. Similarly, for value addition, paper and paper products (QSIC 323) is the biggest contributor followed closely by wood and wood products (QSIC 321-322), and Printing & Recorded Media (QSCIC 324-326) at 15 %. However, given the relatively labour-intensive nature of the FP&M SETA sectors, unsurprisingly, the sector with the largest capital investment is the paper and paper products (QSIC 323) sector given the relatively larger capital intensity of the sector. In terms of employment, the forestry sector (QSIC 12) is the largest contributor to the FP&M SETA, with 27% of the total employment.

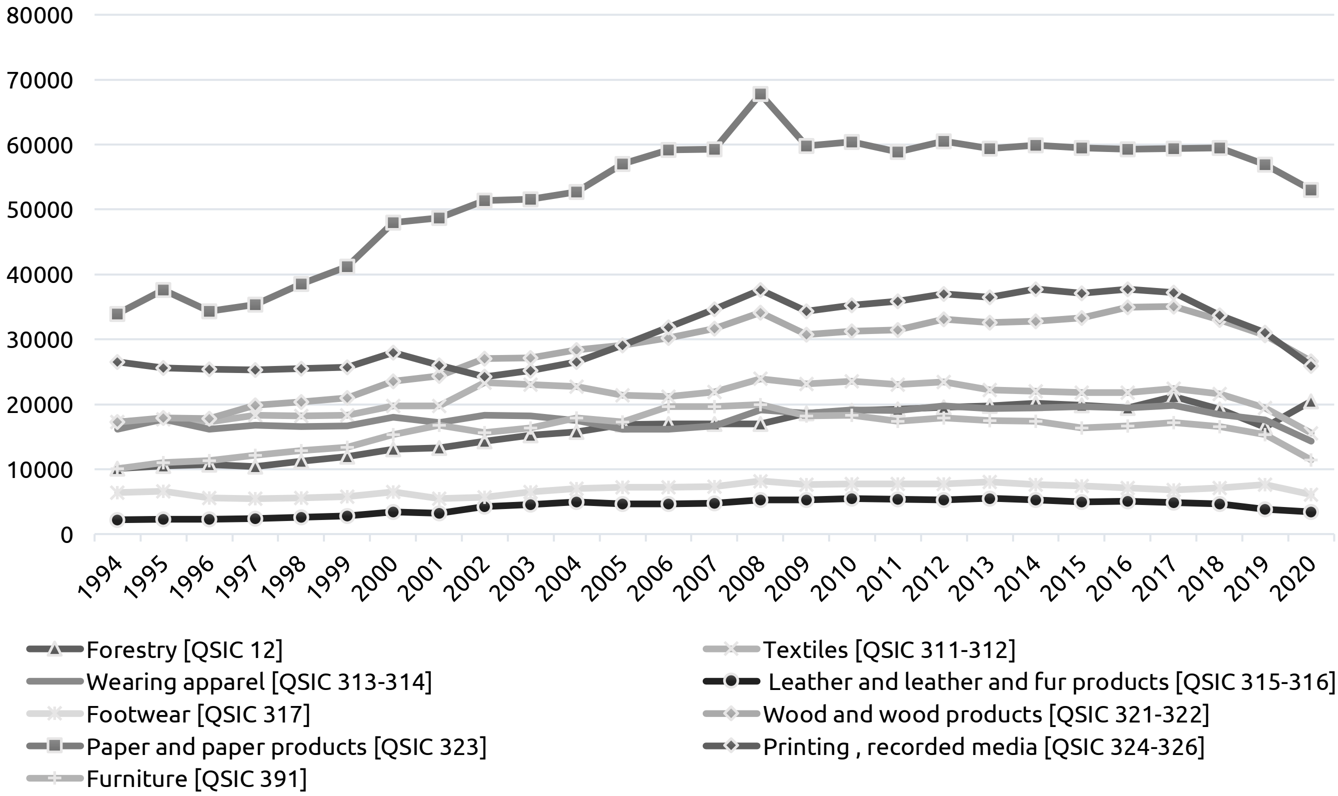
Table 3: FP&M Sub-Sector Performance in 2020

	Output		GFCF		Employment	
	Value (R'Millions)	Share	Value (R'Millions)	Share	Value Number	Share
Forestry (QSIC 12)	20,472	12%	899	10%	10,836	28%
Textiles (QSIC 311-312)	15,556	9%	803	9%	32,981	9%
Wearing Apparel (QSIC 313-314)	14,306	8%	292	3%	50,672	13%
Leather & Leather Products (QSIC 315-316)	3,438	2%	96	1%	5,752	2%
Footwear (QSIC 317)	6,082	3%	105	1%	9,006	2%
Wood & Wood Products (QSIC 321-322)	26,659	15%	1,180	13%	55,611	15%
Paper & Paper Products (QSIC 323)	53,070	30%	3,263	36%	38,047	10%
Printing & Recorded Media (QSIC 324-326)	25,893	15%	2,224	25%	52,092	14%
Furniture (QSIC 391)	11,418	6%	196	2%	28,743	8%
Sector Total	**381,271**	**100%**	**9,059**	**100%**	**381,271**	**100%**

Source: Quantec

Output levels for the sectors within the FP&M SETA have, since 1994, recorded differing levels of growth over the period (Figure 2). The sectors that registered minimal change through the 25 years were Wearing Apparel (QSIC 313-314) and Footwear (QSIC 317) with compound annual growth rates (CAGR) of 0.53% and 0.49%, respectively. The Furniture (QSIC 391) sector's output almost doubled over the period growing from R10 million to R19 million. Other sectors that registered notable levels of output growth were Leather and Leather Products (QSIC315-316) and Wood and Wood Products (QSIC 321-322), which grew at compounded annual rates of 3.04% and 2.62%, respectively. The sector with the most growth in output was paper and paper products (QSIC 323) which grew by R25 million over the entire period.

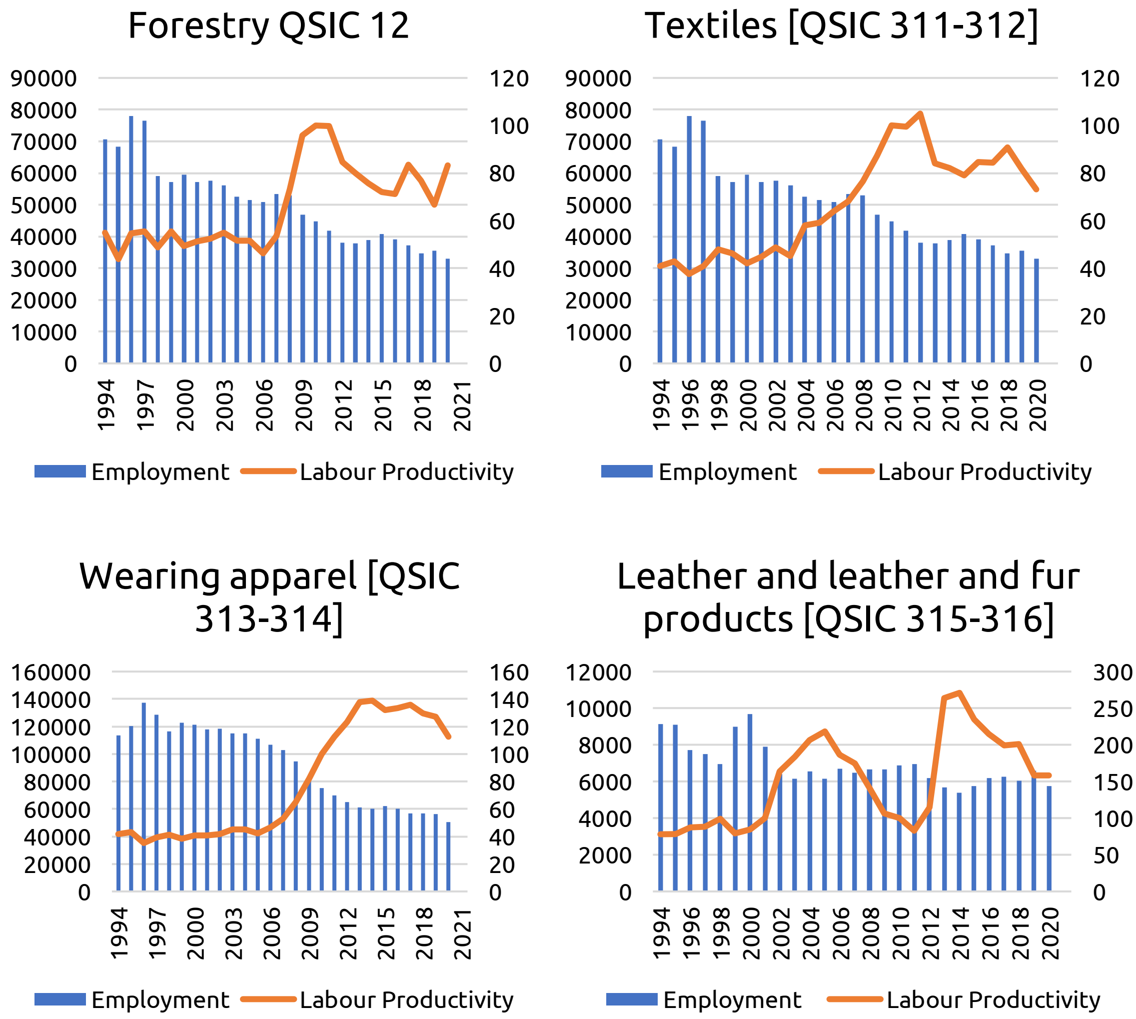
Figure 2: Output in FP&M Sectors, 1994-2020

