Digital Industrial Policy Brief 4

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PRACTICAL IMPLICATIONS FOR THE SOUTH AFRICAN FOOD PROCESSING INDUSTRY

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Introduction

The food processing industry is predominantly characterised by high production volumes and low profit margins. Rising regulatory pressure, commodity price increases, more demanding consumer expectations and economic uncertainties are driving large food companies to search for new ways to optimise manufacturing processes and access new markets with a variety of new products. Digital technologies are emerging as a major opportunity to ameliorate these challenges.

In the upstream portion of the value chain, encompassing farming and associated agriculture activities, precision agriculture utilises sensors, high definition satellite imagery and drone technology to monitor equipment, crops and livestock to increase yields.[3] Raw materials handling uses sensors and more recently blockchain technology to enable full visibility and traceability across the supply chain and to optimize storage handling and associated transport and logistics. In food processing, which is the focus of this brief, connected machinery and robotics have been identified as key disruptors resulting in increased efficiency, enhanced flexibility, reduced costs and higher productivity within the downstream portion of the value chain. However, distribution and retail processes are being disrupted by cloud-based Internet of Things (IoT), big data analytics (powered by machine learning and artificial intelligence) and new technology platforms. The growth in online grocery retail sales affords the food industry deeper insights into shopping trends and the ability to predict rather than react to customer needs.

These new technologies have the potential to fundamentally change the way food is produced, processed and purchased, although, at this stage it is unclear how quickly and pervasively the system will evolve. This brief considers the current and future applications of the various new technologies that are broadly associated with Industry 4.0. It is based on a literature review

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[3] World Bank (2017). ICT in Agriculture (Updated Edition) : Connecting Smallholders to Knowledge, Networks, and Institutions. Washington, DC: World Bank. Available online: https://openknowledge.worldbank.org/handle/10986/27526.

and selected interviews with industry stakeholders and attempts to provide practical examples of how global food processing firms are grappling with digitalisation changes. Additionally, it considers how South Africa's food value chains are positioned for digital transformation, both now and in the future. In doing so, it considers some of the practical implications of these innovations, and provides an overview of emerging regulatory, policy and programmatic responses required to maximise digitalisation opportunities.

For the purposes of defining the scope of this study, a clear definition of food processing is required. Food-processing is defined as the manufacturing process that converts raw animal, vegetable, fruit or marine materials into intermediate or final use foodstuffs for human or animal consumption.[4] Traditionally, food-processing has been strongly linked to the preservation of food, and this remains the most prominent reason for food manufacture, although a more general definition is the value adding conversion of raw materials — through the application of labour, machinery, energy and scientific knowledge‖ (ibid). While the manufacture of food may entail a single step conversion of raw material to a consumer product, the number of conversion steps has increased over time, largely in response to the increasing sophistication of consumers, as well as the increasing capacity of multinational food producers to meet (and lead) consumer expectations.

Big Data, Machine Learning, Cloud computing and Artificial Intelligence

Analytics based on extremely large data sets have emerged only recently in manufacturing, where they optimise production, enhance quality, save energy, and improve equipment reliability. It is anticipated that, in an Industry 4.0 context, the collection and comprehensive evaluation of data from many different sources, namely, production equipment and systems as well as enterprise and customer management systems, will become the standard for supporting real-time decision making. The volume, variety and velocity of data is set to increase as more users are connected in a cyberphysical space.[5]

The growth in online grocery sales afford the food industry deep insights into shopping trends and the ability to predict rather than react to customer needs. Transaction data, as well as software and analytical tools to monitor social media platforms and various other data sources are being used to generate structured and unstructured information that is becoming increasingly valuable for companies, particularly as the technologies that capture and analyse data become more accessible. Retailers who have traditionally relied on third party companies to provide market intelligence can now access real time data insights at a much lower cost. Manufacturers are increasingly looking at ways to access this data to feed into product development.

