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Impact of COVID-19 food supply chain: Comparing the use of IoT in three South African supermarkets

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ABSTRACT

This study aims to understand the impact of the COVID-19 pandemic by comparing the performance of three major supermarkets in South Africa and addressing the following questions. 1) What is the impact of a supply chain disruption on the food system? 2) What interventions (short and long-term) are taken by the food supply chain to mitigate disruption? 3) What does the post-pandemic picture look like for the food retail sector? This study adopts a comparative research approach and investigates direct strategies adopted by various food supply chain actors to mitigate the impact of covid-19. This study compares how retailers Checkers, Woolworths, and Pick n Pay have adapted their business models to remain resilient during COVID-19 lockdown. The results show that the food supply chain remained resilient even with demand management challenges at the lockdown. Food supply chain issues came under a spotlight as borders and production plants were shut down or restricted to contain the spread of the virus. This study establishes that the food shortage is primarily caused by panic buying at the beginning of lockdown, causing shock in the supply chain cadence. The other aspect of food security issue is attributed to food availability and socioeconomic problems resulting from loss of income. On sustainability, there are fears that control measures such as packaging (increased use of plastic), cleaning chemicals, waste and sanitisation of space to maintain hygiene as required for covid-19 can undermine the gains towards preserving the environment.

1. Introduction

The conventional grocery store concept is changing compared to the pre-COVID-19 outbreak, as over 80% of customers adopt online shopping platforms. Walmart partners with Instacart to compete with Amazon-Whole foods that provide same-day service [1]. Similarly, in South Africa, grocery stores had to adjust and redefine operations to keep servicing their customers amid restrictions. In March 2020, South Africa declared its first Corona Virus Dieses 2019 (COVID-19) case caused by the novel coronavirus SARS-CoV2 [2]. Similarly to other undesired global events such as World War 1&2, Great Depression and Great Recessions [3], pandemics cause severe global economic and food security threats. Likewise, COVID-19 severely impacts the food supply chain and other business operations [4–7]. Human and consumer behaviours evolved during the COVID-19 pandemic from hoarding, improvisation, low demand of non-essentials, adopting digital technologies, hybrid shopping, unconventional shopping times, virtual social gatherings and the discovery of new talents, especially cooking [3]. The South African government responded by forming a national command council led by the inter-ministerial team and medical experts to advise a suitable response. The initial lockdown period was declared for 21 days to curb the spread of COVID-19 infections in South Africa [8,9]. The lockdown period brought uncertainty and panic, to which people responded by stockpiling their pantries with essentials. Panic buying led to empty shelves and a severely constrained food supply chain [2,10,11]. As illustrated in Fig. 1 below, the alert levels balance the impact on the economy and reduce COVID-19 infections.

During the lockdown, the South African government communicated the expectations and controls to citizens and businesses, using all media streams. It is a logistical nightmare to manage the unprecedented change of this proportion of limited data. Decisions needed information on how a person gets infected, how they can protect themselves, and what to do once they are infected with COVID-19. Amid the confusion, one aspect remained true, people needed food and jobs to sustain themselves during the pandemic. Various markets have recorded a significant demand increase in food, household, and home electronics, with spikes and demand, shocks around the beginning of the lockdown level 5 to 3 period [10]. A contrary view is that the closure of restaurants led to low

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demand for food resulting in media reports about food dumped in the hospitality sector [5]. Fig. 2 below shows the need for food in the United States between March and May 2020, with an initial shock in March and stabilisation from April 2020. The initial shock period is due to uncertainty driven by the lockdown of distribution channels. The food supply chain shock could also be a panic response not driven by real threats of food scarcity. Data visibility on the food supply chain can alleviate consumers’ initial fears. With regards to the lack of prediction of the impact of COVID-19 on the food supply chain, data analytics could have produced predictive models of effects when the virus started spreading outside of the epicentre in Wuhan, China.