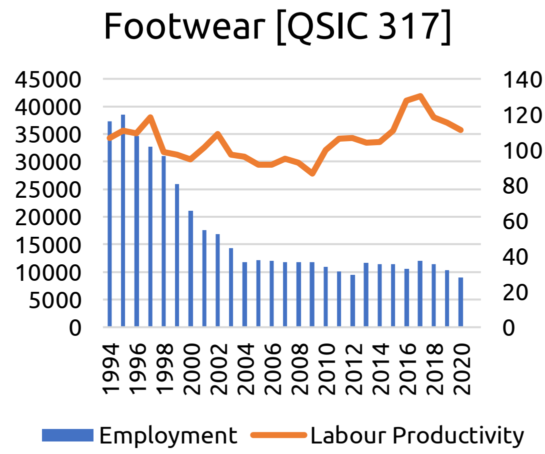


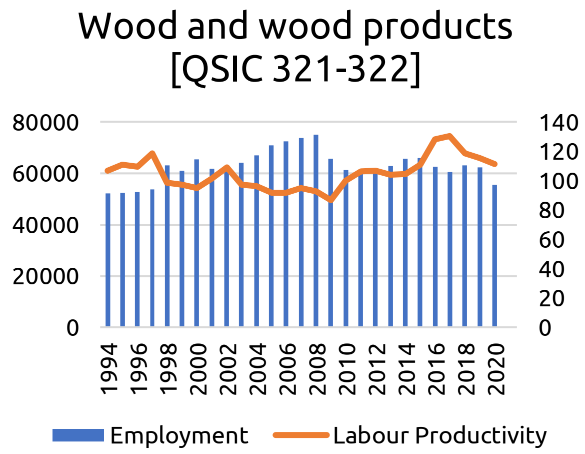
Source: Quantec

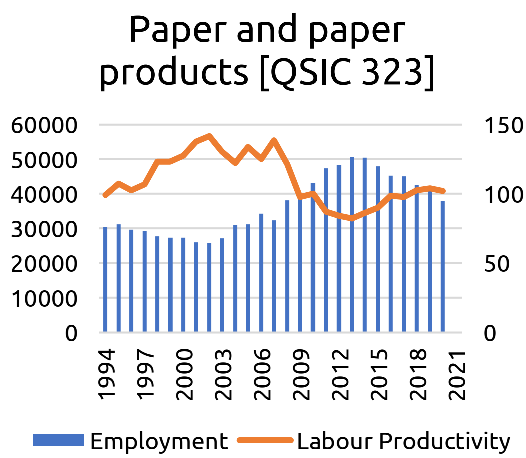
A look at the employment data of the FP&M sectors highlights that the typical relationship between employment and labour productivity holds in many of these sectors; however, some sectors displayed some degree of heterogeneity, for instance, paper, printing and wood products (see Figure 3). Economic theory posits that with the same level of capital infrastructure, more employment would result in lower labour productivity. However, labour productivity can be increased through improving the technology or the skills the workers utilise in producing their output. This increased productivity should result in increased output. The sectoral data in the below figure seemingly confirms this throughout most of the period (Figure 3). The only sector that is contrary to this relationship is the Footwear sector. During the period, employment in footwear declined dramatically as its capital formation grew by around 45%. A sharp decline in labour productivity accompanied this. This converse relationship may also be rooted in other factors, for example, import penetration and the resulting loss of competitiveness.

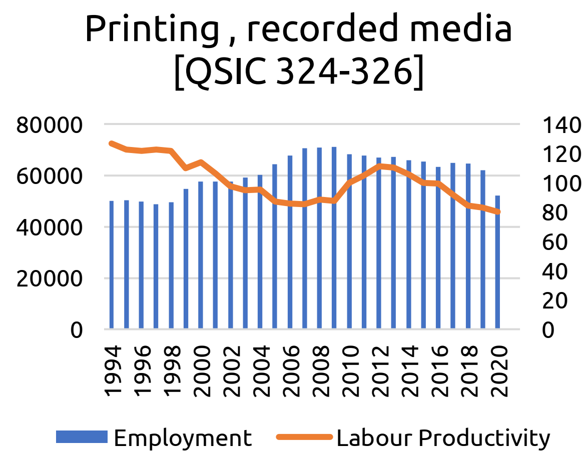
Figure 3: Employment and Labour Productivity of FP&M Sectors, 1994-2020

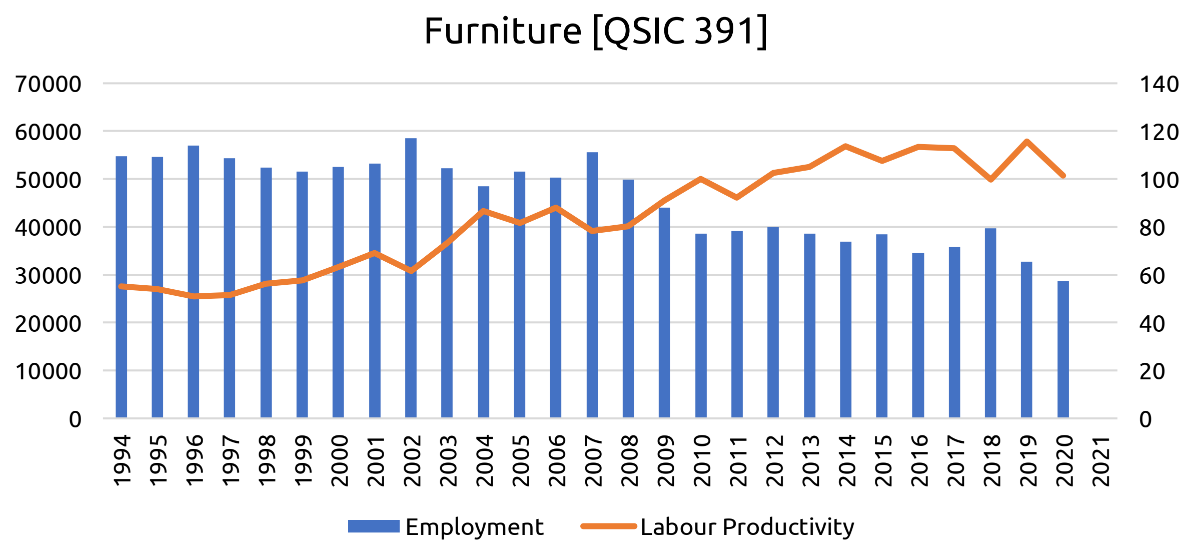










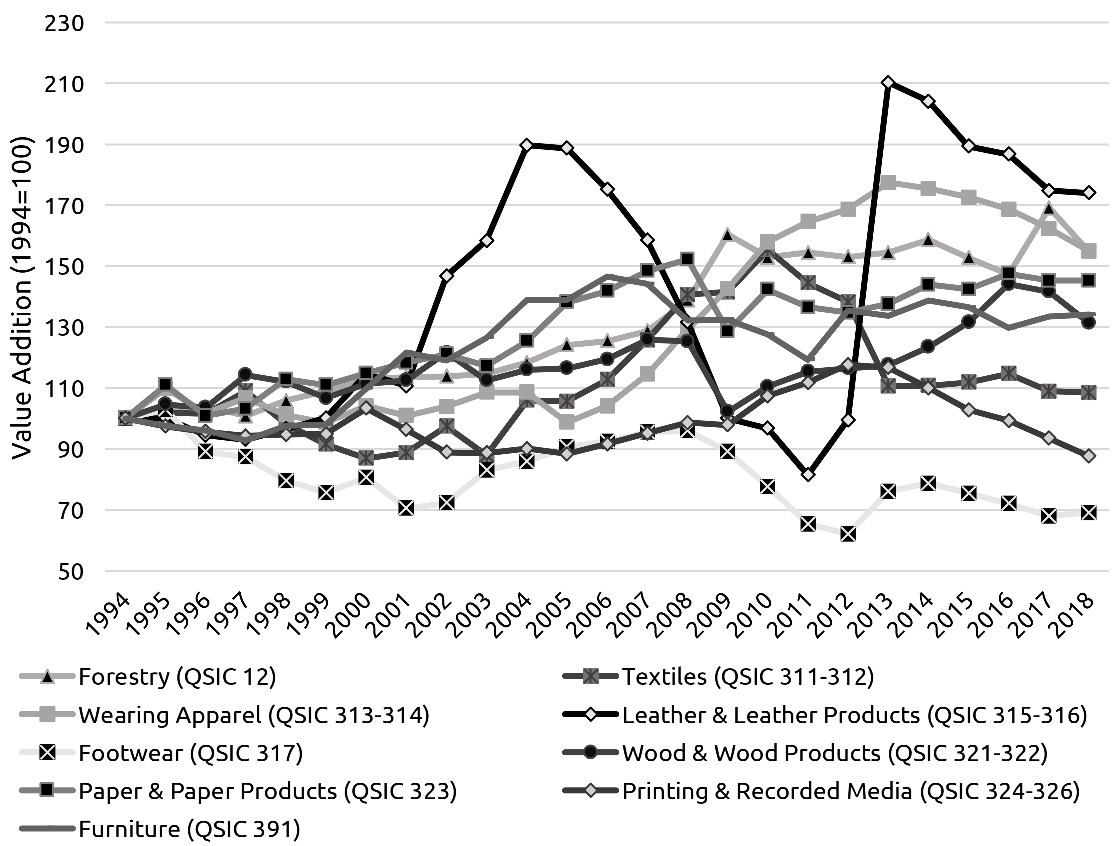


Source: Quantec

Another key metric for evaluating the development of a sector is value addition. Value addition is the difference between the sale price of a good and the cost of the good. As such, value addition can be increased through investments in better technologies that increase productivity, both capital and labour. Increased labour productivity results in more output given the same labour inputs so that value addition would increase because the per-unit labour cost is declining, increasing the relative value that labour imposes on the final good (Kniivilä, 2005).

