Hotspots of vulnerability and disruption in food value chains during COVID-19 in South Africa: industry- and firm-level "pivoting" in response

Ferdinand Meyer [a,*], Thomas Reardon[b] ; Tracy Davids[c], Melissa van der Merwe[d], Daniel Jordaan[e] , Marion Delport[c] and Gerhard Van Den Burgh[c]

[a]Bureau for Food and Agricultural Policy, Department of Agricultural Economics, University of Stellenbosch, Stellenbosch, South Africa; [b] Michigan State University, East Lansing, MI, USA; [c] Bureau for Food and Agricultural Policy, Department of Agricultural Economics, University of Stellenbosch, Stellenbosch, South Africa; [d] Bureau for Food and Agricultural Policy, Department of Agricultural Economics, University of Stellenbosch, Stellenbosch,
South Africa; [e] Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Pretoria, South Africa

*CONTACT: Ferdinand Meyer. Email: ferdi@bfap.co.za

Abstract

We use a primary data set from a survey of medium and large firms and farms in the beef, citrus, and maize value chains in South Africa during March-June 2020, the early and late phases of the initial COVID-19 lockdowns. We have five main findings. (1) The initial lockdown regulations declared as "essential" the product (vertical) value chains but left as "inessential" the important "lateral" value chains delivering labour, materials, and logistics to the segments of the vertical value chains. This hurt the three vertical value chains as constraints in the laterals choked key segments of the verticals. (2) Vulnerability of the whole value chain emanated from vulnerability to shocks of critical "hotspot" linchpin segments (such as livestock auctions) or infrastructure (such as at ports). (3) Collective, industry-level "pivoting" was crucial both to organize the private sector response and to interact with government to course-correct on COVID-19 policies. (4) Responses to pre-COVID-19 challenges (such as drought and international phytosanitary rule changes) had prepared the beef and citrus value chain actors to respond collectively to the pandemic challenges. (5) Individual firm- and segment-level "pivoting" was also crucial for resilience, such as cattle auctions going on-line with the help of e-commerce firms.

Keywords: Value chain vulnerability; agrifood system resilience; agribusiness strategies; COVID-19 response

1. Introduction

COVID-19 and policies to contain its spread affected food value chains (VCs) in South Africa, as elsewhere. Despite the pandemic's causing South African GDP to shrink by 7% over 2020, the agricultural sector was resilient and grew by 13.1% (STATS SA 2020). The pandemic little affected overall food demand but did drive consumers to shift from restaurants to home meals (NIDS-CRAM 2020).

However, VCs were impeded by "lockdown" restrictions particularly in the early lockdown period (26 March–30 April 2020). There was a policy paradox: (1) the government declared as "essential services" the VCs that we call "vertical" value chains, moving food from farms, via wholesalers, processors, and retailers, to consumers; (2) but at the same time government classified as "inessential" what we call "lateral" value chains supplying labour, materials, and logistics to the segments of the vertical VCs; restrictions on movement were applied to inessential services.

We show that the unintended consequence of policies restricting the lateral VCs was to choke the vertical VCs. The analysis of the dependence of vertical VCs on lateral VCs such as logistics has been rare in the COVID-19 impacts analysis literature, in particular for the midstream segments of vertical VCs. The choking of the vertical VCs by restrictions on lateral VCs was: (1) magnified at vulnerable nodes of "hotspots" in certain product VCs; (2) dampened where agribusiness firms "pivoted" to mitigate the effects of the policies on their supply chains, with the capacity for such pivoting built over years of responding to zigzags in foreign market requirements; and (3) dampened by parallel conditioners including better rainfall and less animal disease in 2020 compared with 2019.

We examine three quite different VCs: (1) beef as a relative luxury and perishable product, mainly focused on the urban domestic market with a small share exported; (2) citrus as mainly an export product and perishable; (3) maize as a staple and non-perishable product, mainly focused on the domestic and regional markets. We show the impacts of COVID-19 policies and agribusiness strategies differ widely over these VCs.

South Africa as a transitional, "emerging market" country, is an interesting intermediate case between developed countries where agrifood sectors are relatively concentrated, and other developing countries especially in Africa where much of the agrifood sector is fragmented. South Africa has dualistic sectors such as beef where there are small enterprises as well as large actors in each segment of the VC; the country has concentrated sectors such as citrus and maize where, beyond trading and aggregation, each stage of the product value chain is concentrated, although maize has a very limited informal sector as well with less than 10% share of total production. While it is of interest to understand the impacts of the policies on the small-scale actors in the beef and maize VCs, in this paper we focus on medium-large formal sector firms and farms in all three VCs. This focus was determined by practical considerations: due to mobility restrictions we could not do in-person interviews, so we had to do a cellphone-based survey and that was more practicable with medium-large actors. However, the great majority of the volumes of the beef, citrus, and maize VCs is generated by medium-large firms, and so we capture the main impacts and strategies used in these key food sectors.

We make three contributions to the literature which also structure the paper. First, we ground the analysis of what happened during COVID-19 in an assessment of the structure and conduct of the VCs before the pandemic. We believe this has often been missing in pandemic analyses and allows us to interpret the impacts as well as adaptation or "pivoting" strategies of actors during the crisis. Second, we discuss the surveys we used to track an integrated set of shocks to and effects in VCs, by tracing policies and impacts to VC actors during different stages of the pandemic. We believe that this kind of integrated survey is rare. Third, we draw on case study information to categorise the resilience or "pivoting" strategies used at the industry association level and at the individual firm and VC segment level. We believe that

the firm- and segment-level analysis of pivoting strategies, especially by firms in the midstream of the VCs, is rare and a key knowledge gap.

2. Key characteristics of the beef, citrus, and maize VCs before the pandemic

Table 1 provides the characteristics of the VCs before the pandemic that conditioned the effects of COVID-19 policies.

Table 1. Value chains' key characteristics.

	Beef	Citrus	Maize
Chain complexity	Complex	Semi-complex	Simple
Degree of concentration	Dual	Concentrated	Dual
Export share	Low	High	Medium
Diversity of marketing channels	High	Medium	Low
Nature of the product	Luxury	Normal – luxury	Inferior
Labour – upstream	Low	High	Low
Labour – midstream	Low	High	Low
Labour – downstream	Low	Low	Low
Imported inputs	Low	Low	High
Mechanization	Low	Low	High
Industry associations	Medium	High	High

2.1 Beef

About 75% of South Africa's beef output is consumed in cities, 4% is exported (mainly to Asia and the Middle East, ITC 2020), and the other 21% is consumed in rural areas. Beef is a luxury compared with cheaper chicken and eggs (Delport et al. 2017, Vermeulen 2020).

The beef VC feeding the urban and export markets is long and complex. It stretches across large swathes of the country funnelling into intense value-adding areas (e.g., clusters of feedlots) that mainly supply urban areas. The mainstream, commercial cattle production system is a weaner production system on small-medium and large cattle ranches. Feedlots typically purchase these weaner calves to finish them for the market in an intensive feedlot phase. Most beef consumed in the country comes from the feedlot segment which is relatively concentrated, with several large feedlots and feedlots that are forward integrated into midstream operations of slaughter (abattoirs) and processing (meatpacking).

The upstream segments' structure has changed over the past 30 years. It has gone from extensive cattle production on natural pasture to weaner calf production. Feeding shifted from pastures to concentrated feed. The inputs to the latter are mainly domestically produced (such as maize), a few, constituting a minor share in volume but a significant share in value, need to be imported (such as vitamin packs and premixes) to be included in cattle feeds.

The midstream consists of two segments: slaughter (abattoirs) and processing (meatpacking) both of which exhibit economies of scale. However, large firms and concentration is mainly observed in packing and less in the slaughter segment where there are still many small operations, especially in the hinterland areas and around small towns (SAMIC 2018). Some large abattoirs are forward integrated into packing, and some are backwards integrated into feedlot operations.