Two challenges associated with the food supply chain are food insecurity and production effects on climate change [12]. The outbreak of COVID-19 amplifies these challenges, especially food security, due to reduced production rates imposed by restrictions to manage the spread [11]. However, supply chains had kept up with customer demands alleviating the need for panic buying that began when country lockdown started. As identified by Ref. [11], the major challenge is not food availability but the ability for consumers to access food, primarily driven by economic and social factors. The outbreak of COVID-19 drives high food prices, and low income will undermine Sustainable Development Goal (SDG) 2 [5]. Countries that already have challenges such as geopolitical issues, conflicts and governance issues will feel the effects of COVID-19 on food systems more [6]. Access to food is a fundamental human right defined in the SDGs, and food systems have a strong influence on achieving SDGs. Inability and reluctance to fix the food systems can render the SDGs unachievable [13]. The food system is vulnerable to many challenges, from plant and animal disease to climate change. Likewise, the COVID-19 outbreak impact is not an exception. COVID-19 has impacted the food supply chain from the inputs to the

| Alert Level | Description of Alert level | Controls Public Movement | Controls Economic Activities |
|-------------|-----------------------------|--------------------------|-----------------------------|
| Level 1     | The low virus spread with high health system readiness | In-country travel with all modes of transport, restrictions on international travel | All sectors open |
| Level 2     | The moderate virus spread with high readiness | Movement between provinces and air travel/car rental allows | Almost 100% of economic sectors open |
| Level 3     | The moderate virus spread with moderate readiness | No travel except for essential needs, public road transport opened with strict hygiene requirements transportation of goods & funerals | Essential services plus further economic sectors opening |
| Level 4     | The moderate high virus spread with low/moderate readiness | No travel except for essential needs, public road transport opened with strict hygiene requirements transportation of goods & funerals | Essential services plus other sectors crucial to the economy but have means to observe protocol |
| Level 5     | High potential for virus spread and low readiness | No travel except for essential needs, public road transport opened with strict hygiene requirements and restricted times transportation of goods & funerals | Essential services only |

Fig. 1. State of emergency alert Levels for COVID-19 in South Africa.

Fig. 2. Typical demand of food in 2020 [11].

Fig. 3. Data-driven value chain.
end-user due to the policies restricting the movement of workers and the public in general [4,11]. The food and beverage sector is regarded as an essential service in South Africa and can operate even at alert level 5 [7, 8,14]; however, it is not safe from the challenges posed by the infectious nature of COVID-19.

One of the crucial mitigations of COVID 19 is social distance. To achieve social distancing, most facilities can only operate at half the capacity of their usual staff complement; this constraint can reduce regular production rates [4]. Climate change is another challenge for food systems because if agricultural practices are not sustainable, they impact food security. The yield of major crops is estimated to shrink by an average of 8% in Africa and Asia by 2050, while Wheat, maize, sorghum and millet yield shrink by 17%, 5%, 15% and 10%, respectively [15]. During the COVID-19 pandemic, food consumption will increase by 14% due to boredom and wastage. An increase in food consumption during supply chain disruptions is a challenge for food systems in South Africa because of its citizens changing their regular lifestyle to be indoors during the COVID-19 pandemic. Food supply chain data availability could alleviate uncertainties associated with supply chain disruptions. The immaturity of data-driven supply chains negatively impacts operational effectiveness and sustainability [16]. Data needs and the capacity to process and synthesise data can minimise risks associated with uncertainty in the supply chain [16]. The framework below outlines the attributes of a data-driven food supply chain. One of the essential enablers is the availability of data to enhance the operational effectiveness of the food supply chain. According to an interview with the retail industry expert [17], the only winners in the food supply chain embrace technology (see Fig. 3).

South African agriculture industry has already been suffering from effects of climate change such as drought, crop and animal diseases, harsh market conditions, increasing input costs and weak currency [8, 18,19]. PWC devise a five-pillar response approach for South African businesses to mitigate against supply chain disruptions. This 5 - pillar response strategy includes 1) List of critical services, suppliers and products, 2) Development of contingency plans in case of disruption, 3) Assess financial and legal implications, 4) Devise and implement a communication plan and 5) Analyse scenarios to better plan adequate response [19]. This study attempts to understand the impact of the COVID-19 pandemic in the food supply chain as a customer/consumer by comparing the performance of three supermarkets in South Africa by asking the following questions: 1) What is the impact of the pandemic on the food supply chain disruption? 2) What interventions (short and long-term) are taken by the food supply chain to mitigate disruption? 3) What does the post-pandemic picture look like for the food retail sector? The food supply chain is vital to the South African economy as it produces approximately 1 million formal jobs and contributes 13% to the gross domestic product. This paper aims to demonstrate how digital technologies can sustain the food supply chain and security. This paper covers the literature survey to understand the impact of COVID-19 in supply chains across the world, attributes of a resilient and sustainable food supply chain and reviewing 4IR technologies, especially applications of IoT on the food supply chain. This paper further defines the research methodology applied to construct this paper’s argument, presenting results and discussion.