Improving skills is another critical determinant of improving value add for a particular product or industry. This is because as firms seek out new markets through increased value addition, they must upgrade the skills of their workforce (Verma, 2012). Data on value addition in the FP&M sectors shows significant fluctuations during the period for many sectors, most notably in the Leather and Leather Products and Textiles sectors (Figure 4). The Footwear sector experienced the most significant decline in value add as most of its output was increasingly outsourced and imports met more of the domestic demand over the period. This performance decline speaks to the growing lack of competitiveness of the local industry compared to international competitors. Additionally, Wearing Apparel also saw a significant rise in import penetration from 9% in 1994 to 43% in 2018, likely due to the rise of cheap import destinations such as China and Bangladesh that compete predominantly on price with an intense focus on cheap labour costs. The Furniture sector was another sector that suffered from cheaper deep-sea imports as its import penetration grew by 6% between 1994 and 2018. The biggest jump came between 2004 and 2005, and this figure has averaged around 23% since 2005.

Figure 4: Value Addition in FP&M Sectors (1994=100)

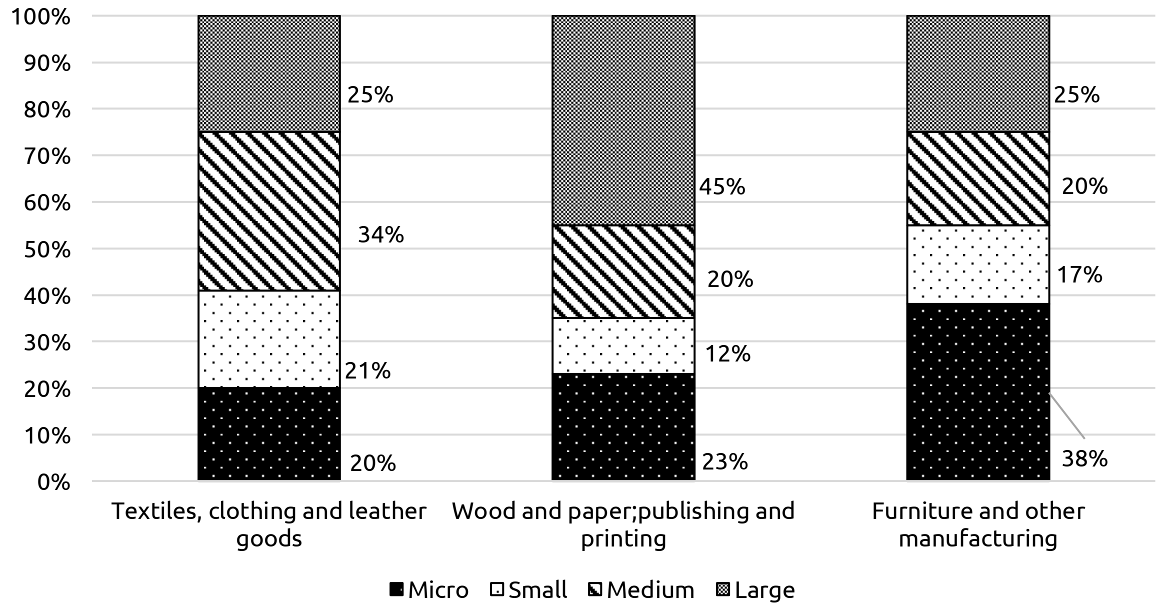


Source: Quantec

The increasing threat of deep-sea imports for South Africa's labour-intensive sectors threatens the survival and ability of the sectors to continue absorbing labour. It further reduces the incentives for firms to engage in skills upgrading thereby potentially creating a vicious circle of low growth, value addition, investment, and skills upgrading. The increasing import penetration in the Footwear, Wearing Apparel, and furniture sectors mean that these sectors have struggled to realise significant levels of growth as they attempt to compete with international competitors in terms of price, technological advancement, and complexity of their products. This trend of loss of competitiveness may persist over the long term as more significant numbers of developing nations enter the global market and attempt to compete mainly on cost. Thus, South African manufacturers can gain some ground through the adoption of advanced technologies and manufacturing techniques. The technologies associated with the 4IR improve efficiencies and productivity of firms. If South Africa does not keep up, it runs the risk of falling further behind. However, possessing the requisite skills to utilise these new technologies and adapt to these fast-paced and ever-changing operational and business environments. There is also evidence which suggests that firm size is positively correlated with innovation, internationalisation, adoption of advanced technologies, and ability to face new competitive challenges (Amatori, et al., 2013).

The size distribution of firms in the various sectors suggests that the wood and paper; publishing, and printing sector are primarily made up of large firms (45%), while Furniture and other manufacturing are primarily made up of micro firms (38%) while textiles, clothing and leather goods is primarily made up of medium firms (34%) (Figure 5). As such, it may likely be more difficult for furniture and other manufacturing firms to attract the scarce skills required to adopt and adapt fourth industrial revolution technologies.

Figure 5: Size distribution of FP&M firms



Source: StatsSA manufacturing survey

The size of the firm also has implications on skills upgrading and as well technology adoption (See Section 7). In addition, the firms that are the first movers to adopt fourth industrial revolution technologies and strategies have tended to be linked to multinational firms with research and development (R&D) departments (Bell et al, 2019 and Nkhonjera et al, 2019). R&D plays an important role in innovation and evidence has that R&D expenditure are found to be statistically and economically significant determinants of innovation in manufacturing firms (Leiponen,2012). The R&D capabilities provide powerful knowledge and insights that aid in improving existing processes leading to increased efficiency and decrease in costs (Liu, et al., 2021). Investment in R&D also facilitate and support accumulation and sharing of knowledge in innovation strategies and plays in important role in manufacturing's firms. Over the period 2007/8 to 2016/17, R&D expenditure for FP&M sub-sectors tended to fluctuate in line with the general trends in economic performance across the manufacturing sector and larger economy. However, R&D expenditure by these FP&M sub-sectors registered a net decline over the 10-year term. For where data on R&D expenditure was available, the shares of total manufacturing R&D expenditure also declined for the Wood and Paper products and textiles sectors. The Furniture sub-sector registered strong growth in both the value and share of its R&D expenditure.

Table 4: R&D expenditure for FP&M Sectors by SIC code (2007/08 to 2016/17) (R'000)

	2007/08	2008/09	2009/10	20010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
All Manufacturing	4,222,127	4,787,581	4,321,327	3,592,204	3,551,234	3,476,647	3,793,066	4,501,146	4,442,466	4,107,936
Manufacture of Wood and Products of Wood and Cork, except furniture; Manufacture of Articles of Straw and Plaiting Materials; Manufacture of Paper and Paper Products; Manufacture of Publishing, Printing, and Reproduction of Recorded Material,	118,535	118,016	111,255	106,448	80,255	50,531	60,437	72,870	95,555	87,814
Manufacture of Textiles, Clothing and Leather Goods	17,888	13,755	16,946	2,437	0	2,073	32,091	34,609	9,335	8,932
Manufacture of Furniture; Recycling; Manufacturing not elsewhere classified	7,449	60,849	60,743	57,240	81,914	93,145	100,261	117,649	118,102	22,692

Source: South African National Survey of Research and Experimental Development Statistical Report: 2016/17

The next section provides a deep dive analysis into the FP&M SETA by looking at the age and occupation distributions and educational qualifications and trainings.