Smart labels (using embedded sensors) provide more information on food products allowing for greater traceability, transparency and sustainability than was ever possible with pre-existing barcodes and labelling technologies. Home automation is also becoming a reality with smart appliances, linked up to the cloud to inform customers when stocks are low or when produce is approaching its expiry date. The Samsung Smart fridge has a smart interface that allows customers to check inventory, monitor purchases and use, and links to other devices.

[4] Heldman et al (1997). Principles of Food Processing. 3rd edition. Aspen Publishers, New York.
[5] Sturgeon (2017). The 'New' Digital Economy and Development. UNCTAD Technical Notes on ICT for Development.

Data collected via smart systems feedback through the value chain providing greater market intelligence for food brands which can more effectively plan output and target their marketing more effectively.

Production data is equally valuable to manufacturers to enhance productivity, precision, quality and food safety. Sensors are becoming increasingly affordable and powerful and are now being used in a variety of ways, including but not limited to the tracking products, the retrofitting of old machinery and enabling greater control and monitoring of robots. IoT enables devices to share data directly with one another, without a human intermediary, via cloud-based operating systems. The ability to analyse, in real-time, vast amounts of data collected by these sensors is key to optimising manufacturing processes within the time-sensitive food processing industry.

The application of these combined technologies also appears to be increasing exponentially within the line functions of food companies. For example, Unilever recently ran a pilot project testing the use of artificial intelligence in their recruitment process. Machine learning algorithms were used at the initial screening phase based on candidates' applications and CVs. The second stage of the assessment involved online psychometric tests, followed by a video enabled interview using AI. The AI asked questions, processed answers and identified cues from vocal intonations and facial movements. The results were largely positive with 50,000 hours of human labour saved, and a diverse and capable group of recruits secured.[6]

Another example using a combination of these technologies is Danone who have piloted the use of Voice recorders programmed to automatically identify and quantify bouts of crying in infants to collect time data to help create products to combat colic.[7]

Applications on the factory floor are becoming increasingly common. Data from sensors on equipment and the mining of this data with algorithms allows manufacturers to shift from preventive maintenance where a set plan is followed, to predictive maintenance processes, reducing maintenance costs and increasing productivity by reducing machine downtime due to unscheduled maintenance. Tetra Pak Inc. has developed a remote monitoring service involving its global installed base of more than 5,000 packaging machines fitted with advanced sensor technology. Sensor data are uploaded to a cloud server and analysed by service experts who identify abnormalities. The manufacturer is alerted to the predicted time to breakdown, based on machine failures across the network. This is of importance in the food industry where hygiene, safety and the adherence to strict regulations require the continuous upgrade of equipment. Similar systems, based on IoT technology and machine learning can be used to identify inefficient processes, external or environmental factors affecting production and even human errors which can be addressed to increase efficiency and optimise processes. Kraft Heinz has been investing in artificial intelligence tools to identify inefficiencies throughout the company, Starting with sales and marketing, and more recently in the supply chain and manufacturing.

[6] Business Insider (2017). Consumer-goods giant Unilever has been hiring employees using brain games and artificial intelligence — and it's a huge success. Available online: https://www.businessinsider.com/unilever-artificial-intelligence-hiring-process-2017-6?IR=T.
[7] https://www.nutraingredients-asia.com/Article/2018/06/11/Infant-nutrition-and-machine-based-learning-Preliminary-findings-from-Danone-reveal-colic-promise.

Robotics and automation

Automation and the use of advanced, often customised equipment has been a feature in food manufacturing for some time due to the nature of industrial processes required to mass produce food products, under strict quality and safety requirements. The emergence of collaborative robots (or cobots) are becoming increasingly popular in both primary and secondary food processing as recent developments in artificial intelligence and sensor technology, as well as mechanical advances to enable soft gripping, have broadened their scope for use. An alternative to the costly and cumbersome, primitive industrial robots which require guard fences, lockout systems and advanced safety features, the cobots are designed to work alongside humans. In addition, the cobots are intended to relieve workers from carrying out physically demanding, monotonous, dangerous and generally unfavourable tasks.