The downstream consists of retail and foodservice segments. Urban consumers buy beef from large retailers (supermarkets and e-commerce), large foodservice outlets (fast-food chains),

SME retailers (a variety of small shops called butcher shops and spaza shops), and SME foodservice (barbecue stalls). Large-scale firms tend to sell high-and low-quality beef for different consumer strata; SMEs tend to sell low quality beef to their mainly poorer clientele.

The beef value chain is more labour-intensive in the upstream compared to the midstream and downstream, but less so compared to other value chains such as citrus. Larger abattoirs and packers are more mechanised compared to smaller abattoirs and packers; some smaller firms still slaughter and process cattle by hand.

The many segments of the beef VC chain and its dualistic character in each segment have made it so that there is an overarching body (Red Meat Industry Forum, http://www.redmeatsa.co.za), which combines multiple independent organisations representing parts of the chain. However, there is no evidence that the industry responded as a collective in coordinating the response to the pandemic. The same goes for influencing government policy during COVID-19.

Before COVID-19, the beef VC had been facing a multi-year regional drought that led to the liquidation of large proportions of cattle herds. This led to an oversupply of slaughter cattle and a dip in prices. This was followed by a period of herd rebuilding after good rains, which ultimately constrained the supply of market-ready cattle and increased prices (BFAP 2016). The beef value chain was further strained by outbreaks of Foot and Mouth Disease (FMD) that led to export bans (Phakhati 2020), and more stringent traceability requirements for the 4% of the sector that exported (ITC 2020).

2.2 Citrus

South Africa's citrus sector is the largest contributor to the value of agricultural exports (ITC 2020). 75% of citrus output (and 92% of citrus sales in value terms), the highest quality fruit, is exported (DALRRD 2020). South Africa is the second-largest citrus exporter after Spain and is the largest exporter in the Southern Hemisphere (ITC 2020). On average, it sells 20% of global citrus exports all year and 40% in the southern season.. Its export markets are somewhat diversified: 43% goes to the EU (UK and non-UK) with the balance to the US and Asia. 20% of output (the lowest quality fruit) goes to domestic processing for juice, a product affordable to both the middle and lower-middle classes. 5% (medium quality fruit) goes to the domestic fresh market (DALRRD 2020).

The upstream segment consists of medium and large-scale farmers. The organisation which represents commercial producers, the Citrus Growers Association (CGA), has approximately 1400 members (CGA 2019). Large producers with sufficient scale are forward integrated into packing. Medium farms rely on independent packing firms among which many evolved from previous cooperatives and have farmer shareholders (Chadwick 2019). This model of grower shareholding but legally independent entities can be described as an "equity-based alliance" (Greyling and Pardey 2009). Producers retain ownership of the fruit but pay a fee for it to be packed by one of the large packhouse firms.

After packing, the fruit moves downstream to four ports via 3PLS (third party logistics firms) in refrigerated trucks or already packed in refrigerated shipping containers. Lower grade fruit go to a handful of domestic juice processors by non-refrigerated trucks. The 3PLS trucking segment is concentrated with a few lead firms moving the fruit. The National Ports Authority, a subdivision of the state-owned enterprise Transnet (Meyiwa and Chasomeris 2020) runs the

port facilities. Most cold storage facilities are privately owned, some by big exporters, others by independent firms which lease them to exporters. The fruit moves from the ports to the export markets via a few shipping firms such as Maersk or Seamax (Freshplaza 2020). Shipping is highly concentrated and "high technology" with refrigerated containers or breakbulk reefer vessels. The fruit is sold in one of three ways: (1) bought directly by supermarket chains in Europe; (2) via traders who buy South African fruit and market it in destination countries; (3) via completely integrated chains where the farmer also owns a marketing outlet in the importing country. Regardless of the method, the fruit must meet food safety standards such as GLOBALGap and adhere to specific quality traits. Export procedures must adhere to destination country protocols.

Farms rely heavily on seasonal workers for the harvest (Fana 2020; BFAP 2012). The workers migrate over production zones. Packing houses use some labour for sorting, but the internal plant system is mainly mechanised.

Despite there being many medium farmers, most are members of the Citrus Growers Association (CGA), an affiliate of Fruit South Africa (FSA). Under the FSA umbrella and within the confines of the Fruit Industry Value Chain Round Table (FIVCRT), the sector collaborates with other fruit sectors, as well as government and organised labour, regarding policy issues. Important here is the role of the CGA in interacting with importing country governments (through close collaboration with the South African government) and firms on requirements such as phytosanitary standards, safety standards, and eventually, in the case of COVID-19, pandemic-related requirements imposed by importers in Europe, the US, and Asia.

Before COVID-19, for five years, farmers had established new orchards rapidly in response to rising real prices and competition in global export markets, good profitability, and availability of water either through crop substitution or efficiency gains in irrigation which allowed for expansion in the area under production (CGA 2019). Farmers, packing house firms, and exporters expected large increases in volumes as the trees matured. CGA engaged with the government on multiple fronts: (1) to prioritise new markets for citrus fruit where SPS protocols still have to be established to gain access (particularly in Asia); (2) to assure port capacity and the needed support from the phytosanitary service for SPS compliance with EU phytosanitary requirements.

The latter is especially important. Since 1992 South Africa and the EU have had disputes over Citrus Black Spot (CBS), a fungal disease that can be transmitted through the movement of infected plant material (Truter 2010, Agostini et al. 2006). In 2012 the EU told South Africa that the EU would close their market if there were more than 5 CBS interceptions in any one year (BFAP 2013). South Africa's Citrus Research International (CRI) developed a comprehensive risk management programme that kept the interceptions in range. In 2018, South Africa exported 40,000 containers of citrus to the EU with only 2 CBS interceptions (EU Commission 2020). The farmers, packing houses, and exporters collaborated closely among themselves and the government's phytosanitary service to put in place stringent protocols and large investments in preventative measures. This increased the citrus association's reputation, inter-segment coordination, and experience in managing these risks; the sector entered 2020 and the challenge of COVID-19 with this inheritance of unity, inter-segment and private sector – government collaboration, and systems in place to deal with new requirements and crises.

Moreover, even in normal years, the capacity of ports is strained. In 2019, even before COVID-19, inefficiencies (related to poor management, old infrastructure and equipment, and persistent labour challenges) in these ports were a big challenge to the citrus VC (Jansen 2019; Zestfruit 2019). The citrus sector dealt with those challenges by engaging various government departments and Transnet, which resulted in management changes, as well as the development of a joint strategic plan and the initiation of procurement of additional equipment. Some of the equipment installations were delayed by the lockdown in 2020. However, the collaborative actions were an "inheritance" it drew upon in 2020 with the shocks to the labour and logistics of the port system that came with COVID-19.

2.3 Maize

Maize (white and yellow) is the second largest contributor to agricultural GDP after poultry. 70% goes to the domestic market; 30% goes to the Southern Africa regional market as well as deep-sea exports (mainly Asian and Middle Eastern markets) in bumper crop years like 2020. Maize flour is a basic staple and an inferior product according to its income elasticity; when household incomes rise, they shift from maize to white bread and potatoes (Vermeulen 2020). The implication is that the poor are especially dependent on maize and sensitive to its price.

The maize VC is simple, connecting maize farmers to wholesalers and millers of maize flour and feed, to retailers and exporters. According to the latest Stats SA Household survey, 975,000 households grow cereals (typically maize); the Census of Commercial Agriculture reports that 21,000 large, medium, and small commercial farms fall in this category. Despite the large number of households, only 5% of the national maize crop is grown by small farms (Greyling and Pardey 2019); 95% of maize production is by medium and large farms that are highly mechanised (Stats SA 2020).

The midstream is composed of: (1) a concentrated feed and flour milling sector (where a few large firms account for approximately 70% of output; AFMA 2020); and (2) a fragmented wholesale segment. The latter was concentrated until 1997 when the single-channel marketing board was abolished, and private SME wholesalers took over.