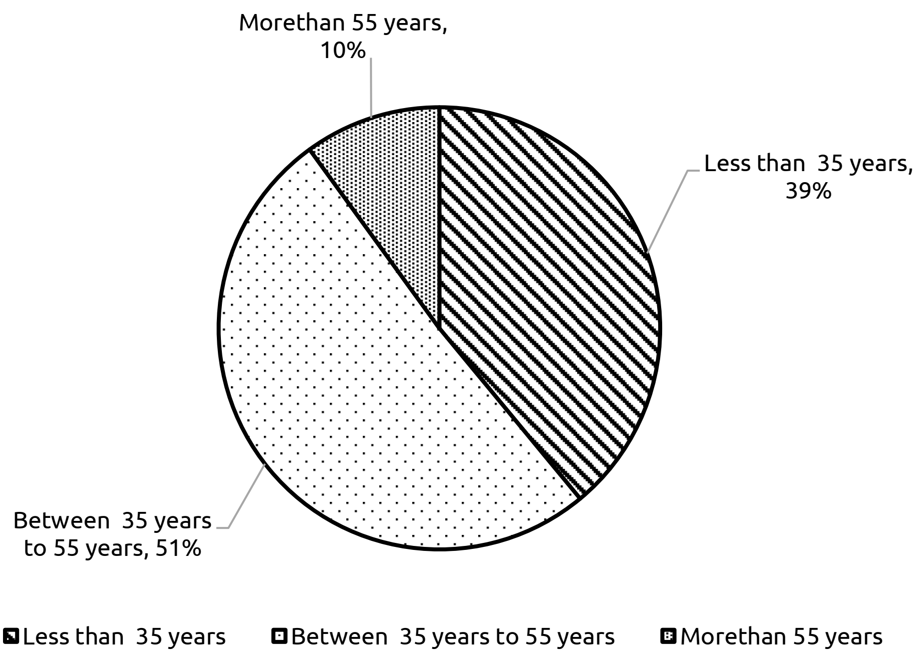
5. Analysis of FP&M SETA, Training and Education

The FP&M SETA currently comprises 25,616 employers. The majority of these employers are small enterprises employing less than 50 employees (FP&M, 2017). In total, the FP&M SETA employs approximately 332,194 people. However, this number has declined quickly over the past few years. Moreover, compared to the broader manufacturing sector, FP&M sectors have seen their employment fall faster (FP&M, 2017). This section examined the distribution of skills among the employees in the different sectors that comprises the FP&M SETA.

5.1. Age distribution in FP&M SETA

Age is an essential variable in determining how an industry can be productive and adapt. Improvements in productivity in industry depend mainly on the ability of employees to innovate and adapt to changing conditions, and it has been observed that a younger workforce is more adaptable (National Research Council, 2012). Human capital is essential for total factor productivity (TFP) growth; hence an ageing workforce is likely to impact productivity through TFP (Huang, et al., 2019). Furthermore, in line with the thrust of this research and amid the fourth industrial revolution, the age distribution of the sector employees is of greater importance, particularly around the changing capability requirements of firms to keep up with the technology transformations. An ageing workforce is likely to struggle with the adaption and innovation required to enable productivity improvements in the industry. A breakdown of the age profile of employees per subsector in the FP&M was categorised into three groups, namely those below the age of 35, between 35 and 55 years, and lastly, those more than 55 years (Figure 6).

Figure 6: Age distribution in the FP&M SETA employees, 2017



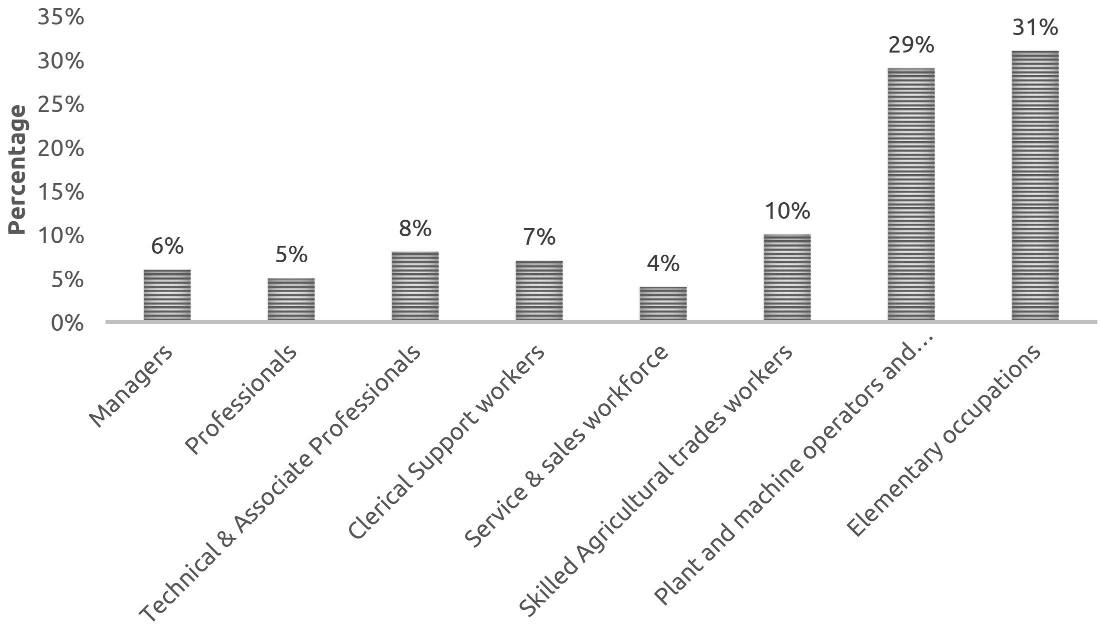
Source: FPM SETA WSP and ATR database, 2017

The number of employees between the ages of 35-55 in the FP&M sector in 2017 was higher than the rest of the other age categories at 51%. While employees less than 35 stood at 39% and employees more than 55 years accounted for 10% of the total. Across most sub-sectors except general goods (43%) and packaging (46%), the workforce is between 35 and 55. The above figure does not create significant concern for an ageing workforce across the FP&M sector. However, sector studies have shown that an ageing workforce is a concern in technical skills (such as pattern making) in the clothing and textiles sub-sectors (FP&M, 2015).

5.2. Occupational distribution of FP&M SETA employees

The occupational profile of the FP&M sector is informed by the nature of the business that the sector and, therefore, the type of skills required in the production process. Based on an analysis of Work Skill Plan (WSP) submissions, the highest proportion of the workforce employed in elementary occupations (31%), followed by Plant and Machine Operators and Assemblers (29%). These occupational groups account for 60% of the workforce. Service and Sales Workers has the lowest accounting for 4% of the workforce whilst managers (6%) and professionals (5%), together account for 11% of the workforce (Figure 7).

Figure 7: Occupational distribution of FP&M SETA employees



Source: FPM SETA WSP and ATR database, 2017

The occupational profile of the sector implies a requirement for a relatively higher proportion of lower-level skills. This is mainly because the FP&M sectors are largely labour intensive, as most of them are related to plant and machine operations and elementary occupations. Elementary occupations consist of simple and routine tasks that mainly require hand-held tools and often some physical effort. Most occupations in this major group require skills at the first International Standard Classification of Occupations (ISCO) skill level (ILO, 2019). Examples of elementary occupations include drivers, cleaners and refuse workers, sales and services workers, forestry labourers, and food Packaging assistants. This has implications in adopting Industry 4.0, which prescribes a list of skills priorities to conduct industrial activities in digitalisation, production, and management. In the FP&M sectors, digitalisation will mainly focus on the plant machine and operations level and would imply a requirement on the upskilling at the technical and associate levels. Upskilling is critical due to the increasing computational power in reshaping the context of changing work environments and the interconnectedness in manufacturing in the 4IR.

Developing high-level skills and exposure to cutting-edge knowledge, best practices, and trends in plant and machine technology, innovation, and entrepreneurship is key to promoting world-class manufacturing (FP&M, 2017). Changing demands by industry and consumers solidifies the need for workers and managers to be multi-skilled. The core strategic challenge facing skills development in the sector is where to concentrate resources in ways that will best support the sub-sectors to achieve inclusive growth (FP&M, 2015). The top ten scarce skills in the FP&M SETA are summarised in the table below (Table 5). The skills are identified by the Organisation Framework Occupations (OFO) code. Furthermore, the table identifies whether the skills are critical or not. The critical skills needed in the industry are provided in the FP&M sector skills plan for 2018-2022[2].

[2] Critical skills in the sector are: Operations management, Technology-related expertise, Design and Innovation, Supervisory, Project management, planning, solving, coaching and mentoring, sales and marketing.

Table 5: FP&M scarce skills

OFO Code	Scarce Skill	Critical Skill	Non-Critical Skill
715302	Machinist	✓	
214908	Materials engineering technologist	✓	
653301	Machine mechanist	✓	
214101	Process engineer	✓	
683401	Upholster		✓
131102	Production/ Operations manager	✓	
821501	Forester		✓
652204	Pattern maker	✓	
312201	Production/ Operator supervisor	✓	
216603	Multi-media designer	✓	

Source: FP&M SETA (2017)

Some occupations are hard to fill across multiple subsectors within the FP&M sector. For manufacturing companies in the clothing, textiles, pulp, and paper, printing, and packaging industries, these are generally mid-to-high level, technical occupations such as plant and machine operators, machine assemblers, machine mechanics, coded welders, technologists, and technicians (FP&M SSP interviews, 2017). At the same time, there are elementary occupations in some subsectors that are also hard to fill. In clothing, for example, pattern makers, cutters, and machinists are difficult to source, particularly those that work in factories. The existing pool of pattern makers is aged, and a small scale of young people is attracted to the occupation. Likewise, in forestry, about 90% of the workforce is low-skilled and, in some cases, illiterate in occupations such as planters and basic firefighting. Labour turnover in the industry is high, and this increases demand for short courses and skills programme type training as this turnover creates a constant flow of recruits that require training (FP&M SSP interviews, 2017). Industries in print media and publishing subsectors experience difficulties in filling high-level, professional occupations including editing, digital publishing, translator, and design (FP&M Employer survey, 2015). Other reasons for the occupations that are hard to fill across the FP&M sector include:

- Low wages in the sector rendering some occupations less attractive to young people;
- Technological improvement in the sector requiring a new skill set;
- Industry trends creating new pressures for employers in the sector to operate differently;
- Lack of immediate skills to replace an aging and experienced workforce;
- Need for multi-skilled people to perform functions that people previously filled without multiple skills; and
- Graduates lacking the requisite basic skills to function.