In food manufacturing, typical fields of application for cobots encompass packing and moving products and materials between production steps. Key drivers of this growth in their use and application include labour shortages in high labour cost economies, the rise in demand for more flexible manufacturing configurations, and the need for consistent quality. The rapidly growing range of robots featuring increased cognitive and technical abilities extends the fields of application for cobots creating opportunities for companies of all sizes to automate their manufacturing processes. Nestle has, for example, reported great success running cobots on their packaging lines, with 14 installations running in 2018. Axiom Foods Inc, a medium sized manufacturer of snack foods, purchased two cobots in 2016 as they shifted from fixed to flexible automation. The cobots have been used in packing finished products into shipping containers and their high speed and precision have made them a cost-effective solution for the company. Unilever, is also using cobots on its packaging lines. The cobots are easily programmable and are fitted with cameras and artificial intelligence (AI) technology to ensure products meet quality standards, while generating swathes of data to continuously improve operating processes.

Of the various technologies associated with Industry 4.0, robotics is likely to result in the most significant displacement of labour within food processing facilities. As the technology becomes cheaper, and robotics companies begin to develop robots that respond to the specific requirements of food manufacturers, the risk of this displacement will increase, posing significant challenges for manufacturers in developing countries where regulations and labour unions will resist further automation that threatens jobs.

Augmented Reality and Virtual Reality

Augmented Reality (AR) is an emerging form of technology in which the real world is enhanced by computer-generated content. AR based systems have been applied in manufacturing processes, such as, selecting parts in a warehouse and sending repair instructions over mobile devices. These types of applications are in their early stages, but AR has the potential to provide workers with real-time information which can effectively inform decision making and work procedures, creating opportunities for improved monitoring and measurement. For instance, employees will, hypothetically, be able to receive detailed maintenance instructions for a machine while they look at it. These instructions could directly overlay the workers' field of sight using devices such as AR glasses. Applications of VR also extend to virtual training. This can result in significant saving in cost and time as expert technicians abroad can assist local artisans remotely.

Retailers are exploring AR's huge potential to boost sales, by purposely blurring the lines between online, mobile and the real world. China's largest online grocer, Yihaodian (51% owned by Wal-Mart), is using AR to create virtual supermarkets, allowing shoppers to walk through virtual aisles, selecting items simply by tapping on the screens of their devices, then arranging to have the selected groceries delivered directly to their homes[8]. As digital platforms for connecting with consumers become more sophisticated, food manufacturers may not need retail supermarkets to sell products to customers, and the virtual supermarket could be an innovation that increases adoption of online grocery shopping.

Additive Manufacturing

Although scientists have been able to produce 3D printed foods in laboratory conditions to demonstrate potential future applications of the technology, additive manufacturing does not seem to be widely seen as an imminent disruptor in food manufacturing. There are, however, examples of additive manufacturing being applied to create product prototypes in confectionary. Nestlé is using 3D printing technologies as a tool to test new packaging designs and to quickly fix failing equipment components, but they currently have a specific policy against using 3D printing as a substitute for OEM supplied parts.[9]

Blockchain technology

Blockchain technology has the potential to enable greater traceability, transparency and efficiency in the food industry, replacing barcode systems with much more powerful store encrypted data, thereby ensuring information accuracy and maintaining supply chain integrity. Blockchain will allow producers, processors, distributors and other players in the food supply chain to add and access detailed information about products, including dates, places, farm buildings, distribution channels, ingredients and potential allergens relating to the product.

Europe's largest retailer, Carrefour, is piloting the use of blockchain technology to track and trace produce through its supply chain with the aim of extending the technology across all brands by 2022. This is part of the company's 2022 transformation strategy and is intended to enhance consumer confidence in their brands.[10] Unilever has also announced a pilot using blockchain technology to ensure transparency in its tea supply chain. The company has partnered with banks and technology start-ups to track roughly 10,000 tea farmers in Malawi. The primary objective is to ensure transparency in the system such that both the consumer and the company know about the origin of their tea purchases.[11] The challenge for early adopters of new technologies is that others will follow, and it is possible that when all products have smart labels, the brands will themselves become less important as signals of quality and safety.