2. Theoretical framework

This research aims to effectively study the retail side of the food supply chain’s response to disruptions imposed by the COVID-19 pandemic. Mishra et al. [20] develops a framework by applying a dynamic capability theory to demonstrate supply chain resilience as an operational excellence tool to mitigate against supply chain disruptions caused by global events such as a pandemic illustrated in Fig. 4. The study finds that flexibility has worsened post-COVID-19; however, collaboration can improve resilience. Supply chain capability limitations pointed out in Ref. [20] suggests that enablers of supply chain resilience have multiple factors. This framework does not effectively demonstrate all the links required to support a resilient supply chain.

3. Literature review

This section reviews literature associated with the impact of COVID-19 in the supply chain and the interventions taken at various levels to mitigate supply chain disruptions. COVID-19 effect on the supply chain has been widely documented across the globe [21], seeking to understand and ensure that the supply chain for essential services and products is resilient and sustainable amid the pandemic challenges [14]. The food supply chain needs to be flexible agile and respond to the shocks of the pandemic while protecting vulnerable people from food price increases caused by scarcity or uncertainty [4,8,11]. Food security fears posed by supply chain disruptions due to COVID-19 will affect vulnerable groups [6]. Movement restrictions resulting in panic buying by consumers influence food scarcity [4,8,10,14]. Although calls by the government and food supply chain actors to the public to not panic regarding food availability, consumers are still not assured because they are not privy to the data to allay such fears. Panic buying demonstrated by consumers resulted in shocks and spikes in the food demand as consumers purchased many supplies leading to stock out of certain products [22-25]. Table 1 below shows the response of the world retails to manage supply chain disruptions imposed by COVID- 19.

[5,40] outline six dimensions that the food security system needs to satisfy. The six dimensions are access, availability, stability, agency, utilization and sustainability. Each element has key sub-elements to fulfill. 1) Access sub-elements include income, food prices, social support programs, access to markets and commodities. 2) Availability elements include supply chain disruptions, labour, exposure to threats, availability of other retail points such as restaurants. 3) Stability elements include supply chain disruptions, price volatility, access to inputs and trading markets, export restrictions. 4) Utilization includes a change of diets and malnutrition. 5) Agency sub-elements are extensive; they

![Fig. 4. Framework of a pandemic resilient supply chain [20].](image-url)
World response to COVID-19 imposed supply chain disruption.

| Issues introduced by COVID-19 pandemic | Response of the demand side of the food supply chain worldwide | Technologies introduced on the demand side | Reference |
|---------------------------------------|---------------------------------------------------------------|------------------------------------------|-----------|
| Regulatory Enforced:                  |                                                               |                                          |           |
| Lockdown & social distance mandate    | Hybrid shopping models to manage numbers at the shops         | Online shopping/ eCommerce/ Click & collect, Apps like Skip the Dishes and Uber Eats | [3]       |
| changing customer shopping behaviours | Restrict sales of non-essential items                         |                                          |           |
|                                       | Spatial planning in the supermarkets                           |                                          |           |
|                                       | Manage supply-side shocks influenced by labour shortages and blocked market links |                                          |           |
|                                       | Move from global to local/short food supply chains             |                                          |           |
| Food Security                          | Manage the supply of food to avoid empty shelves – even sourcing from new suppliers and transportation | Smartphones, the internet applications Social media Checkout/point of sale data (to determine service time & Basket size) technology Agent-Based simulation | [3]       |
| Changing patterns                     | Communicate with customers to manage panic                     |                                          |           |
|                                       | Limit number of items per customer                             |                                          |           |
|                                       | Increase food prices                                           |                                          |           |
|                                       | Predict consumer consumption patterns and peak times            |                                          |           |
|                                       | Stoping product marketing campaigns                           |                                          |           |
|                                       | Panic buying behaviours in Indian families correlate with income, family age, and buying mode. |                                          |           |
| No Regulatory                        | Hybrid models remain as a choice of customers used to the new normal Building and improving capacity for non-store shopping Permanent structural changes in consumer behaviours |                                          |           |
| Requirement:                          |                                                               |                                          |           |
| Post COVID-19 customer shopping       |                                                               |                                          |           |
| behaviours                            |                                                               |                                          |           |
| Increase in non-store food shopping   |                                                               |                                          |           |