Maize farming (except for the 5% of maize farmed by smallholders) and milling are machine-intensive and depend little on labour (Gouse 2014). South Africa imports 80% of its fertiliser and more than 95% of plant protection chemicals. The farm gate price of fertilisers is strongly influenced by international price fluctuations, currency exchange rates, and domestic and foreign shipping and distribution costs. Depreciation in 2020 drove up that price.

Each maize VC segment is represented to the government by a separate organisation but they work together in the Maize Forum to lobby the government. There is also a market information system of the National Crop Estimates Committee, the Supply and Demand Estimates Committee, and the South African Grain Information Service (SAGIS). These systems played a key role during COVID-19 by reducing panic in the market and planning for possible export volumes based on harvest expectations.

Before COVID-19, the National Crop Estimates Committee estimated a bumper crop that would be large enough to exceed domestic demand by a third in 2020 and futures market prices for the new crop were already at export parity levels before COVID-19. In normal years, the large mills run at only 80% utilisation, so there was plenty of slack to

accommodate the sharp rise in maize meal demand (SAGIS 2020) that occurred, especially during early lockdown.

3. Survey used to monitor disruptions during the lockdowns: the food-Chain tracker

Exogenous shocks included COVID-19 itself, as well as the (positive) shock of good rainfall during the period. Endogenous shocks were measures taken by the government and other non-value chain actors (such as associations) as responses to the exogenous shocks, that became conditioners of the behaviour and outcomes for actors in the value chains. The prime example of an endogenous shock is the lockdown regulations; secondary examples include currency depreciation.

The type and intensity of endogenous shocks evolved: (1) as responses to the evolution of exogenous shock changes (such as waxing and waning of disease incidence); (2) as challenges from exogenous or endogenous shocks became apparent and had to be addressed, such as shortfalls in port capacity or the need to add lateral supply chains (such as materials) to the list of essential services so that constraints to the lateral VCs would stop impeding the vertical VCs.

The Bureau for Food and Agricultural Policy (BFAP) developed a web-based monitoring and reporting system referred to as the *End-to-End Agro Food Chain Tracker* to inform government and private sector of FVC disruptions during COVID-19. The on-line survey was implemented on average weekly over three months (26 March-30 June) to 53 respondents in VCs, including industry organisations and leading large and medium firms in the various segments. The survey focused on commercial formal sector firms rather than small informal enterprises as discussed above. About 80% of the respondents completed more than one iteration of the tracker survey. 11 respondents were in the beef value chain, 10 in citrus, and 13 in maize.

In step 1 of the survey, respondents were asked to rank the deviation from their normal operations from the perspectives of "procurement & inputs", "operations and output", and "sales" (Figure 1). The Likert scale is shown in Table 2.

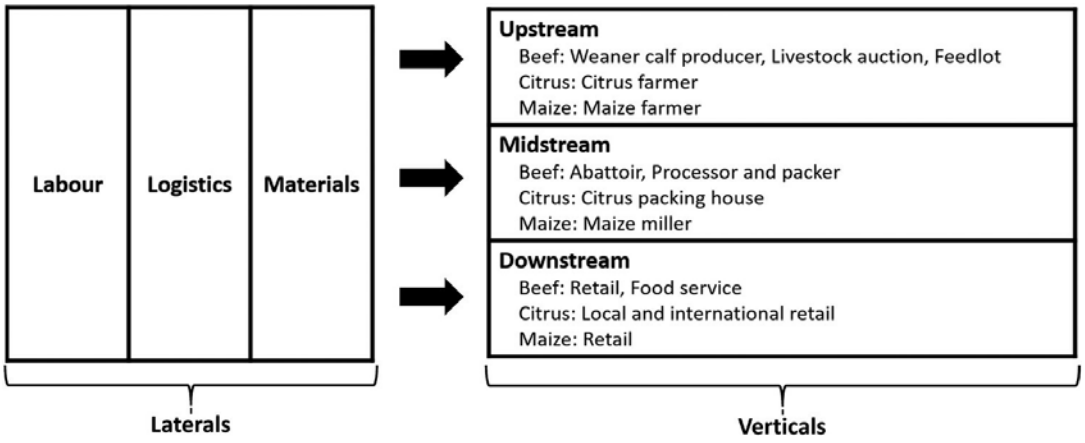

Figure 1. Vertical and lateral value chains for beef, citrus and maize.

Table 2. Likert scale used in survey responses.

5	4	3	2	1
Business as usual	Minor disruption – manageable for the foreseen future	Minor disruption – manageable only in the short run	Major disruption	Totally disrupted

In step 2, the respondents ranked the severity of the disruption in lateral VCs supplying their vertical VC. The disruptions in the laterals included: (1) physical input supply issues (e.g., getting crates for packing); (2) labour supply constraints (e.g., reductions due to regulations and/or COVID-19 cases); (3) economic distress (e.g., rise in input costs due to regulations).

In steps 3 and 4 respondents were asked to identify the verticals (i.e., vertical VCs such as that of maize) where disruptions were experienced, and in what segments (upstream, midstream, or downstream). In step 5 respondents were asked to suggest interventions (such as government measures) that would alleviate the disruptions.

While the citrus and maize samples were adequate, only three key stakeholders in the beef VC participated in the survey. For the beef VC, the tracker data were complemented by BFAP's using a qualitative survey the design of which was informed by prior qualitative interviews with stakeholders. The beef survey focused on longer semi-structured interviews by phone in July 2020 with 12 stakeholders (including industry representatives, livestock agents, auctioneers, feedlots, abattoirs, wholesalers, exporters, and retailers), having them discuss open-ended questions about how COVID-19 affected their businesses.

4. Regulatory and non-regulatory shocks to vertical and lateral value chains early and late in the pandemic

4.1 Early (hard) lockdown regulations

We call the first four weeks of the lockdown (26 March to 30 April 2020) the "early lockdown" during which the government implemented a "hard lockdown". Only actors designated by the government as "essential" were allowed to operate. In vertical VCs the "essentials" were deemed to include: farm input suppliers, farmers, feed mills, feedlots, abattoirs, wholesalers, packing plants, food manufacturers, and retailers. Small-scale firms selling uncooked beef could operate if they had a permit (Battersby 2020), but many did not know this, and many who tried to get permits could not get them.

Excluded from being "essential" meant being in a list deemed "non-essential" services in vertical VCs, which included: the foodservice segment (restaurants, quick service/takeout restaurants, catering firms, and small-scale foodservice firms). This is because selling cooked food was banned in the early lockdown. Many foodservice firms, including small-scale foodservice firms such as beef barbecues, shut down.

The following were named as essentials in "lateral" value chains: farm labour and logistics firms including small and large truckers. Hard and soft infrastructure linked to logistics were also classed as essential: ports; road transport of "essential" goods; fresh produce (wholesale) markets; and inspection services (South African Government 2020). However, some lateral value chains were not listed as essential in the early lockdown: packaging manufacture; raw material supply for manufacture of packaging material (such as wood required for construction of citrus fruit pallets); and mechanics and mechanical input and parts suppliers.

Beside the proximate shocks of movement restrictions, there were knock-on or indirect shocks to VCs even though the services were classified as essentials. On the one hand, ports ended up not operating efficiently as they were not fully staffed; some terminals were closed and non-essential products were not being handled – which increased congestion. Many port officials were required to work from home without being fully equipped to do so. On the other hand, there was a farm labour shortage in labour-intensive fruit harvesting and retail as worker mobility was constrained by evening curfews and inter-province travel restrictions (except for workers in sectors deemed essential, and if the worker had proof of employment). This implied that seasonal fruit pickers, who were not yet in possession of a work contract, could not move across provincial boundaries. This included workers that had finished picking fruit in a province other than their residence that needed to return home.

The severe lockdown for some parts of the VCs and a relaxed context for other parts created confusion and unequal effects that made the VCs vulnerable and disrupted. Furthermore, various enforcement agencies, provinces, and tiers of government interpreted the lockdown regulations differently, which led to inconsistent application and implementation.