[8] CNBC (2015). Retail's new reality: Invisible shopping centers and virtual assistants. Available online: https://www.cnbc.com/2015/04/24/retails-new-reality-four-ways-technology-can-boost-sales-commentary.html.
[9] Automation World (2018). Nestle samples selection of IIoT and Industry 4.0. Available online: https://www.automationworld.com/article/food-and-beverage/nestle-samples-selection-iiot-industry-40.
[10] http://www.carrefour.com
[11] Reuters (2017). Can blockchain ensure Unilever's tea farmers produce a fairer brew? Available online: https://www.reuters.com/article/us-malawi-tea-technology/can-blockchain-ensure-unilevers-tea-farmers-produce-a-fairer-brew-idUSKBN1E729G.

Blockchain technologies appear to be advancing most rapidly in food processing, and IBM has announced that it will be working with some of the world's largest food companies (Walmart, Nestlé, Tyson, Unilever and McCormick) to identify ways they can incorporate blockchain technologies. This trend may indicate that a future key driver of digital transformation will be changing regulations, rather than efficiency improvements. For, as the major food companies introduce these technologies, it is likely they will initiate lobbying to have them made mandatory, thereby ensuring a new entrance requirement into the world's leading markets.

There are many more applications of new technologies in food processing firms. Most of these are not reported in company annual reports as new digital strategies are still being defined and tested. While it is too soon to say how these innovations will play out in time, there is an urgent need for firms, government and society to engage with the changes that may come about from digitalisation and to develop strategies, and policies to ensure positive outcomes.

Digital readiness of the South African food industry

Food processing is of particular strategic importance for promoting industrial development in South Africa, due to its close ties with the agricultural and food retailing sectors, which serve as critical sources of employment.[12] Currently, there are approximately 198,522 people employed in food manufacturing[13], making it the largest manufacturing sector in South Africa, although still employing fewer people than those employed directly by agriculture, retail and food services. While employment has increased since 2009, it has not increased in relation to sales and production growth.[14] The industry is dominated by relatively large commercial farms, manufacturers and supermarket chains; however, it is still of great importance for small employers and for self-employment. Since most of the value chain is relatively labour intensive, it generates opportunities for small-scale production from smallholder farming, food processing, spaza shops and cafes and food service for both low and high-income groups.[15]

Like other manufacturing industries, food processing, can contribute to technological development and diffusion. In South Africa, industrialisation and especially, small business growth, requires greater diffusion and adaptation of existing technologies rather than more basic research and development. Upgrading technology on a large-scale basis is particularly important for smaller producers, many of whom employ low-level design, production and marketing technologies.[16]

The new wave of digital technologies associated with Industry 4.0 have only recently begun to find traction in the business strategies of larger South African food processing firms. Current innovations in the digital space involve the development of platforms for sharing information with agricultural suppliers, particularly small-scale growers, to improve the quality and consistency of their yields (and thereby ensuring materials supply to the food processers). Blockchain technologies that track products through value chains are also being explored. Following the international examples, a key feature of these developments is a collaboration

[12] TIPS (2017). Strategic Framework for Agro-processing. Draft Report [unpublished].
[13] Stats SA (2018). Quarterly Employment Statistics (Food manufacturing less beverage and tobacco products)
[14] Statistics SA (2018). Manufacturing: Production and Sales, various issues. Statistics South Africa.
[15] See footnote 12 above.
[16] See footnote 12 above.

between suppliers and distributors, as well as technology start-ups aimed at developing solutions for the food value chain – from agriculture through to market sales.

Retailers and brand owners are also developing new strategies to connect with customers and generate more data which can inform their marketing strategies. Online grocery shopping in South Africa is still a relatively new market for most, where only two of the country's major grocery retailers currently offer the service. The use of loyalty and rewards cards that track food purchases and generate customised promotions and targeted advertising strategies have become increasingly popular.