Table 1 (continued)

| Issues introduced by COVID-19 pandemic | Response of the demand side of the food supply chain worldwide | Technologies introduced on the demand side | Reference |
|---------------------------------------|---------------------------------------------------------------|------------------------------------------|-----------|
| Sustain online shopping               | Ease of use of shopping technology sustained quality & customer service | e-grocers | [36]       |
|                                       | Even non-food sales are on the increase                        |                                          | [17]      |
| New positive trends to support food production & consumption | Direct deliveries, online farmers markets, small local grocers to emerge & thrive, food-producing community groups, home gardens, seed buying, home cooking. Other trends influence positively the GHG emission leading to climate change gains | Social media, apps like Instacart, Grubhub, DoorDash, smart retailing, online queues | [37]       |
|                                       | Address the food processing capacities and mitigate vulnerabilities of the supply chain, particularly deliveries and payment systems. |                                          |           |
|                                       | Increase in supply consumer business model                     |                                          |           |
| Negative trends                        | Short supply chains                                           |                                          |           |
|                                       | Online shopping channels                                       |                                          |           |

include social, economic, technological and political factors. 6) Sustainability sub-elements include distraction from climate change actions due to the threat at hand, food losses and waste, social and economic issues, and increased packaging and plastic use—the conditions brought by COVID-19 threatened both the food security and the sustainability of food systems.

3.1. Sustainable food supply chain

A sustainable supply chain is the management of the supply chain that focuses on fiscal deliverables and considers the triple bottom line while meeting customer and environmental needs [41,42]. Internet of Things (IoT) is a potential solution for manufacturing organisations to achieve operational excellence by overcoming global competitiveness, adaptability, demand forecasting, and supply planning [42]. For IoT to be value-adding in supply chains, it must be compatible with other business processes and systems. IoT systems need to feed into Enterprise Resource Planning to inform supply chain management activities and decisions [7,42]. It is imperative to have access to supply chain data that will, in turn, support decisions made, leading to operational excellence [16,43]. Actions of the food supply chains must align with food production policy organisations such as World Bank, UN Food and Agriculture Organisation and Organisation for Economic Cooperation and Development [44]. All these organisations are at the forefront of supporting the delivery of SDGs.

3.2. Overview of digital technologies

The application of digital technologies in agriculture continues to expand [44], although food production system innovations have consistently trailed behind the industrial revolution. However [44],
caution that the application of digital technologies to agriculture is not a panacea; adverse social impacts must be anticipated and mitigated. The industrial revolution traces back to 1780, where the first revolution was about mechanisation and steam power, followed by the second industrial revolution from the 1870s, characterised by mass production powered by electrical energy [45]. The third industrial revolution in 1969 introduced automation, electronics, programmable logic controllers (PLC) and information technology (IT) [45]. The fourth industrial revolution (4IR) started around 2011 in Germany to promote concept innovation and computatisation of production and improve manufacturing competitiveness [45–47]. The idea of 4IR is to transform theory into applications [48] to enable digital collaboration with the physical world [49]. 4IR optimises supply chains to autonomously controlled and dynamic production systems [47]. The clusters of disruptive technologies include 1) Data, computational power, and connectivity; 2) Data analytics and artificial intelligence, 3) Human-Machine interaction and integration; 4) Digital to physical transformation [47]. Galanakis et al. [7] propose using 4IR technologies such as IoT and blockchain to innovate how to consume and manage food and behaviour managing social marketing tools. The concept of 4IR is to link physical systems digitally to constantly communicate through intelligent connections and achieve a high level of coordination, self-operation and control [45,50]. The benefit of these enhanced systems is to create new opportunities for innovation, such as artificial intelligence, sensors, and automation, allowing organisations to be agile, predict, and respond better to customer needs [51].