4.2 Late (soft) lockdown regulations

The "late lockdown" (at least from the perspective of the survey coverage) lasted from 1 May-30 June. Government and private sector discussed bottlenecks that arose during the early lockdown, and the government changed some regulations as follows (South African Government 2020).

First, some economic activities deemed "non-essential" in the early lockdown were allowed to operate in the late lockdown: the packaging and forestry sectors; mechanical input and repair service providers; sales of hot food by small-scale foodservice firms, retailers, and restaurants as well as home deliveries of food by restaurants.

Second, the government clarified the regulations regarding essential and non-essential cargo handling at ports to include all goods. Regulations were amended to allow officials that were unable to perform their duties from home to be able to work from their offices given COVID-19 health and safety protocols were in place. This led to increased efficiency of on- and off-loading of cargos and ports were able to clear backlogs that accumulated during the early lockdown, reducing waiting times with regards to cargo certification. However, COVID-19 cases increased among port workers and the ports were frequently shut down; this also happened in ports in the countries importing from South Africa. Delays in payments and cargo off-loading were also reported, and restrictions of passage through key via-point ports.

Third, inter-province travel was still restricted to workers with proof of employment. As most harvest workers are informal, this continued to constrain the flow of migrant labour, which especially hurt citrus harvesting but did not affect beef and maize farming which does not rely on inter-province labour flows.

Fourth, public gatherings of up to 50 were allowed (after they had been banned in the early lockdown). Although cattle auctions operated, the constraint on the number of buyers and sellers affected competition (and thus prices to sellers) on these auctions.

Overall, as the restrictions eased, interpretations of the regulations were increasingly consistent, which reduced the confusion and inconsistencies. The shift from early to late

lockdown was characterised mainly by a shift from disruptions linked to lockdown regulations and interpretations thereof (restrictions of operations) to disruptions linked to the COVID-19 health shock.

4.3 Depreciation of currency and rainfall resurgence helped agricultural outcomes

From January to May 2020, South Africa's exchange rate depreciated by 26% relative to the US dollar. South Africa follows a flexible exchange rate regime, where the value of the Rand is determined by market forces (SARB 2007). The Rand is among the top 20 currencies globally in terms of value traded (BIS 2019) and is one of the most frequently traded emerging market currencies. This makes it particularly sensitive to risk sentiments in the global economy. COVID-19 sent shockwaves through the global economy and investors moved to low-risk options such as the US dollar. The resultant selloff of emerging market currencies sent most of them into a rapid depreciation which made South African exports cheaper for importers and imported inputs such as fertiliser more expensive for South African farmers.

Moreover, during 2014–2019 recurring droughts over many parts of South Africa severely reduced agricultural output. This included the El Niño event in 2015/16, which resulted in the lowest annual rainfall in 100 years (Baudoin et al. 2017). This drought led to livestock herd reductions in 2016 on the back of increased slaughtering. Rainfall returned to normal in 2019 and 2020 (ARC 2020), initiating a phase of cattle herd rebuilding and replenishing grain stocks. This upturn overlapped with the COVID-19 period.

4.4 Food expenditure dipped for beef but not for maize and citrus

South Africa's economy has been plagued by structural challenges for some time, and consumer spending power was drifting down for several years before COVID-19. However, incomes dropped fast in the lockdown period and stayed low over 2020, with an annual contraction of 7% in GDP (STATS SA 2020). Unemployment was already at 30% before lockdown (Stats SA 2017). The government survey (Stats SA) done at week 6 of the lockdown showed that the lockdown added to unemployment: 9.5% of respondents lost their jobs, and 19% had income drops while still employed. There was a 20% decline in monthly take-home pay in June 2020 compared to June 2019 (Businesstech 2020). Income drops reduce spending on income-elastic foods like beef relative to inelastic demand foods like maize (BFAP 2020). Consumers, however, perceive citrus as a product high in Vitamin C and supportive of immune systems, and so the demand for citrus did not dip (Leahy 2020; Smoley 2020; Ferrer 2020).

5. The impacts of the shocks on vertical and lateral value chains: findings from the survey & the semi-structured interviews

Here we present our survey findings on the impact of the shocks on value chains, with each of the vertical value chain segments (upstream, midstream, downstream) is discussed separately with its associated lateral value chains for materials, labour, and logistics (Figure 2).

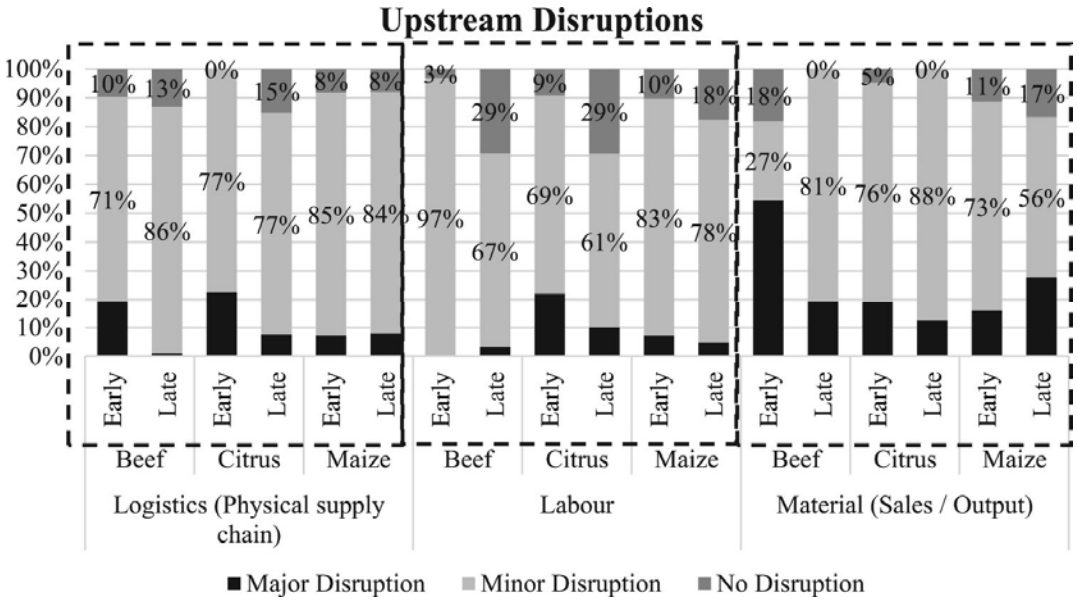

Figure 2. Upstream disruptions – BFAP End-to-End Agro Food Chain Tracker.

5.1 Impacts on upstream input supplies

Table 3 provides the major impacts of COVID-19 related shocks on the upstream of the three vertical (product) value chains per lateral (input) value chain.

Table 3. COVID-19 shocks on upstream.

			Major disruption	Minor disruption	No disruption
Logistics (Physical supply chain)	Beef	Early	19%	71%	10%
		Late	1%	86%	13%
	Citrus	Early	23%	77%	0%
		Late	8%	77%	15%
	Maize	Early	7%	85%	8%
		Late	8%	84%	8%
Labour	Beef	Early	0%	97%	3%
		Late	3%	67%	29%
	Citrus	Early	22%	69%	9%
		Late	10%	61%	29%
	Maize	Early	7%	83%	10%
		Late	5%	78%	18%
Material (Sales / Output)	Beef	Early	55%	27%	18%
		Late	19%	81%	0%
	Citrus	Early	19%	76%	5%
		Late	13%	88%	0%
	Maize	Early	16%	73%	11%
		Late	28%	56%	17%

5.1.1 Labour constraint impact in the upstream of the product (vertical) value chains

The upstream segments of the beef and maize VCs were hardly affected by labour constraints because they use relatively little hired labour, they are far from the population-dense COVID-19 areas, and their activities (except auctions) do not create crowds. Even in the late lockdown with a rapid rise in infection rates, stakeholders indicated that maize harvesting and feedlots were not affected.