These developments challenge the conventional system whereby manufacturers are the custodians of science and product development, while retail manages the interface with customers. Shifting the focus of strategies could result in significant improvements in the way in which products are designed in response to changing consumer needs, while simultaneously ensuring there is less food loss in the distribution chain to end markets. The optimisation of value chains, a potential impact of digitalisation, reduces production costs and food waste which could support national and regional food security. For example, the South African government's National Development Plan (NDP) argues that producing more affordable, quality basic goods and services is an important way to improve living standards without increasing the relative cost of labour. Furthermore, ensuring affordable food staples is critical for household food security – that is, the assurance that all families will be able to meet their basic nutritional needs.[17]

Outside of these pockets of innovation, the South African food processing industry does not appear well positioned for digital transformation. The WEF assesses the state of networked readiness of 139 economies using the Networked Readiness Index (NRI). In 2016, South Africa had improved its ranking and currently stands at 65th, almost entirely driven by improvements in infrastructure and affordability. Although the country is perceived by South African business executives to be performing relatively well in terms of its regulatory and political environment, its innovation and business environment is rated significantly worse and exhibiting signs of deterioration—especially regarding venture capital availability, government procurement of the latest technologies, and procedures to start a business. However, South Africa's digital transformation is mostly business driven, as the country performs best in business usage (32nd), followed by individual usage (77th), and government usage (105th).[18]

Foresight analysis

The nature of global food systems, and the various factors that influence the choices people make about what to eat, combined with persistent poverty and changing climate conditions that threaten food security, make it very difficult to predict how the system will evolve in future. The current wave of global innovations appears to be led by the need for traceability of products to improve safety and supply chain efficiency. Recognition of the unnecessary burden of foodborne diseases on the public health system have led to increasingly stringent

[17] National Planning Commission (2012). National Development Plan. Pretoria, National Planning Commission, Office of the Presidency.
[18] WEF (2016). The Global Information Technology Report 2016: Innovating in the Digital Economy. Available online: http://www3.weforum.org/docs/GITR2016/GITR_2016_full%20report_final.pdf.

food safety regulations, shifting from reactive to preventative food safety management systems.

The recent listeriosis outbreak in South Africa, claimed the lives of 180 people and resulted in a massive product recall affecting producers, retailers, food services and consumers across the country. Estimates of the economic impact of the recall have been estimated to reach hundreds of millions of Rands and class action law suits could increase the figure. In June 2018 the R638 "Regulations Governing General Hygiene Requirements for Food Premises, the Transport of Food and Related Matters" which replaces the R962, were gazetted, with more stringent provisions than the previous version. Key changes will ensure that business owners and persons in charge of the food premises have a good understanding of the importance of food safety and that they have the required records in place.[19] This is likely to increase the relevance of new digital technologies for firms to respond. Digital technologies will enable companies to be responsive enough to quickly bring new products to the market to maintain market share but maintain high quality and safety standards to comply with changing regulations.

Firms that are developing digital strategies and adopting new technologies to address specific challenges or enhance business strategies, are finding increasingly useful applications for digitalisation, the scope of which is expanding across food value chains.

There are three broad scenarios for developing countries in the new digital economy.[20] The first is that the routine business functions such as manufacturing, software coding and back office services, which have served as the backbone for rapid development, could be the first to be re-shored or eliminated by advanced manufacturing and automation. This could drive a retreat from Global Value Chains (GVCs) and potentially cause social disruptions in less developed countries, where export-oriented factories can employ tens or even hundreds of thousands of workers in very concentrated manufacturing clusters. In the second scenario, the digital technologies could empower developing country firms to move up the value chain, become less dependent on the innovation and coordination functions of lead firms in GVCs, thus producing globally competitive and compatible products on their own. The third scenario is that the “innovate here/produce there” geographic division of labour remains relatively stable as the NDE alters products and processes in existing technology and production clusters.