In some instances, occupations are not hard to fill, but there is a high turnover of employees because the jobs are used as a stepping-stone into other more lucrative jobs. In other words, people only hold on to the jobs because they have no options (FP&M, 2015). High turnover exists from manufacturing into retail, which is considered more lucrative (SSP interviews, 2017). The occupational profile of the sector implies a requirement for lower-level skills to ensure the competitiveness of the people employed. The increased investment in technology by employers in the sector is likely to negatively impact the demand for low-level skills and a move towards intermediate skills.

5.3. Educational qualifications and training in the FP&M SETA

A primary objective of a SETA is the development of the sector skills plan (SSP). The SSP outlines an overview of the sector skills situation, challenges, gaps, scarce skills and is used to identify key priority areas better and more credible planning around skills development. One area the FP&M SETA has focused on in its quest to develop skills involves facilitating relationships with the Quality Council for Trades and Occupations (QCTO) and stakeholder organisations to mutually work towards the development of qualifications across sub-sectors (FP&M, 2017). This supply-side partnership has led to approximately 54 occupationally directed qualifications for ten industrial subsectors (clothing, textiles, footwear, leather, forestry, pulp, and paper, printing, publishing, packaging, furniture, and wood products). These qualifications are intended to improve the sector's competitiveness at a local and national levels, and form part of a national effort to align qualifications to specific occupations, combine theory and practical training and improve the relevance and quality of education and training. Some of these qualifications will be provided at public TVET colleges (FP&M, 2015).

Secondly, the FP&M SETA partnered with the South African Graduates Development Association (SAGDA) in an R30 million project facilitating the placement of approximately 857 University and TVET college graduates on internships, work experience, and work-integrated-learning programmes (FP&M, 2015). Central to the partnership is recognising that graduates exposed to professional environments are better placed to find employment. In recent years, one of the weaknesses of the education and training system has been the lack of work-integrated learning and work experience as part of the programmes targeted at meeting the training needs of sector occupations in demand. Many providers have failed to integrate theory and practical experience into their curricula, and many learners and graduates have not been provided with adequate opportunities to gain practical and work experience in the industry (FP&M, 2015).

Thirdly the FP&M SETA has accredited 21 TVET colleges, providing occupationally directed programmes (FP&M, 2017). The Furniture Skills Development Initiative in Khayelitsha, in the Western Cape, is a partnership between FP&M SETA and False Bay TVET College; this collaboration provides furniture and cabinet-making learnerships for 60 unemployed learners. TVET partnerships like these contribute to enhancing the role of public TVET colleges in the education and training system and provide programmes relating to critical occupations needed in the system. Public TVET colleges are located across the country, close to communities needing skills development, education, and training. Partnerships such as these will improve the quality of programs offered by these colleges and target skills needs within these communities and the broader economy (FP&M, 2017).

However, while the above actions are commended, the challenges have been linking public universities, TVET colleges output with the industry requirements and the adequacy and relevance of the SETA training programs in equipping employees for the changing skills requirements in the Industry 4.0 era. Technology is changing the skills being rewarded in the labour market. The premium is rising for skills that cannot be replaced by robots' general cognitive skills such as critical thinking and socio-behavioural skills such as managing and recognising emotions that enhance teamwork. Workers with these skills are more desirable in labour markets than those lacking these skills. Technology is also disrupting production processes by challenging the traditional boundaries of firms, expanding global value chains, and changing the geography of jobs (World Bank, 2019). Finally, technology is changing how people work, giving rise to the gig economy in which organisations contract with independent workers for short-term engagements. High-skill workers are gaining with technological change, whereas low-skill workers, especially those in manual jobs, seem to be losing out (World Bank, 2019).

The rapidly changing operating environment and advancing technologies already have had a massive impact on the FP&M sectors (FP&M, 2017). This will require the employers to seek advanced levels of training and new skill sets that can manage and cope with the ever-changing environment. However, the South African clothing and textile sector, along with other FP&M firms, are struggling to fill low-skill positions while at the same time failing to find suitably trained mid- to high-skills - mainly technical skills like plant and machine operators, machine mechanics, technologists and technicians - to try and meet the mechanisation and changing technologies (FP&M, 2017).

Quality tertiary education is a necessary precursor for advancing the industrial ecosystem of any country in terms of gearing the workforce will the requisite skills and knowledge to effectively usher in a new manufacturing era. However, the sectors are seemingly hampered by supply-side constraints in that there is a lack of adequate external training partners, and so many employees are trained informally and on an ad-hoc basis (FP&M, 2017). However, the FP&M SETA does support a large number of prospective learners. Around 80% of the learners on learnerships are studying towards national certificates applicable to the clothing, textiles, furniture and forestry sub-sectors (FP&M, 2017). The FP&M scarce critical skills list identifies critical and non-critical skills in high demand from the industries. The clothing, footwear, leather, and textiles sectors employ a significant proportion (between 30% and 40%) of their workforce as plant and machinery operators. Owing to the varied nature of the different sectors that make up the FP&M SETA, the critical skills will differ.

6. Skills Training in the Context of 4IR

The world is in the midst of a technological revolution. Advances ranging from the field of information and biotechnology to materials science and communications are occurring at an accelerating pace, bringing about radical changes in all dimensions of life (Pouris, 2012). Rapid technological advancements have increased the need for high-level technical skills and machine mechanics. However, shortage of overall technological expertise (e.g. mechanics and machinists) has meant that skills have had to be brought into the country from elsewhere to maintain and repair machinery and train employees on how to use them. In some subsectors, such as clothing and textiles, basic-level skills training for patternmakers, cutters, and machinists has succumbed to a heightened focus on design-type skills. The result has been growing skills gaps at lower skills levels, negatively affecting clothing and textiles manufacturing. Although higher-level skills such as design are essential for the growth of the local clothing and textiles industry that is targeting high quality, niche market, the potential for generating large numbers of jobs lies primarily with manufacturing, and this requires large numbers of low-level skills in addition to smaller numbers of high-level skills. There are not enough mentors and potential trainers in the FP&M sector to mentor and train on the factory floor (FP&M, 2015).

Creating new production capacity is not a simple matter, as it implies planning beyond the traditional scope of current industries and projecting skills needs not based on current production but future potential production processes. Skills development for productivity improvement is thus an area that the FP&M SETA needs to give urgent attention to, including training in the use of future technologies and production methods. It will be essential to develop skills development solutions to address emerging technologies.

Digitisation has changed the FP&M subsector considerably in recent years, with further innovations to be expected. Those employees whose jobs will change due to the application of modern production methods must be provided with the opportunity to learn these new production methods, retain their jobs, and occupy more highly skilled and better-paid jobs. There is also potential for expanding eLearning within the sector. Notably, there must be the development of local skills for maintaining imported equipment and machinery; and training trainers on the use of new machinery and equipment.

Many occupations that demand scarce skills, such as machinists and machine mechanics, have an ageing workforce. As such, the FP&M SETA needs to identify the scarce skills occupations where the skills may be lost due to retirement and design interventions to address the challenges. This could include encouraging succession planning linked to internships, supported by quality coaching and mentoring. The SETA has begun implementing strategies such as retaining experienced people in different capacities linked to skills transfer, and these will be supported by assigning to be a mentor to coach the inexperienced staff and giving them more responsibilities.

Given the dearth of adequately educated employees, training on the factory floor becomes increasingly attractive for manufacturers in terms of the practical training delivered on-site and the reduction in opportunity costs associated with off-site training. It also helps to address gaps, given that new graduate employees are often not work-ready. Expanding workplace located training must also consider employers' capacity to plan and supervise effectively on-the-job training and for improved partnerships between employers and providers to integrate workplace and institution-based training. In some subsectors, there is a desperate need for an expansion of internships, and the SETA will need to assist in structuring such programmes and supporting employers and interns to obtain maximum benefit.

Modern production models such as air-vortex spinning are often based on producing smaller product lines, producing the right product at the right time with minimum wastage and at high speed. Such production models require a different approach to skills development. The creation of industry-specific incubators that include skills development as a central pillar, maybe one approach to providing support to FP&M sectors acquire technical up-skilling aligned with the global developments and readiness for the manufacturing in 4IR. The industry's future depends on two levels of skills provision, the first being the production of the lower level, technical skills, and the second, the production of higher-level, technical and design-orientated skills needed to meet the high-fashion demands of large retailers. A multi-layered, partnership approach must be developed between the firms, SETA, training and education institutions and government.