However, citrus farming is intensive in trucked-in seasonal labourers who move across provinces. 22% of respondents indicated that they experienced major disruptions related to labour in the early lockdown (Figure 2). The lockdown's effects on labour mobility hurt citrus farmers who received fewer workers and had extra costs for private labour transport as public transport was shut down. Also, citrus harvesting in the Eastern Cape starts when grape harvesting ends in the Western Cape and workers usually go from one to the other. That movement needed to take place through the early lockdown, but inter-province travel required a permit. However, informal seasonal workers do not have employment contracts to show to the border police. The use of labour brokers had been increasing before COVID-19 because the use of seasonal migratory labour for harvesting was increasing (Genis 2018). Seasonal workers do not typically live on the farm; hence the need to travel to and from work increases their risk of contracting the disease and being stopped.

5.1.2 Logistics constraint in the upstream

During early lockdown, truckers had to obtain permits and wait in roadblocks while they were checked. Travel restrictions affected the citrus sector the most as it needed logistics firms to quickly move labour in and perishable fruit out. 21% of respondents in the upstream of the citrus value chain indicated that they faced major disruptions in their logistics in the early lockdown. This reduced to 8% in the late lockdown (Figure 2). During the late lockdown, increased certainty with respect to regulations and their application resulted in smoother functioning of roadblocks and fewer disruptions where reported.

5.1.3 Materials constraint impact in the upstream

The main vulnerability for all three value chains is the dependency on imports for critical inputs, affected by currency depreciation, logistical challenges at ports, and supply blockages from restrictions in input exporting countries. Feed mills and feedlots reported initial delays during early lockdown in imports of specialised feed ingredients from China. This was confirmed by the survey where 55% of respondents reported major disruptions of materials during early lockdown. These delays cleared in late lockdown.

Citrus and maize farmers reported delays in imports of tractor parts and irrigation equipment. Maize heavily depends on imports for more than 80% of its fertiliser and 95% of its plant protection chemicals. The domestic fertiliser price is conditioned by world price fluctuations, currency exchange rates, and shipping and distribution costs. However, maize farmers did not suffer because fertiliser was bought in November 2019 in the peak of planting, well before COVID-19.

5.2 Impact on midstream operations

Figure 3 and Table 4 provide the major impacts of shocks on the midstream.

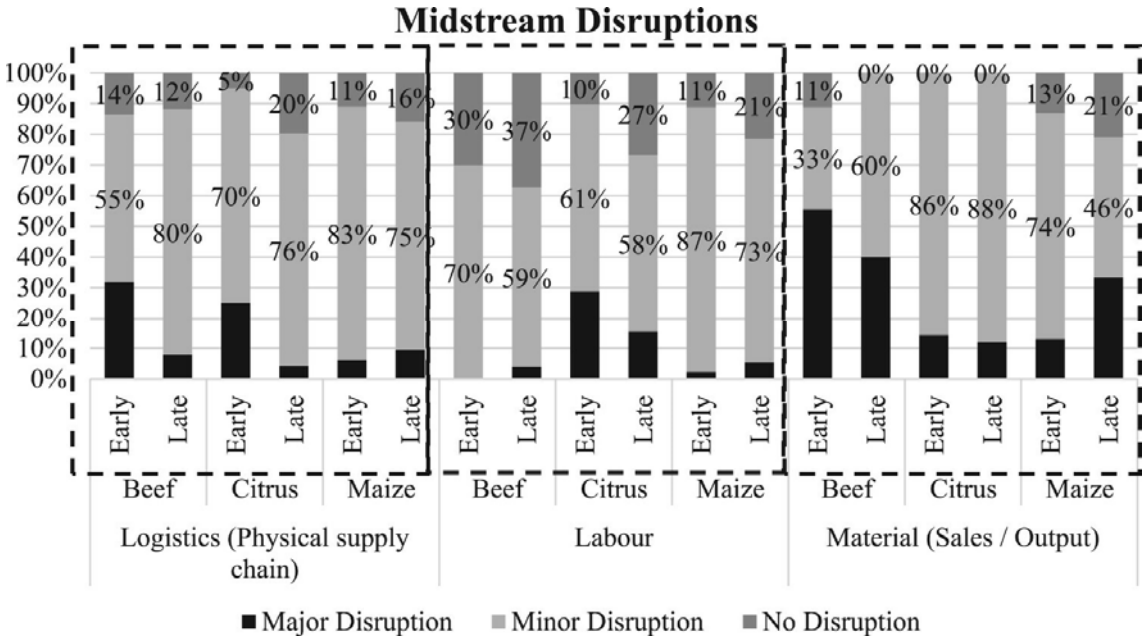

Figure 3. Midstream disruptions – BFAP End-to-End Agro Food Chain Tracker.

Table 4. COVID-19 shocks on midstream.

			Major disruption	Minor disruption	No disruption
Logistics (Physical supply chain)	Beef	Early	32%	55%	14%
		Late	8%	80%	12%
	Citrus	Early	25%	70%	5%
		Late	4%	76%	20%
	Maize	Early	6%	83%	11%
		Late	10%	75%	16%
Labour	Beef	Early	0%	70%	30%
		Late	4%	59%	37%
	Citrus	Early	29%	61%	10%
		Late	15%	58%	27%
	Maize	Early	2%	87%	11%
		Late	5%	73%	21%
Material (Sales / Output)	Beef	Early	56%	33%	11%
		Late	40%	60%	0%
	Citrus	Early	14%	86%	0%
		Late	12%	88%	0%
	Maize	Early	13%	74%	13%
		Late	33%	46%	21%

5.2.1 Labour impacts in the midstream

Interviews in the beef value chain confirmed that abattoirs and meatpackers are largely mechanised but still require workers. Curfews and social distancing measures limited worker density on-site. Staff transport contributed to costs as plants needed to schedule more trips to transport workers to and from the plants. The spike in COVID-19 cases in the late lockdown put plants at risk for closures which required careful staff planning to ensure mitigation strategies in the case of COVID-19 cases to prevent plant closures.

Citrus packing houses were constrained during early lockdown by social distancing requirements and the need for personal protective equipment and sanitation materials increased costs. Labour-dense packing facilities increased the risk of disease outbreak during the late lockdown, but no packing houses needed to close through July 2020. Nevertheless, 29% of respondents indicated major disruptions in the early lockdown.

Maize silo operations and mills are highly mechanised and require only a few people to run 24-hour operations seven days a week; the labour restrictions had little impact.

5.2.2 Logistics impacts in the midstream

According to key stakeholders, logistics in the beef midstream were not disrupted: animals were hauled short distances by local truckers from farms to feedlots, and feedlots to abattoirs, and carcasses (in branded cooled trucks allowed hassle-free passage through roadblocks) to meatpackers and butcher shops in cities.

Citrus also went by refrigerated trucks from packing houses to port or plant; the trucks could wait at roadblocks without fruit damage and the truckers had papers as essential services. But roadblocks did result in delays and 25% of respondents indicated major disruptions in the early lockdown. Significant improvements were evident in late lockdown, with only 4% of respondents pointing to major disruptions. While the bulk of products was transported by road, citrus producers also increased the use of rail transport relative to previous years.

For maize, the logistics between farms, silos, and mills became more congested than usual due to the confluence of events. Lockdown slowed the movement of trucks. A bumper harvest of 15.3 million tons required more trucks than usual. Traders surveyed during the pandemic felt that inefficiencies in rail transport led to 20% more of the maize harvest than normal having to be transported in trucks. 10% of the respondents reported major disruptions of logistics in the midstream.

5.2.3 Materials impacts in the midstream

During the early lockdown, meatpackers, especially SMEs, reported moderate shortages of packaging material. Citrus packing plants, however, faced significant disruptions. The forestry and wood sector was not classified as essential, and so manufacturing of fruit pallets was halted. The survey identified this bottleneck in the early lockdown, and the government then rendered “essential” all lateral value chains supplying vertical VCs for food products and thus alleviated the problem.