In food manufacturing, product development and design tend to be more localised than in other industries due to highly differentiated local tastes, economic conditions and nutritional requirements, the perishability of some foodstuffs and the ready availability of local ingredients. Larger companies consequently have teams of food technologists, chefs and product developers working on new products and recipes, but a common trend has been for these firms to acquire small emerging producers to add new brands to their range. It is therefore more likely that scenario 2 or 3 will prevail with leading firms benefiting the most in the short run as they are the first to adopt new efficiency enhancing technologies and adapt more quickly to changing consumer needs. The advantage for early adopting firms will decrease over time as technologies become cheaper and more firms begin to develop and

[19] Department of Health (2018) Regulations governing general hygiene requirements for food premises, the transport of food and related matters. Foodstuffs, cosmetics and disinfectants Act, 1972 (Act No 54 of 1972).
[20] See footnote 5 above.

implement strategies. However, the most significant gains, which will continue to benefit leading firms, will be the data insights generated from new tools and applications.

In the long term, as digital technologies reshape processes, products and market access, could brands become less important as a signal of quality and safety? Smart labels could provide product information for individual products changing the fundamental mechanisms in marketing and advertising.

Although new digital technologies enable faster changeovers and more flexible production suited to mass customisation, advances in data analysis and seamless information exchange across value chains could lead to the modularisation of production with smaller, smart factories producing customised products to specific market segments. This is not likely to disrupt larger producers manufacturing commodity food products at scale. In these instances, mass customisation will be less important and Sturgeon's scenario 3 is likely to prevail.[21]

Perhaps the most significant value chain disruption resulting from increasing rate of digital transformation could be a rapid reduction in the need for food retail outlets and supermarkets. Brand owners could connect directly with consumers, through online platforms, collecting valuable consumer data to help shape marketing strategies and develop new products. Globally, online grocery sales have been on the rise, but still represent a relatively small share of the total market, with the highest growth rates reported primarily in South Korea, Thailand and Malaysia.[22] New digital technologies such as augmented or virtual reality, combined with greater consumer insights from data, customised services and greater traceability of products, could lead to rapid growth of online sales, as new platforms are introduced to unlock latent demand[23] This could displace the large numbers of employees who currently work in food retail services, and through automated on-line purchasing systems create the platform for highly routinised warehousing, delivery and logistics processes that lend themselves to automation. On the other hand, some traditionally online retailers are opening brick and mortar outlets[24]. Amazon, for example bought wholefoods in 2017 and is currently rolling out new concept stores, featuring advanced technology to enhance the customer experience.

There are many other possible future scenarios and more will emerge as the food system evolves. While there is a possibility that the changes occurring now will gather momentum as new products, platforms, devices and processes emerge in response to digital transformations, it is also possible that changes will be slow, uneven and unpredictable.

Impacts and implications

If the cost of capital in African countries remains high (especially in relation to labour costs) and digital-readiness remains low, most countries will not be able to finance investment into newer technologies. As a result, digitalisation in these countries will remain low, suggesting

[21] See footnote 5 above.
[22] Nielsen (2017). What's in store for online grocery shopping: Omnichannel strategies to reach crossover shoppers. Available online: https://www.nielsen.com/content/dam/nielsenglobal/de/docs/Nielsen%20Global%20Connected%20Commerce%20Report%20January%202017.pdf.
[23] McKinsey (2013). The future of online grocery in Europe. Available online: https://www.mckinsey.com/~/media/McKinsey/Industries/Retail/Our%20Insights/The%20future%20of%20online%20grocery%20in%20Europe/The_future_of_online_grocery.ashx
[24] See footnote 22 above

an increasingly divergent path between African countries and the rest of the world.[25] A widening of this digital divide can have severe consequences for the developing countries in terms of job loss, growing income inequality and concentrations of power and wealth. On the other hand, if the developing countries increase digitalisation in their economies, by improving their existing ICT technologies, skills and physical infrastructure, it can lead to new economic growth opportunities.