7. Technology Adoption in the FP&M SETA– Evidence from the Digital Skills Survey

Firm-level innovations and technological changes do not occur in isolation but rather through an array of interdependent internally and externally driven processes and structures (Bell, et al., 2018a). This interdependence is critical in production and technological upgrading because new technologies are dependent on complementary changes in a firm's environment. In light of the growing assertions around the transformative potential of automated and digital-enabled processes in improving efficiency and competitiveness. This section analyses the readiness and preparedness of firms affiliated with FP&M for high-tech and digital skills using data collected by the Digital Skills

Survey (2020/21) and leverages the firm's responses on production methods, both current and future ambitions, and the firm's constraints in adopting digital technologies.[3]

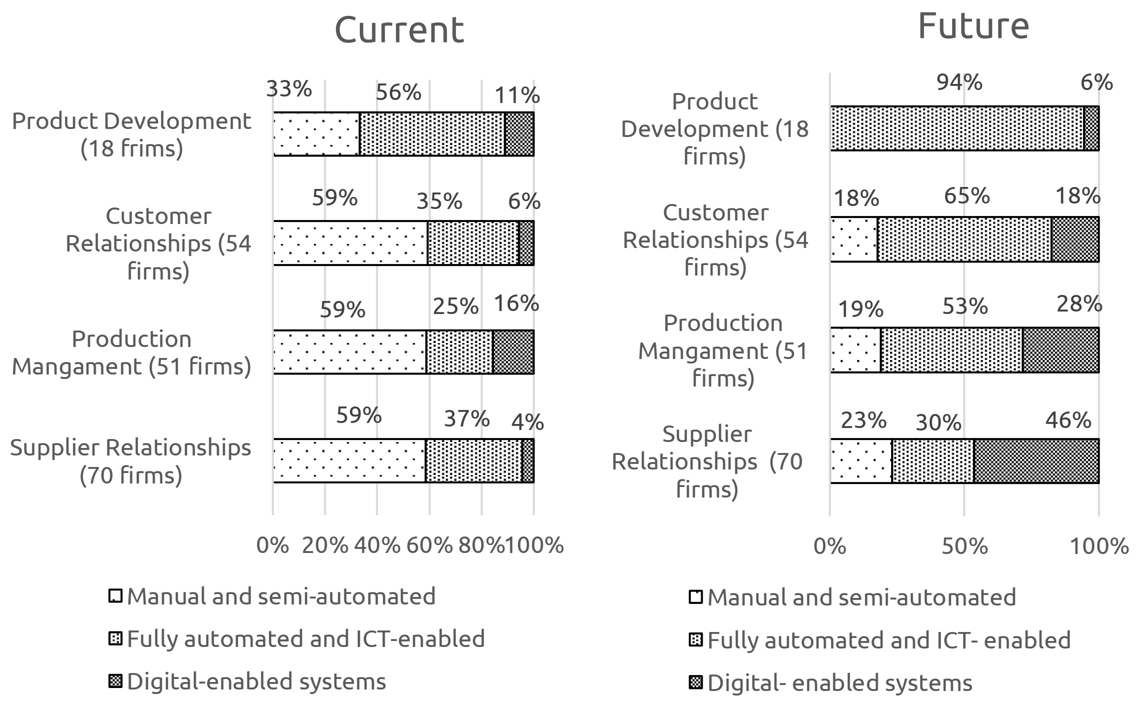
7.1. Current and future technological infrastructure of FP&M SETA firms

The firms in the Digital Skills Survey were required to indicate their current technology infrastructure and their future ambitions regarding upgrading this infrastructure in the next 5-10 years across four interrelated business functions. The business functions are drawn from Kupfer et al. (2019) who define different generations of technologies (from G0 and manual to G4 and digitally-enabled) that operate in each of the following business functions. These business functions are supplier relationships, customer relationships, production management, and product development. For analytical ease, the technological generations were consolidated into three distinct categories. The first category referred to manual- and semi-automated processes used to explain the use of analogue and rigid processes. The second category referred to fully automated and ICT-enabled processes that described lean production processes. The last category referred to digital-enabled systems that depicted the use of integrated and smart processes. The results offer some high-level insights into the current complexity of operations of the FP&M firms surveyed with direct implications for digital skills.

The current technological infrastructure prevailing in the industry points to most of the business functions among the surveyed firms as largely driven by manual-and semi-automated technologies and processes (Figure 8). The data shows that some have adopted fully-automated and ICT-enabled processes with a small proportion having already implemented advanced processes linked to digital-enabled systems. The current status in the industry shows that most of the processes are largely driven by manual and semi-automated technologies except the product development function (33%) the other business functions (Customer relationships, Supplier relationships, and Product management) 59% of these functions were manual. This appears to suggest that firms within FP&M that participated in the survey have affinity in adopting new technology in the product development business function as evidenced by their embrace of fully automated and ICT-enabled and digital-enabled systems.

[3] 74 FP&M-linked firms that participated in the survey

Figure 8: FP&M SETA Current and Future Technological Adoption



Source: Authors' illustration using survey data[4]

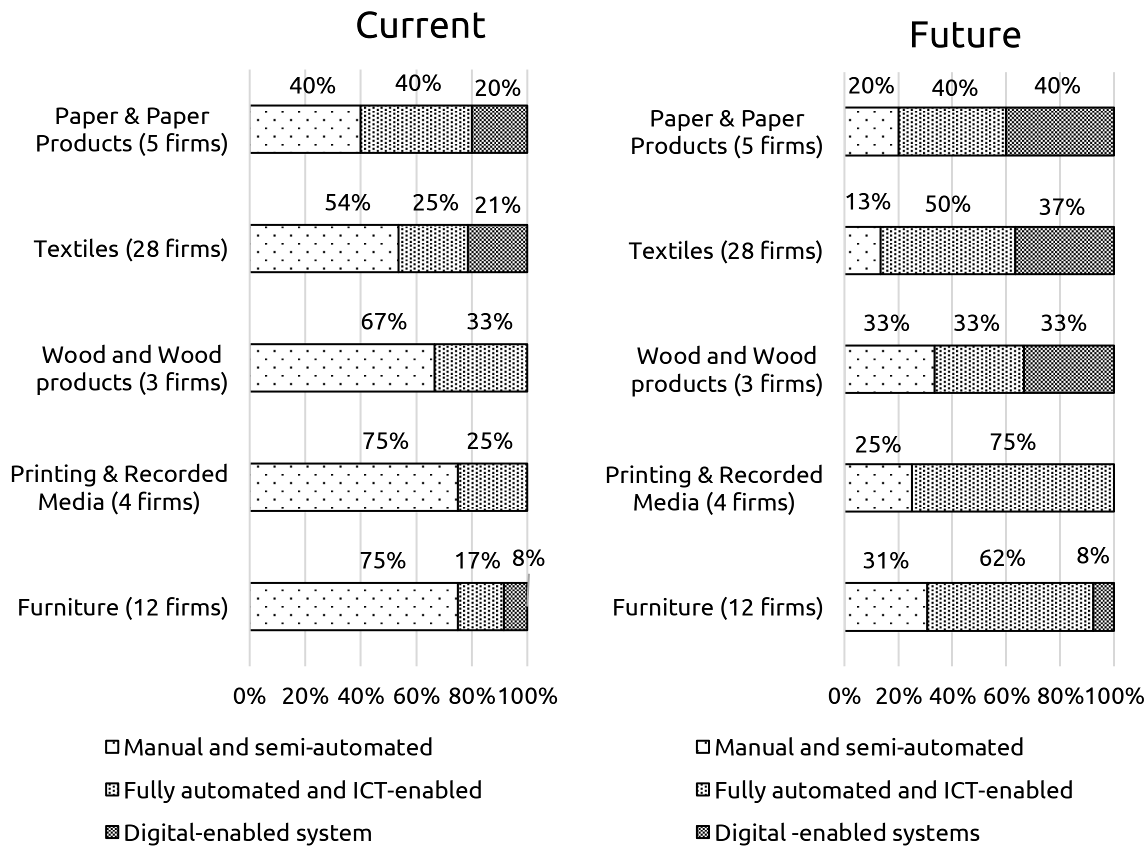
The future outlook paints a different picture with the firms recognising changes and the dynamic environment in which they operate. A reduction in the manual-and semi-automated processes is forecasted as firms embrace new technologies and systems. Product development (94%) looks set to continue adopting automation and ICT-enabled systems while other business functions such as customer relationships and product management follow behind with 65% and 53%, respectively. There is also evidence of a future aspiration by firms to move to digital-enabled systems, and the supplier's relationships (46%) seem to provide a pathway to this followed by production management (28%).