Blockchain technology is a distributed ledger technology based on distributed databases and smart contracts [52]. Blockchain provides a simple, fast and secure way of performing transactions in the supply chain and e-commerce platforms, thus eliminating trust issues associated with delayed payments [52,53]. Blockchain enables transparency, sharing information, assures food safety in the agriculture and food supply chain [52,54]. Blockchain enables on-demand scheduling and tracking of product movements in real-time from the farmer/producer to the retailer and consumer [41,55]. Blockchain technology can create new economic streams, streamline existing and improve the efficiency of the food supply chain [41,55]. Usage of blockchain is increasing fast in various industries; however, a lack of governance and regulatory frameworks hinder faster adoption [52,56]. Blockchain technology provides the interconnectedness of the supply chain and offers traceability of the products. Blockchain supports data analytics capabilities that assist the agriculture supply chain in digitalising and automating operations to achieve sustainability [41]. Blockchain Technology is crucial in reducing the number of intermediaries and transaction lead times, thus simplifying the exchange of monies and goods in the supply chain [52,53]. For countries where emerging technologies are still in infancy, practitioners who support the agriculture supply chain need tools to encourage and assist participants with adoption strategies [53]. Blockchain technology promises to disrupt traditional transactions through a database accessible to all who uses, participates, and is interested in blockchain. Blockchain technologies offer a safe marketing and record management platform to ensure that all transactions are valid while in the transparency of all the actors [57]. Even with all the benefits of blockchain technology, the adoption behaviours of individuals and organisations are not fully understood. Blockchain technology integrates well with other digital technologies such as IoT, Smart & RFID tags, AI, GPS, 3D printing and point of sale technologies [56]. Blockchain brings better management of decentralised supply chain systems and compliments IoT applications with more centralised systems [58].

3.3. IoT applications in the food supply chain

IoT has several definitions and meanings, a term that defines a range of technologies, applications, and use cases [58] to connect cyber-physical systems via assigned internet protocol [59]. The objective of IoT is to collect data and turn it into intelligence to support operations and business decisions. IoT collaborates with other technologies such as edge and cloud computing, data analytics, blockchain, machine learning, and artificial intelligence to achieve this objective. In retail, IoT applications enable optimisation of the inventory supply chain to enhance customer experience reduce operating costs through collaboration with other technologies such as intelligent shelves to communicate with the supply chain stakeholders [59,60]. There is an urgent need to define and apply 4IR technologies to cope with the changes posed by COVID-19 [7]. There are several digital technologies applicable to all the stages of the agriculture supply chain. These include Geographical Information and Positioning Systems and geo-mapping sensors; remote sensors, assisted and autonomous steering systems, electronic communications systems, variable rate technologies, telecommunications, mobile computing, big data, and data analytics [7,61–65]. Data collected through 4IR technologies inform decisions to proactively manage the food supply chain [52,64,66–68]. Specific retail technology and point of sale can help grocery stores to create a hybrid shopping experience while collecting customer intelligence and enhancing the customer experience while reducing human contact [1]. Smart and connected devices enable the food supply chain to face opportunities and threats, observe industry and competition and adjust response adequately [69]. IoT refers to intelligent, interconnected devices interacting through the internet [40,70–72]. IoT technology will account for two-thirds of the global GDP in the next ten years [69]. IoT is beneficial for reducing fresh produce waste, although there is a lack of adoption in emerging economies where food security is a challenge [41]. The major obstacles in implementing digital solutions are access to technology infrastructure and connectivity costs [73]. Although internet connectivity is improving, less than 60% of the world population has access to the internet [74]. The digital divide makes it difficult for everyone to access digital solutions. Inconsistent communications because of the low bandwidth of wireless communication is a challenge that makes it difficult to access data for planning and managing variability [75,76]. The food supply chain needs to communicate with all the supply chain stakeholders and get support regardless of physical location.