There is ambiguity in the literature on the impact of digitalisation on the food processing labour market, the analysis of which has mainly been carried out for developed countries. On one hand, automation can threaten several kinds of jobs and lead to displacement or substitution of labour, with negative consequences on employment. This will, in turn, result in downward pressures on low-skilled workers and increasing returns to the owners of capital. On the other hand, the resulting decrease in the average cost of production due to the application of new technologies can significantly boost output and exports, consequently increasing the demand for labour used in those products and services. Moreover, instead of labour being displaced or substituted by advanced technology such as robots, it is possible that workers will be absorbed by different sectors or their duties will transition to tasks that are complementary to routinised robotic activity.

It is too early to quantify the impacts on South African food manufacturing as the large lead firms that are beginning to grapple with digitalisation are still in the search phase of the innovation cycle and have yet to deploy major disruptive strategies.

The pace at which new technologies are adapted in industrialised countries will require South Africa's exporting food producers to adapt more quickly than their locally focused counterparts. The emphasis on traceability and current pilot testing of blockchain technologies, smart labels and sensors will require South African producers to integrate into these systems to maintain market access. This is not an immediate and significant threat since most processed foods are for regional markets that are laggards in this space, but it will become a factor for firms seeking to expand exports in future and as stricter regulations re enforced locally.

Regulation, policy and programmatic response

The relatively fast pace at which digital technologies are spreading globally has resulted in newly formulated production processes and business models. The reshaping of past processing and business frameworks contain important implications for the economic diversification and structural transformation of countries. Digital technologies can improve the productivity of labour and capital and facilitate connections to global markets by lowering transaction costs and information asymmetries. Yet, these technologies can also present serious challenges. For example, robot-based automation can potentially reduce the traditional benefit of industrialisation as an economic catch-up strategy.[26] Additionally, the beneficiaries of outcomes resulting from new digital technologies may be shared across or

[25] Banga, V and te Velde, D.W (2018). Digitalisation and the future of manufacturing in Africa. Supporting Economic Transformation (SET) programme.
[26] UNCTAD (2018) Adapting industrial policies to a digital world for economic diversification and structural transformation. Note by the UNCTAD secretariat. Available online: https://unctad.org/meetings/en/SessionalDocuments/cimem8d5_en.pdf; Banga & te Velde (2018) (See footnote 25 above)

within countries which, when coupled with the limited regulatory influence of developing countries, can hinder their entry into increasingly automated Global Value Chains.

Securing benefits from the outcomes of technology waves, such as transitioning to a digital economy, is not an autonomous process. It is shaped by policies. To maximise the contribution of a digitalisation to economic diversification and structural transformation, policymakers need to adjust, *inter alia*, their infrastructural, regulatory and industrial policies in a proactive way.[27]

Furthermore, the uncertainty surrounding the future evolution and impacts of digital transformation and advanced technologies require policy makers to develop and implement frameworks that are responsive to change. For instance, industries quick to adopt new technologies, as well as large companies with broad linkages across value chains, are capable of accumulating vast amounts of data and intelligence. These data require meaningful regulations to ensure that they remain safe and are used in a responsible and ethical manner.

Harnessing the benefits of digital transformation will require improvements to South Africa's ICT infrastructure with affordable data prices and reliable network coverage. This is particularly important in the food industry where various innovations are connecting small scale suppliers of agricultural inputs to larger value chains to increase yields and improve consistency. In developing countries, such as South Africa, a lack of ICT infrastructure and smart phone penetration requires the use of hybrid systems, which can limit the efficiency gains of using smart platforms. Most South African food processing currently takes place within urban areas where there is reasonable ICT infrastructure, however, reliance on this infrastructure may reduce as advanced technologies begin to enable more decentralised production closer to supply sources.[28]

Increasing automation and the use of robots to improve the efficiency, hygiene, safety and precision of processes currently performed by human labour in food factories may be a challenge in South Africa. This is especially the case if these technologies are seen to displace workers. Thorough stakeholder engagement and sensitivity towards impacted livelihoods are required to ensure mutually beneficial and socially just outcomes from improved processes. Failure to appropriately manage the situation and ensure procedural transparency could lead to major labour disruptions and threaten the future of digital transformation in South Africa. For this reason, it is important that government and private sector role players involve the relevant labour unions in the digital transformation process.