Maize flour demand spiked (discussed below) and mills faced a shortage of packaging, which was exacerbated by the recycling industry not being operational. This is evident from survey data that illustrate that major disruptions in materials increased from 13% during early lockdown to 33% during late lockdown. Parallel to our point about the forestry sector's wood VC being at first not deemed essential, the same had been a problem for the packaging VC. In the late lockdown, the regulations were amended.

5.2.4 Output demand in the midstream

Output demand from the midstream was varied in the period of the lockdown: it was extremely high then extremely low then just low. Key stakeholders reported a sharp increase

in beef demand by supermarkets and butcher shops as consumers cold-stored beef products, fearing a shortage in early lockdown. Abattoirs and meatpackers reported that they had to operate at full capacity to fulfil supermarket and butcher shop demand.

By contrast, demand for beef in the foodservice sector abruptly stopped at the onset of early lockdown due to the closure of all restaurants which manifested as a decline in restaurant beef cuts that rippled through the beef VC. When regulations were eased in the late lockdown, beef demand by supermarkets and butcher shops recovered. However, foodservice demand only recovered partially as consumers still did not want to go out to restaurants.

Although only 4% of beef is exported, these sales reduced the amplitude of the demand swing. Even though export channels remained open throughout lockdown, some abattoirs reported a decline in international restaurant orders due to foreign country foodservice lockdowns or consumer fears similar to those in South Africa. According to export abattoirs and meatpackers, export diversification pre-COVID paid off. Exports of boneless cuts (chilled and frozen) destined for Asia picked up in late lockdown as these food economies opened earlier than South Africa's (ITC 2020).

Citrus packers and maize millers were helped by larger volumes and better prices (the latter linked to the depreciation of the Rand). Plants had under-utilized capacity before COVID-19; they had the flexibility to move to full capacity use with the demand increase. Their output includes maize husks and other by-products that do not go into flour (only 57% of a ton of maize is made into flour), and so the output increase went to feedlot operations and feed mills, supporting their operations.

5.3 Impact on downstream output demand

Figure 4 and Table 5 shows impacts on the downstream of the three vertical (product) value chains per lateral chain.

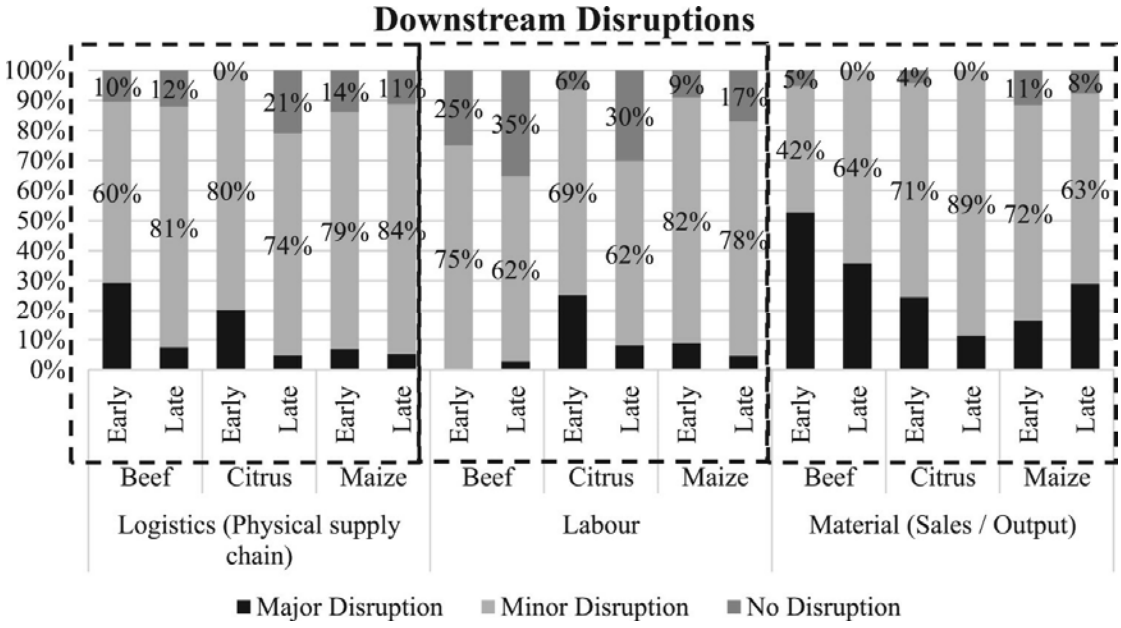

Figure 4. Downstream disruptions – BFAP End-to-End Agro Food Chain Tracker.

Table 5. COVID-19 shocks on downstream.

			Major disruption	Minor disruption	No disruption
Logistics (Physical supply chain)	Beef	Early	29%	60%	10%
		Late	7%	81%	12%
	Citrus	Early	20%	80%	0%
		Late	5%	74%	21%
	Maize	Early	7%	79%	14%
		Late	5%	84%	11%
Labour	Beef	Early	0%	75%	25%
		Late	3%	62%	35%
	Citrus	Early	25%	69%	6%
		Late	8%	62%	30%
	Maize	Early	9%	82%	9%
		Late	5%	78%	17%
Material (Sales / Output)	Beef	Early	53%	42%	5%
		Late	36%	64%	0%
	Citrus	Early	24%	71%	4%
		Late	11%	89%	0%
	Maize	Early	16%	72%	11%
		Late	29%	63%	8%

5.3.1 Labour impact in the downstream

Similar to the midstream, constrained labour supply to supermarkets and butcher shops was reported in early lockdown due to curfews and social distancing regulations. Some supermarkets and butcher shops also had to close temporarily because workers got sick. Stakeholders reported an increase in costs to meet the COVID-19 protocols in their facilities. However, even in late lockdown when infections spiked, overall retail sales of beef and maize were not slowed significantly.

For citrus, port constraints and delays were combined with problems with importers. For instance, Indonesia and South Korea did not accept electronic clearance and inspection certificates. South Korea required its inspectors to visit South Africa, and yet that was prohibited by travel restrictions. 25% of respondents reported major labour disruptions in the downstream, mainly as a result of skeleton staff in the ports and inspection services.

5.3.2 Logistics impact in the downstream

Retailers of uncooked beef cuts did not report any delays in the movement of beef products from the midstream to the downstream in the early or late lockdowns. The trucks passed through roadblocks with ease as long as the truckers had permits for the movement of carcasses and beef cuts across provinces.

For citrus, ports and cold storage facilities receive 100's of refrigerated trucks each day during harvest, and each must unload to a cold container that is transferred to a ship. These steps are sensitive to any break in the cold chain, which alters fruit quality and thus exportability, which makes the truck-port-ship locus a point of vulnerability for the whole chain (Boin et al. 2003; Wagner and Bode 2006; Wagner and Neshat 2010).

Among the four ports, Durban is most vulnerable, as it handles 60% of citrus export volumes. To enable early action concerning port efficiency, the Citrus Growers Association introduced a daily port report. From mid-May to the end of June, capacity utilisation in Durban fluctuated between 40% and 70%, reflecting significant volatility, but no clear trend. In Cape

Town and the Eastern Cape, utilisation rates improved throughout May with the late (softer) lockdown but declined again through June as infection rates, particularly in the Western Cape, rose. Operations in Cape Town were delayed periodically because of infections among the workforce, with delays exacerbated by operational challenges and poor weather. In June, congestion resulted in multiple shipping lines electing to bypass Cape Town and congestion surcharges were implemented from July. Berthing delays of up to two weeks were reported. Many producers redirected fruit to the Eastern Cape, which was costly but ensured consistent supply to international clients and reduced the risk of quality loss due to port delays.