The retail sector in South Africa has been moving towards digitalisation; however, the advent of COVID-19 has accelerated the rollout of digital technologies in the retail industry to ensure that consumers can complete purchasing activities on digital platforms as the lockdown regulations minimised drastically in-person shopping and removing existing scepticism as there were no many alternatives [77]. The hybrid world now exists where the physical world intertwines with the digital world in various forms to create a more engaging customer experience driven by IoT with heavy collaboration with AI and machine learning, a helpful tool now that it is taking longer to replenish stock [77]. A notable innovation for IoT deployment in retail South Africa is called Covision to digitalise the real-time management of safety distance inside shops to move away from taking manual processes to control the numbers inside shops [78]. The retail sector in 2021 experienced a decrease in sales to the extent that significant shopping events such as Black Friday were extended by big retailers such as Pick n Pay and Shoprite checkers and incorporated IoT to enhance customer experience and demand planning [79]. Demand planning requires data from demand and the supply side to forecast. The critical IoT applications for retail are smart store, connected consumer, predictive maintenance, energy consumption, smart transportation and demand forecasting [80], deployment of IoT can help manage issues related to overstock, stockouts and returns through accurate insights [81,82].

4. Research methodology

This study adopts a comparative research approach and investigates direct strategies adopted by various food supply chain actors to mitigate the impact of COVID-19. The comparative approach studies several objects to identify similarities and differences [83,84]. The comparison
allows establishing relationships between two or more variables based on various areas or objects of interest through individualising, universalising, variation and encompassing [85]. The comparison method is suitable for comparing like-for-like retailers in South Africa and how they respond to supply chain disruptions posed by COVID-19. The rationale for choosing these food retailers viz Checkers, Pick n Pay and Woolworths instead of Spar, Makro, Game and Food Lovers Market service similar clientele, operate from similar locations (shopping malls). This study applies concepts of the comparison research approaches to conclude. The approach involves a literature search with keywords such as “Impact of COVID-19 on the food supply chain”, “resilient food supply chain during COVID-19”, “Fourth Industrial Revolution technologies applied to predict demand scenarios”, Food retailers are chosen as the area of focus for this study. Retail is the most consumer-facing supply chain actor and essential service that remained open throughout the lockdown. It will be interesting to find out if there are any changes that food retailers have adopted to respond directly to the challenges and restrictions of COVID-19. For this paper, this study will compare interventions that leverage IoT to conduct business, limit customer inflows to the shopping capacities through digital shopping platforms, and manage demand. This study aims to achieve its objective by comparing interventions made by three upmarket supermarkets using IoT applications to changing environment and threats posed by COVID-19. The comparison results are compared to the theoretical framework Fig. 4: Framework of a pandemic resilient supply chain [20].

5. Results and discussion

Covid-19 brings uncertainties, threats and opportunities. These include loss of income, revised investment plans in the food sector, fluctuating food prices that could shift diets, and shifting focus from climate change actions [5]. Scientists anticipate that covid-19 will be a health challenge and a threat for about 1–3years, leaving a lasting societal and economic impact. Several countries have gone through three waves of intense infection and death period. Full or partial movement restrictions are mitigative responses used to curb the spread. Restriction in movements and number of people in indoor spaces means that spaces where people usually gather, e.g. Shops, are required to control the number of people they host to comply. Shops developed means to service customers while ensuring safety. Online shopping is an alternative to reduce numbers; however, the standard online delivery service has a long turnaround. The online shopping service needed to overall offer on-demand shopping and delivery service. Various businesses have adopted multiple mechanisms to remain resilient in challenging and uncertain conditions. This study explores the response strategies of three South African grocery retailers to keep servicing their customers while keeping their businesses operations and staff safe from the risk of infection and closure. This study compares how Checkers, Woolworths, and Pick n Pay have adapted their business models to remain resilient.