To further understand the current status, it was prudent to delve deeper to get the sectoral breakdown in the industry (Figure 9). This was critical in determining leading sectors at the forefront of driving the adoption of digital technologies and identifying sectors that fall behind. Printing and recorded media emerged as the sector with the highest percentage of its processes being driven by manual and semi-automated, followed by the Furniture, Wood and Wood products and textiles. These are largely labour intensive, which can explain why the aforementioned sectors are laggards in technological adoption. The Paper and paper products subsector had at least 50% of their processes being fully-automated and ICT-enabled, suggesting that there are at the forefront in championing technological adoption (Figure10). In the printing and recorded media, the use of electronic media is increasing rapidly and is expected to change the face of the printing and publishing subsectors locally and internationally. Paper products used for communication purposes, such as newspapers, are under threat from digital technologies and have dropped substantially over the past few years. Existing technology in large manufacturing companies in packaging, printing and print media, paper and pulp, textiles, clothing, for example, are designed to operate faster and more efficiently. Therefore, in the context of Industry 4.0, the sector is more receptive to

[4] Based on the 74 firms that participated in the survey

new technology adoption, and a possible policy implication will be to support them in improving their processes.

Figure 9: Technological Adoption by FP&M SETA Sectors



Notes: Sectors with single responses were excluded and the number of firms is in brackets.

Source: Authors' illustration using survey data[5]

The future ambitions of FP&M firms are in line with SETA forecasts of a transition to fully automated and digital-enabled systems that will transform the workplace in the next 5 to 10 years as people begin engaging with more intelligent machines. Textiles, paper and paper products, printing and recorded media, and furniture are the leading subsectors in their future ambition to move to new technologies while the rest exhibit the willingness to adopt. Advanced technology is fundamental in the FP&M Industry, and continuous improvement, breakthroughs, and technological development are critical rudiments of the industry. Therefore, a firm's future ambitions impact the availability of relevant skills and the need to upskill in the foreseeable future. As a result, policymakers must foster and fast-track the relevant skills needed to enable this smooth transition to new technologies. To ensure this smooth transition, there is the need for industry-research partnerships with research institutions, science councils, and technology universities in areas identified for innovation.

The ability to engage in technological upgrading is strongly linked to various firm-specific factors. These can range from them being exporters or to their age, but most often, the ability to adopt more advanced technological infrastructures is due to an individual firm's size (Avenyo & Bell, 2022 forthcoming). The survey of FP&M firms showed that medium and

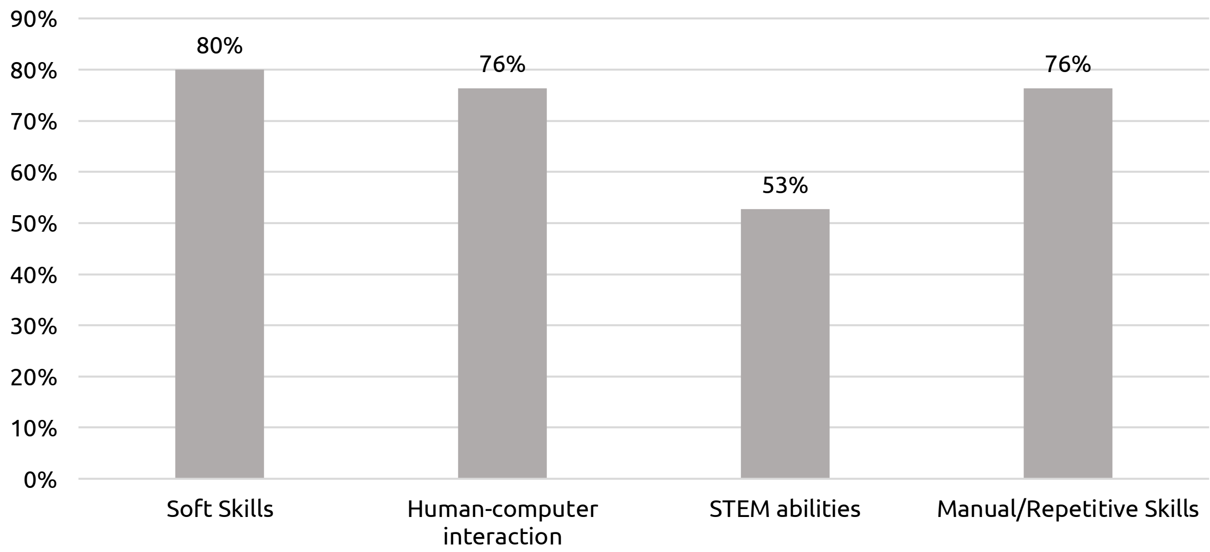
[5] Based on the survey of 74 firms that participated in the survey.

large were leading in the adoption of fully-automated, ICT-enabled, and digital-enabled systems. This may be due to differences in budgets and other resource advantages attributable to medium and large firms that afford them the capacity to be leaders in new technologies unlike micro and small firms.

7.2. Role of skills in technological adoption

Another factor that explains why the current technology adoption status is dominated by manual and semi-automated processes is linked to the skills the firms identified as necessary. At least 80% of the FP&M firms that participated in the survey indicated that soft skills were critical when hiring (Figure 10). The soft skills include problem-solving, communication, and interpersonal skills. In addition, the firms also regarded that human-computer interaction (76%), manual (76%), and STEM abilities (53%). This breakdown depicts the current technology adoption by the FP&M firms in that since most of the subsector's processes are largely manual and semi-automated, it is an implication on what they regard as essential skills. Hence, soft skills, human-computer interaction, and manual skills were identified as the top 3 skills. As a result, this has a bearing on firms' ability to transit to fully automated and digital enables systems that place a huge role on Science, Technology, Engineering, and Mathematics (STEM) abilities.

Figure 10: Important Skills in FP&M SETA firms when hiring



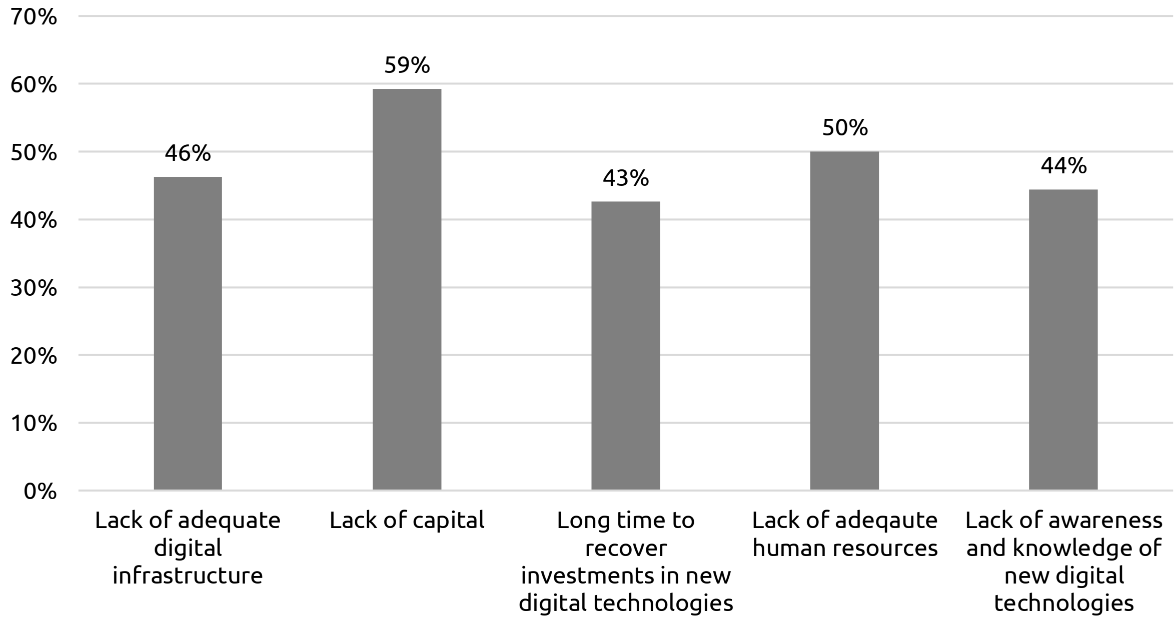
Source: Authors' illustration using survey data

From the subsector's perspective, FP&M firms, on average, possess a greater affinity towards manual skills with furniture, textiles, wood, and wood products firms, indicating the importance of the skills. The dominance of manual skills suggests the labour intensity of the FP&M subsectors, while the ranking of STEM skills in fourth exhibits the current status quo of largely manual-and semi-automated processes.

7.3. Challenges in technological adoption in FP&M firms

The surveyed firms from FP&M highlighted that the lack of capital (59%) was a significant obstacle in the adoption of technology followed by the lack of adequate human resources (50%). Other factors include the lack of adequate digital infrastructure (46%), lack of awareness and knowledge of new digital technologies (44%), and a long time to recover investments in new technology (43%) as shown in figure 11.

Figure 11: Obstacles to technological adoption



Source: Authors' illustration using survey data

The digital age has also exponentially raised the demand for Science, Technology, Engineering, and Mathematics (STEM). In the survey, FP&M firms identified that a lack of adequate human resources was an obstacle to technology adoption. However, skill shortages vary in the subsectors and firms because of a short supply of people with the right kind of skills. For instance, a lack of experience and specialised skills directly affects the adoption of technology. The FP&M SETA acknowledges skills shortages, which is in part perpetuated by a lack of local capacity to train employees for new technologies and machinery, mainly where these are imported (FP&M, 2017). These structural issues have necessitated global outsourcing of such training in some instances.