5.3.3 Materials impact in the downstream

The citrus VC reported container shortages among major shipping lines (Phakhati 2020). 24% of respondents in the citrus VC reported major disruptions in the early lockdown. Delays were alleviated later as more countries opened operations – particularly China. Maersk also launched a special consignment with 1800 empty containers from Dubai to South Africa at the end of April, to help ease these shortages (www.maersk.com, 2020). Consequently, the share of respondents reporting major disruptions declined to 11% in the late lockdown.

5.3.4 Impact on output demand in the downstream

In early lockdown beef sales in the restaurant sector dropped to zero during early lockdown (South African Government 2020). According to suppliers of beef to the foodservice sector, sales to restaurants were still (by July during the interviews) 60% lower despite the reopening of the foodservice sector in the late lockdown (South African Government 2020).

Large and medium supermarkets and butcher shops reported increased sales of up to 30% as richer consumers stockpiled meat, fearing shortages, in the early lockdown period. Stakeholders in the meatpacker segment reported a spike in demand for prepared meat such as roasts and marinated meats that are easy to cook as home cooking replaced meals away from home. The sudden increase in demand at the supermarket level quickly led to higher prices for high-value beef cuts, as abattoirs and meatpackers were unable to meet all the supermarket orders. In late lockdown, supermarkets reported 15% higher sales compared to pre-lockdown levels. By August 2020 beef sales stabilised to pre-lockdown levels at supermarket level.

In early lockdown, the small-scale foodservice firms selling cooked beef were not allowed to trade (South African Government 2020), and even later, only those in possession of a municipal permitFootnote[1] could trade (Battersby 2020). In contrast to the wealthier clientele of large formal supermarkets, the small-scale butcher shop clientele did not have the purchasing power or the necessary storage facilities to stockpile beef in the early lockdown. Small-scale spaza shops and butcher shops, therefore, did not show the same level of increases in sales.

According to the Quarterly Labour Force Survey (STATS SA 2020), agricultural jobs declined by around 40,500 jobs in 2020. Despite the announcement by the government of a massive relief package mainly for the poor, the purchasing power and employment of low-income households were affected little by mobility restrictions and demand decreases. Consumers did however make a run on maize flour as a storable and cheap staple. This is seen in maize milling data over February-June (SAGIS 2020). Maize used for human

consumption increased by 14% in 2020 compared to the same period in 2019. The increase is maize flour was further supported by the relative shift in staple prices of maize flour, bread, and rice.

6. Strategies of firms to manage vulnerability

Firms had strategies to address, and sometimes even avail of market opportunities created by lockdown constraints (Table 6), discussed below.

Table 6. Value chain segment strategies in response to COVID-19 shocks.

	Beef	Citrus	Maize
Upstream	**Early:** • None **Late:** • Reduced feedlot workforce concentration • Reduced stocking by feedlots	**Early:** • Provided transportation to reduce dependence on public transport • Increased reliance on local workers • Distance and protect workers **Late:** • Risk register with mitigation strategies	**Early:** • None **Late:** • On-farm storage to cushion logistics bottleneck • Order inputs early
Midstream	**Early:** • Plants split shifts, truck in workers • Preventative measures for disease and increased capacity to manage surge in demand • Alternative suppliers of carcasses to compensate for demand spike • Redirected supplies from foodservice (zero demand) to supermarket (demand spike) **Late:** • Back to pre-COVID capacity • Exports switched mainly to China	**Early:** • Plants split shifts • Prevented measures for disease **Late:** • Same as early	**Early:** • Boost mill capacity use • Compete for 2019 stored maize **Late:** • Bumper harvest; lobbied for ports open longer
Downstream	**Early:** • Truck in workers **Late:** • Increased use of e-commerce to reach consumers	**Early:** • Harvest and export earlier than usual to ease peak season volumes **Late:** • Shifted workers between ports • Shifted fruit to different ports • Consistent, high-frequency information	**Early:** • Push delivery of maize flour at all levels of retail • Sell food aid **Late:** • Line up global shipping space fast

6.1 Strategies in the beef value chain

6.1.1 Beef upstream strategies

COVID-19 spread when weaner producing cattle ranchers were already rebuilding their herds following multiyear droughts that had ravaged their herds; ranchers did not have weaner surpluses to feed the sudden surge in beef demand from retail.

Although the prior multi-year droughts did not necessarily support the building of resilience, the FMD (foot and mouth disease) shock in 2019 did. FMD led to government restrictions on inter-provincial movement of livestock. According to interviewees, these led to strengthening of strategic capacity of actors along the beef VC to respond to COVID-19 challenges. On the one hand, these regulations required cattle farmers to complete livestock removal permits that showed the provinces of origin and destination. These regulations acclimatised the sector to the practical challenges of inter-provincial movement of trucks, workers, and products.

On the other hand, the 2019 FMD outbreak led to a shift to online cattle auctions in lieu of physical auctions. COVID-19 lockdowns accelerated this shift because physical auctions capped their in-person client capacity at 50 to comply with regulations restricting large gatherings. An emergent IT solutions company, swiftVEE (www.swiftvee.com), that hosts real-time livestock auctions on behalf of livestock companies, reported a 400% increase in online-auction bookings by traditional livestock dealers during the lockdowns. By 2021, most large livestock auction houses now offer an online option for auctions through the swiftVEE platform. Interviewees in July 2020 noted however that while online auctions increased, they are not likely to completely replace physical auctions soon.

The lockdowns did not bring major disruptions to the feedlot sector. Feedlots and feed manufacturers dealt with delays of imported feed additives by drawing down their buffer stocks. They dealt with the shortage of weaner calves by cutting back feedlot stocking volumes. Larger integrated cattle farmer/feedlot-abattoirs also slaughtered more older cattle for the local market.

6.1.2 Beef midstream strategies

Abattoirs and meatpackers implemented three main strategies to manage the impacts of the lockdown. First, meatpackers implemented split shifts and social distancing, and trucked in workers. Second, packers sourced carcasses from alternative suppliers when the supply of carcasses from their usual suppliers (or from their vertically integrated abattoirs) was not enough to meet the surge in retail demand in early lockdown as consumers stockpiled beef.

Third, abattoirs and meatpackers reported that 100% of beef destined for the foodservice sector had to be repurposed and sent to alternative channels in early lockdown. Many of the packers added shifts or overtime in the initial spike in retail demand. Products typically destined for the export and local restaurant market (wholesale primal cuts) were sold in local supermarkets and at discounted prices. The repurposing required flexibility in operations and marketing to be able to quickly pivot to alternative products and channels in a short period.

6.1.3 Beef downstream strategies

Even though only 4% of beef is exported, the industry's market differentiation strategy from 2016 to expand beef exports to Asia strengthened the beef value chain's resilience during COVID-19. According to key stakeholders, this strategy counterbalanced the initial reduction of demand domestically for higher-grade beef. Exports did not flag as the Chinese market opened early just as domestic demand was flagging. The fact that exports did not stop meant that over-supply did not occur in the local market due to a shift of exports as occurred in some other countries.

Supermarkets increased their sales through e-commerce in early lockdown. Some online platforms reported a 37% increase in new users (Paterson 2020). Some farmers, abattoirs, and packers retailed to consumers via company websites and social media platforms. During late lockdown home-delivered food also surged as restaurants become operational, albeit constrained by COVID-19 government regulations (South African Government 2020). Some restaurants also reported that they began selling prepared raw meat for consumers to barbecue at home.

6.2 Strategies in the citrus value chain

6.2.1 Citrus upstream and midstream strategies

Farmers and packers trucked in workers on locally hired private trucks. To deal with the challenges of inter-provincial migration of labour, some farmers increased the use of contracted labour (or labour brokerage), to deal with unavailability. But some said they just employed and trained more local workers to replace migrant workers, partly to reduce their workers' risk of disease exposure from migrants; as the Western Cape was thought to be the early epicentre of the disease, workers from the Western Cape were considered more likely to have COVID-19. The Citrus Growers Association published best practice guidelines for the workplace and trained growers and packers in COVID-19 regulations compliance.