| Variables compared | Application Characteristics |
|--------------------|-----------------------------|
| Mobile application name | Woolworths | Dash | Sixty60 | ASAP! (Bottles) |
| Application download cost | Free | Free | Free |
| Type of service | On-demand | On-Demand |
| Turnaround time | Same day service | Delivers in 60 min from order | Same day service |
| Launch date | Dec-20 | Nov-19 |
| Reason for launch | Customer demand | Customer demand |
| Delivery areas | Selected Suburbs in KZN, GP & WC | Customer demand |
| Care | Track your order from the store to house | Track your order from the store to house |
| Demand Management | 30 items | Max 3 products per customer & 30 items per basket |
| Service Days | Everyday | Everyday |
| Sustainability | Reusable bags | Recyclable bags |
| Cost | Free during trial for orders over R75 | 35 |
| Preservation of temperature-controlled foods | Specified unique technology |
| Variety of products | Not specified | 15 000 including Alcohol |
| Differentiator | First on-demand delivery service to offer a store to door cold chain through high tech cooler boxes that stay refrigerated |
| Delivery Mode | Motorcycles | Not specified (Observed motorcycles on the road) |
| Compatibility | iOS & Android | iOS & Android |
| Radius from store | 5 KM | 5 km |
| Reward Program | Not linked | Not linked |

6. Applications

Applications enhance the existing online shopping system that these grocery retailers always had. As can be deduced from Table 1 below, Checkers, Woolworths, and Pick n Pay have launched the on-demand grocery system, albeit with different launch dates. Their application attributes have close similarities. The closeness of these application attributes suggests that these supermarkets serve a similar type of consumers. These retailers mainly cater for the South African upper and middle class. Pick n Pay and Checkers on-demand service has a presence in most metropolitan cities around the country. At the same time, Woolworths is only available in selected suburbs in Gauteng, KwaZulu-Natal and Western Cape. Pick n Pay’s services some township areas, thus differentiating their service and closing the digital and social class gap. All three food retailers have order limits that assist demand
management and limit product stock-outs. Since 2018, Pick n Pay has collaborated with a technology house to utilise Bottles mobile application to deliver alcoholic beverages. Eventually, in 2020, Pick n Pay acquired the Bottles application and expanded it to deliver groceries. The acquisition of Bottles by Pick n Pay is perceived as a direct response to the launch of Checkers Sixty60. Pick n Pay offers a differentiator because the service is available in certain townships, bridging the spatial planning divide created by the Group Areas Act of 1950, systematically segregating South Africa’s residential areas according to race. The township availability bridges this gap and can offer Pick n Pay a competitive advantage. The on-demand promise of Bottles by Pick n Pay is that a consumer can place an order and select a delivery slot on the same day. The consumer can also track the order from the store to the delivery address.

Checkers launched an on-demand mobile application called Sixty60 in November 2019 before the COVID-19 outbreak; however, the uptake and subscription of the product became popular during the lockdown period that started in March 2020 in South Africa. Sixty60 promises clients that delivery will be made within 60 min of placing an order and having the most extensive range of products available. Sixty60 promises a product range of 15 000 compared to 8000 that Bottles by Pick n Pay. Checkers is the only supermarket that allows consumers to recycle their shopping bags during delivery; this is in line with the circular economy and can win consumers who are conscious about sustainability and environmental protection. Woolworths was the last to offer an on-demand mobile application among the three food retailers. Woolies dash was launched in December 2020 when the lockdown alert level was between 3 and 2, allowing more movement of people. Although the lockdown levels were relaxed then, some people still did not feel safe going to public places as the risk of covid-19 is still present. Woolworths probably wanted to retain its market share and not lose customers to on-demand service retailers. The key differentiator of Woolworths on-demand delivery system is their motorcycles fitted with state of the art refrigerated cooler boxes that ensure that the cold storage chain is not broken, thus ensuring the safety and quality of temperature-controlled foods.

The biggest adoption driver of digital technology is perceived usefulness and ease of use [88]. This study compares the customer reviews of on-demand online shopping applications, namely Sixty60, Woolies Dash and ASAP! (Bottles) by PnP. As expected, Sixty60 and Bottles by PnP have more subscribers than Woollies Dash, which is still in the pilot stage. As demonstrated in Table 2 below, the reviews apply a 5-star ranking range where a customer can review the application’s ease of use, ordering of goods, payment options, and delivery. One star denotes the worst customer review and experience, and five stars indicate the excellent customer reviews and experience. These reviews offer an end-to-end customer experience on the application offering an opportunity to the retailer and the application developer to improve. The tested on-demand shopping applications can learn the customers’ shopping patterns and inform better stocks and logistics planning. Linking the rewards program can also provide better insights into the grocery stores and utilise the data to create a more personalised shopping experience.