The current business environment in South Africa is also discouraging of digital technology R&D. The existing definitions, criteria and processes that qualify for R&D support need to be reviewed and shifted in alignment with digital transformation. It may be necessary to develop a specific set of incentives more suited to the current and future wave of technological innovation. Potential areas for further exploration include localization support for machinery needed to automate (machines, robotics, programming, data analytics, financial technologies, platforms, marketing), localisation of digital technology platforms driven by partnerships with new start-ups, and the localisation for cybersecurity systems.

To increase the development impact of digitalisation, and reduce the risk of a widening skills gap, it is crucial for South Africa to develop the necessary skills for digital transformation in

[27] See footnote 26 above.
[28] See footnote 5 above.

manufacturing. Becoming future-ready involves revising and reorienting the curriculum in educational institutions around science, technology, engineering and mathematics (STEM) subjects. A special focus needs to be given to technical and vocational education and training (TVET), including better public–private sector collaboration.[29] Alternative models should also be explored that seek to rapidly bridge the gap, providing on the job training and targeted short courses.

To encourage compliance with international standards, South Africa's digital policies should also support harmonisation of product data, as well as accreditation services. This will ensure that the benefits of efficiency enhancing technologies are obtained – both for local and international supply. As global food markets move increasingly on-line, it will also permit the seamless movement of South African processed food sales into the cyber-mechanical world of on-line food retailing. An associated transition will have to be made throughout the South African food value chain, however. Supply chain visibility and certification will become ubiquitous and will need to be complemented by digitally enhanced efficiency, reliability and flexibility. Machine learning-based Artificial Intelligence will increasingly dominate automated warehousing, distribution and logistics, all of which will be enabled by an ever expanding IoT presence that permeates the space from "farm to fork".

If the South African food processing industry is to gain from this digital revolution, it will need to invest substantial resources into identifying and responding to the way in which the various digital disruptions will combine and then recombine within the complex food value chain. While the future food processing industry is unclear, this brief review of digital disruptions within the industry, raise some clear medium-term lessons for the South African food industry that potentially lay a starting framework for the development of a proactive response.

1. Increasing population pressure, combined with climate change and rising input prices will become key drivers of change in the food industry in future. While more discerning consumers are increasingly demanding higher quality food, free from harmful chemicals and artificial additives, growing hunger and food insecurity will require more affordable, nutritious foods to feed the growing population[30].

2. Digital transformation in the food industry could help firms to meet these divergent needs by understanding changing consumer demands and identifying preferences and reducing food waste.

3. In the short run, changes in regulations around food safety and hygiene will require all food companies to improve safety management systems, and digital technologies have proven to be effective in ensuring traceability of products and ease of record keeping, as required in the new regulations.

4. Like other industries, new skill sets will be required to harness the benefits of digitalisation and reduce negative impacts of job displacement. Data scientists,

[29] See footnote 25 above.
[30] FAO, IFAD, UNICEF, WFP and WHO. (2018). The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO. Available online: http://www.fao.org/3/I9553EN/i9553en.pdf.

process engineers, electrical engineers, and computer programmers will be increasingly important, as well as food technologists, chefs and product developers.

5. Programmes to improve the flow of data and information through the food value chain will improve the outcomes of digitalisation. There will need to be improved collaboration between suppliers, manufacturers and retailers.

6. Platforms to connect industry with technology firms should be established or strengthened to establish mutually beneficial partnerships to advance technologies and unlock funding for new start-ups.

7. Local government should look at investing in digital technologies to advance smart city strategies and identify synergies with industry.