The transition from manual and semi-automated processes to fully automated and digital-enabled systems also depends on the availability of digital infrastructure that can support these new technologies. Previous CCRED studies have indicated that South Africa has expensive, comparatively slow, and unreliable ICT infrastructure, and industrialists deem this to be a significant limitation to the adoption of more advanced digital technologies. The potential efficiencies along value chains, from digitalisation, enabling data analysis and tracking of performance across plants and markets, are undermined by poor connectivity. AI-enabled machine learning systems, particularly data-intensive, appear compromised due to this limitation, especially for SMMEs that do not have the resources to invest in bespoke infrastructures (CCRED, 2019).

Encouraging firms to adopt new technologies requires upgrading the current infrastructure to enable a smoother transition and adoption of 4IR technologies. However, this only solves part of the broader problem. Transitions of the magnitude required to upgrade the technological infrastructure within the FP&M SETA-linked firms significantly necessitates addressing and correcting for several related obstacles to upgrading. For instance, the firms' other reported obstacles (a lack of awareness of and knowledge in digital technologies and the time taken to recover investments in digital technologies) presents an opportunity for a multifaceted approach to expanding technology roadshows and information seminars helmed by both the FP&M SETA and industry associations.

8. Conclusion

The challenge of a skills mismatch between industry needs and the available skills has been a critical challenge for the South African economy for some time now. This is exacerbated by the changes related to Industry 4.0 as more routine tasks are being automated while new jobs are being created that require more sophisticated skills. Technology is also changing how people work, leading to high-skill workers gaining with technological change, whereas low-skill workers, especially those in manual jobs as in the FP&M SETA are at risk of losing out. The upgrading of skills and adoption of cutting-edge technology and innovation is acknowledged as a critical ingredient in improving the productivity and competitiveness of manufacturing, particularly in the FP&M SETA.

The analyses, based on data from the SETA and Quantec, revealed that the core strategic challenge facing skills development in the sector is to concentrate resources in ways that will best support the sub-sectors to achieve inclusive growth. The analysis also identified a skills mismatch between the job descriptors emerging in the key technologies transforming the FP&M sectors, FP&M SETA employees, and the scarce skills list generated by the SETA. The slow pace of adoption of new qualifications has critical competitive implications for firms engaged in these sectors. Moreover, this may be exacerbated by the slow pace of adoption of the Industry 4.0 technologies (and its demand-pull for new skills) in South Africa generally.

Insights from the Digital Skills Survey (2020/21) show that manual- and semi-automated technologies and processes dominate the technological infrastructures of the surveyed firms. Most sectors within the FP&M SETA are laggards in the adoption of technology, which could be due to the relatively higher labour intensity of the sectors concerned. However, the future outlook shows a significant turnaround as firms register their willingness to adopt Industry 4.0 technologies. The ability of these firms to adopt more advanced technologies is strongly linked to various factors such as firm size, age, export capacity, and which skills they consider important when hiring.

Nevertheless, technological upgrading in FP&M firms is being hindered by several obstacles, including a lack of capital, adequate human resources, adequate digital infrastructures, awareness and knowledge of new digital technologies, and the perceived long time to recover investments in new technologies. As a result, the current status quo appears to suggest that the FP&M SETA firms are, on average, not ready to engage in the adoption of advanced digital technologies. To address these shortcomings and accrue the benefits of Industry 4.0 requires prioritising the importance of coordinated skills and industrial policy interventions to support the adoption of the Industry 4.0 technologies. It also necessitates deeper and more sector-specific nuance relating to these broader problems. This sector-specific collaborative approach must focus on combining the mandates of several institutions through industry-research partnerships, designing incentives around technology and skills upgrading, addressing access barriers to technology accumulation and skills training. Once combined, this type of full-scale policy approach can significantly aid the facilitation of, and transition toward Industry 4.0.

9. References

Amatori, F., Bugamelli, M. & Colli, A., 2013. Technology, Firm Size, and Entrepreneurship. *The Oxford Handbook of the Italian Economy Since Unification.*

Andreoni, A. & Tregenna, F., 2018. *Stuck in the middle: Premature deindustrialisation and industrial policy,* Johannesburg: CCRED Working paper 11/2018.

Andreoni, A. & Tregenna, F., 2020. Escaping the middle-income technology trap: A comparative analysis of industrial policies in China, Brazil and South Africa. *Structural Change and Economic Dynamics,* Volume 54, pp. 324-340.

ASGISA, 2007. *Annual Report 2007,* s.l.: s.n.

Barnes, J., Black, A. & Roberts, A., 2019. *Towards a digital industrial policy for South Africa: a review of the issues.Industrial Development Think Tank,* Johannesburg: s.n.

Beare, M., Mondliwa, P., Robb, G. & Roberts, S., 2014. *Report for the Plastics Conversion Industry Strategy. Research report prepared for the Department of Trade and Industry.,* s.l.: s.n.

Bell, J., Goga, S., Mondliwa, P. & Roberts, S., 2018a. Structural Transformation in South Africa: Moving Towards a Smart, Open Economy for All. *Centre for Competition, Regulation and Economic Development Working Paper 9/2018.*

Bell, J., Kaziboni, L., Pamela, M. & Nyamwena, J., 2018b. *Firm Decisions and Structural Transformation in the Context of Industry 4.0.,* Johannesburg: s.n.

Bell, M. & Pavitt, K., 1995. The development of technological capabilities. *Trade, technology and international competitiveness,* 22(4831), pp. 69-101.

Benešová, A. & Tupa, J., 2017. Requirements for Education and Qualification of People in Industry 4.0. *Procedia Manufacturing,* Volume 11, pp. 2195-2202.

CCRED, 2019. *Towards a Digital Industrial Policy for South Africa: A Review of the Issues Industrial Development Think Tank,* Johannesburg: s.n.

Chenoy, D., Ghosh, S. & Shukla, S., 2019. Skill development for accelerating the manufacturing sector: The Role of 'new-age' skills for 'Make in India'. *International Journal of Training Research.*

CHIETA, 2019. Future Skills Needs in the South African Chemical Sector Influenced by the 4th Industrial Revolution & Green Developments.

DHET, 2019. *POST–SCHOOL EDUCATION AND TRAINING MONITOR,* Pretoria: s.n.

FP&M, 2015. *Sector Skills: Update 2015-2020,* s.l.: FP&M SETA.

FP&M, 2017. *FP&M SETA Sector Skills Plan 2018-2022,* s.l.: FP&M.

GEAR, 1996. *Growth, Employment and Redistribution: A Macroeconomic Strategy,* s.l.: s.n.

Hechman, J. & Corbin, C., 2016. Capabilities and skills. *IZA Discussion Paper Series No. 10005.*

Huang, W.-H., Yen-Ju, L. & Hsien-Feng, L., 2019. Impact of Population and Workforce Aging on Economic Growth: Case Study of Taiwan. *Sustainability MDPI,* 11(6301), pp. 1-13.

ILO, 2019. *International Standard Classification of Occupations,* s.l.: International Labour Organisation (ILO).

Kupfer, M. E., Lin, W. H., Ravikumar, V., Qiu, K., Wang, L., Gao, L., et al. 2019. In situ expansion, differentiation, and electromechanical coupling of human cardiac muscle in a 3D bioprinted, chambered organoid. *Circ. Res.* 127, 207–224. doi: 10.1161/CIRCRESAHA.119.316155

Kniivilä, M., 2005. *Industrial development and economic growth: Implications for poverty reduction and income,* s.l.: s.n.

Leiponen, A.,2012. The benefits of R&D and breadth in innovation strategies: A comparison of Finnish service and manufacturing firms. *Industrial and Corporate Change*, 21(5): 1255-1281.

Liu, H.; Luo, Y.; Geng, J.; Yao, P.,2021. Research Hotspots and Frontiers of Product R&D Management under the Background of the Digital Intelligence Era—Bibliometrics Based on Citespace and Histcite. Appl. Sci. 2021, 11, 6759. https://doi.org/ 10.3390/app11156759

Lopez-Acevedo, G. & Robertson, R., 2019. *Sewing Success: Employment, Wages, and Poverty following the End of the Multi-fibre Arrangement,* s.l.: World Bank.

Mclaughlin, S., 2017. Dynamic capabilities: Taking an emerging technology perspective. *International Journal of Manufacturing Technology and Management,* 31(62).

NSDS, 2011. *National Skills Development Strategy III,* s.l.: DHET.

Pouris, A., 2012. *Technology Trends: A Review of Technologies and Policies,* Pretoria: Institute for Technological Innovation, University of Pretoria, .

SAQA, 1998. *Skills Development Act 97 of 1998,* s.l.: s.n.

Sen, K. & Tyce, M., 2018. *The Politics of Structural (De)Transformation: The Unravelling of Malaysia and Thailand's Dualistic Deals Strategies,* s.l.: s.n.

SETA, F., n.d. *Demand of Skills,* s.l.: s.n.

Stewart, R., 2018. Repositioning the future of the South African clothing and textile industries. *IDTT Digital Industrial Policy Brief 7.*

Verma, A., 2012. *Skills for competitiveness. Country report for Canada,* s.l.: OECD.

World Bank, 2018. South Africa Economic Update. *Jobs and Inequality.*

World Bank, 2019. Chapter 1. In: *The Changing Nature of Work.* s.l.: World Bank.