Sixty60 customer review average scores ranked 3.9 and 2.9 on the
Android and iOS operating systems, respectively. The Sixty60 mobile application on iOS has the majority of rankings in one star, while some customers ranked the application at five stars. The android application receives better customer revives on the Sixty60 application; this could suggest the ease of use between the two operating systems. Understanding the detail behind the one-star and five-star ranking will be interesting to know whether the drive is on the application’s ease of use or the shopping or delivery experience. Woolies Dash is the newest and still under the pilot phase. From the reviews in Table 2 below, it seems that the application on both operating systems is performing reasonably well. Whether the low number of subscriptions results in a better performing application is unknown. Application performance is something that the application developers can check if the system’s performance remains the same even with an increased number of users. ASAP! (Bottles) by PnP provides a mixed response from iOS users ranking the system better than Andriod users. Android application experience has several 1-star reviews, and it is not studied in this research what is behind the low ranking. The average review score is 3.5 and 4.7 for Android and iOS users, respectively. The ASAP! (Bottles) by PnP iOS average review score of 4.7 is the highest score achieved among the customer reviews of these three food retailers. There is a possibility that since this application has been in use for longer, as indicated in Table 1, it has gone through rigorous tests to ensure that it works well (see Table 3).

The researcher downloaded the application on Andriod and iOS devices to personally experience how they work. The researcher is based in Brakpan, east of Johannesburg in Gauteng Province in South Africa. These mobile applications are all free to download on both operating systems. When opening the application, it requests to connect to a map application to determine the accurate location. The link to Maps immediately informs the consumer if the service is available in their area. The area at which the researcher tested the on-demand mobile application only had one retailer, ASAP! (Bottles) by PnP servicing the location. Fig. 5 below illustrates the areas across South Africa where the on-demand service is available. The colour code can identify the food retailers offering the service on the map. It can be noted on the map below that small towns rural and semi-rural areas do not have access to these services.

### 5.2. Financial performance year on year

A comparison to check the financial performance of the Checkers, Pick n Pay, and Woolworths, taking into account the same period in 2019 (pre-COVID) and 2020 (during COVID) [89–91]. Checkers, Pick n Pay, and Woolworths shows a total turnover growth of 4.7%, 2.6% and 5.3%, respectively. While all these businesses have demonstrated resilience against COVID-19, as none reported declining financial performance, we cannot attribute this performance to the launch of on-demand mobile applications only (see Fig. 6).

Quantifying the benefit and the cost of deploying digital technologies in the supply chain is not straightforward due to its complex and multifaceted challenges and opportunities; however, the right technology will pay for itself and realise positive returns. It is prudent that the deployment of digital technologies is supported by a digital strategy that considers the organisational culture, vision and mission. One of the critical benefits for digital transformation in this instance is enhancing the customer experience while reducing customer exposure to COVID-19; Woolworths launched the online shopping mobile application later than Pick n Pay and Checkers; however, it shows the highest number of customer satisfaction for both Andriod and IoS users as well as highest sales growth percentage in the period compared.

### 6. Conclusion

The advent of COVID-19 in Wuhan 2019 and its rapid development across the globe has caused disruptions in international and local supply chains. The results of the compared grocery retailers in South Africa show that the food supply chain remained resilient even with demand management challenges that occurred at the beginning of the lockdown due to panic buying.

- What is the impact of a supply chain disruption on the food system?

Food supply chain issues came under a spotlight as borders and production plants were shut down or restricted to contain the spread of the virus. The study also establishes that access or lack of food supply was primarily caused by panic buying at the beginning of lockdown, causing shock in the supply chain cadence. The other aspect of food...
Critical global food supply chains look like they will remain in place even post-COVID-19. The recommendation of this study is for the South African food system to adopt digital technologies that will lead to data-driven supply chains to achieve transparency across the food value chain. The modified theoretical framework in Fig. 7 shows further digital/information links that are crucial to improving supply chain disruptions.

Post pandemic picture suggests that hybrid shopping will cater to in-store and non-store shopping. However, the digital divide in South Africa limits this approach to be accessible to all South Africans regardless of social class. Efforts to ensure that South African society gets some form of social protection pensions can lead to operational excellence, cost and waste reduction that will assist South Africa in meeting the SDGs.

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