Packing plants had been for several years preparing (by adding plant capacity) for the maturing of larger orchards and much more volume by 2020. To avoid congestion and worker density and shortfalls in logistics, packers encouraged growers to harvest early to reduce volumes at the normal peak period. Plants doubled the shifts to reduce worker density, had workers wear masks and wash hands, and installed additional screens between packing lines.

6.2.2 Citrus downstream strategies

The CGA established a COVID-19 response committee and worked with the government and labour. The committee compiled a risk register and list of strategies. The committee helped farmers and packers obtain SPS certificates for exports, lobbied for the continuation of fruit inspection services, and helped the government with daily reports so it could alleviate delays in ports. Transnet (the majority public-owned rail, port, and pipeline company) moved port workers around the ports to reduce work delays. To reduce congestion in the ports and container shortages, there was more use of conventional reefer vessels and reefer freight rail (Meintjies 2020). There was also port substitution to reduce congestion and delays: the CGA's daily port report enabled exporters to divert to the Eastern Cape ports instead of Cape Town at the height of the congestion challenges.

Moreover, packers shifted export destinations to adapt to demand, as well as import countries' changing COVID-19 related regulations. Early lemon and lime exports were concentrated in the Middle East but shifted into Europe from May when Italy and Spain eased lockdown restrictions. Early focus on export of mandarins to the UK shifted to the rest of Europe from June. Grapefruit exports were concentrated in Europe, but significant volumes were shifted into Southeast Asia in early June as that subregion opened, before moving back to Europe. In total, despite all challenges, South African citrus exports reached an all-time record high of 137 million cartons in 2020, which is 17.5 percent higher than in 2019 (Agrihub 2020). Producers selling into open markets through traders had more flexibility to move products between markets, as those delivering into supermarket programmes had commitments to deliver specified volumes. At the same time, those delivering into supermarket programmes faced less risk of changing market conditions. Historic relationships with traders in multiple countries strengthened over time by the challenges brought about by the earlier challenges with regulations around citrus disease (CBS), enabled additional flexibility in marketing decisions.

Also, packers exported more fruit earlier than usual to get it out of the country before it risked being kept in due to movement restrictions. This reduced export fruit prices but the currency depreciation compensated for that. By moving fruit out fast, South Africa defended and even raised its global share in 2020 (relative to 2019) relative to its main competitors, Spain and the US.

Competitors were slowed by COVID-19. For example, Spain, which relies heavily on seasonal workers from North Africa, faced severe labour shortages due to restrictions on international travel (Freshplaza 2020). Exporters such as Egypt diverted additional products into Europe, providing additional competition and price imbalances. Spanish export volumes also increased into Europe, with additional costs as the main logistics channel, trucking, faced movement restrictions and thus higher costs (Netherlands Ministry of Agriculture, 2020; OECD 2020).

6.3 Strategies in the maize value chain

6.3.1 Maize upstream

In the late lockdown, maize was being harvested, and farmers faced both record volumes and logistics constraints. As volumes had been increasing over time, farmers had invested in on-farm storage to market grain directly from the farm to reduce handling costs. This storage became a critical buffer during COVID-19 so that harvesting could continue while farmers were waiting for transportation of their grain to silos and mills.

6.3.2 Maize midstream

Mills responded rapidly to the spike in demand for maize flour by just drawing down excess capacity, as they were running at approximately 80% capacity before COVID-19. Recall the sector is concentrated; they competed for 2019 maize stocks at the start of the pandemic, with a rush created by domestic stocks dipping as South Africa exported maize to Zimbabwe which was low on maize and had dropped its ban on GM maize imports which had increased imports from South Africa. Mills also relaxed their maximum moisture level requirements to take earlier delivery of the new season crop. The additional costs for drying and handling of

maize with a higher moisture content was outweighed by the overall benefits of keeping the supply chains well stocked during the pandemic.

6.3.3 Maize downstream

During the early lockdown, the sharp rise in maize flour sales was by supermarkets and wholesalers because small shops were more constrained by the lockdown. The latter recovered in the late lockdown and human consumption remained high during the full lockdown period. Retailers and millers realised that consumers wanted larger flour packages to compensate for fewer visits to the retail stores and mills increased the package sizes.

Export traders benefitted from the sharp depreciation in the exchange rate. The exports to regional and global markets in 2020 were higher than former years due to the bumper crop and because traders worked around the logistics constraints inland and at the ports.

7. Conclusion

Our paper made seven main points. First, the initial lockdown regulations declared as "essential" the product (vertical) value chains but left as inessential "lateral" value chains delivering labour, materials, and logistics to the segments of the vertical value chains; this appears to have been a common initial government response in other countries as well, such as in Nigeria (see Liverpool-Tasie, Reardon, and Belton 2020). Blocking labour movement hurt labour-intensive operations in vertical value chains, such as in citrus packing plants; blocking forestry and wood product movement hurt crate construction and further hurt citrus packing, for example. This also shows that if a segment's technology is intensive in the factor or material held back by blockages, it is more vulnerable. The problem of "blocking laterals hurts verticals" was resolved later in the pandemic when the government deblocked key laterals.

Second, sectors that dealt with crises before COVID-19 had built capacity for resilience (in "learning by doing") that they brought to bear as resilience in the face of COVID-19. Key examples are: (1) in the beef value chain, domestic FMD (foot and mouth disease) restrictions in prior years trained the industry to work around and work with logistics constraints; (2) in the citrus value chain, frequent international BSD (black spot disease) regulation changes in prior years trained the industry to make rapid adjustments to new structures, in coordinated ways, which came in handy when COVID-19 struck.

Third, redundancy and slack capacity cost a value chain inefficiency in good times but in bad times are valuable for resilience. (This has been found in food supply chains faced with climate shocks; see Reardon and Zilberman 2018.) This was illustrated during the pandemic with South African maize mills quickly increasing flour output from mills that had had capacity under-utilisation before 2020.

Fourth, a value chain's vulnerability is not necessarily conditioned by its degree of complexity (many nodes); rather, the vulnerability of key nodes is what counts for vulnerability of the system, as in the saying "the weak link of the chain". The beef value chain is complex but that complexity per se did not hurt it during the pandemic, nor did most of the firms in the upstream and midstream; what mattered was the ability of linchpin nodes to adjust, such as the segment of auctions under crowd strictures pivoting to e-commerce, and for complementary firms such as e-commerce firms to help the auctions "pivot" (with the

latter illustrated for e-commerce in developing regions in Reardon et al. (2021)). The linchpin or "vulnerability hot spot" can also be a critical infrastructure, such as we discussed for ports that affected all three value chains during the pandemic.

Fifth, sector business organisations promote resilience. We showed that the citrus association gathered information about blockages in lateral value chains and port, told the government, and provided input to the government to rapidly redesign policies. The organisations were also "institutional memory" of past shocks and adaptations such as the livestock and citrus disease travails earlier. Organisations help intra- and inter-segment coordination of firms and farms to respond.

Sixth, timing of policy and business response is critical for several reasons. On the one hand, the relation between when the shock occurs and the business operation cycle of the segment matters; the pandemic hit after not during maize planting so farms were little affected. But the shock hit when citrus farms were harvesting and packing plants operating so they were at first affected, exacerbated by materials and labour constraints.

On the other hand, shocks also build up over time and reverberate over segments. Delays at ports, for instance, accumulated so in the later lockdown ports were more vulnerable. Shocks are also covariate, and the impact is seldom associated with a single, isolated shock.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1 According to the South African legal framework small-scale foodservice firms require a business license (in terms of the Business Act of 1991) and a municipal permit (also known as a health and food safety certificate of acceptability under the Health Act of 1977) to conduct business in the foodservice sector (SME South Africa, 2020).

References

Agostini, J. P., Peres, N. A., Mackenzie, S. J., Adaskaveg, J. E., and Timmer, L. W. 2006. Effect of fungicides and storage conditions on postharvest development of citrus black spot and survival of Guignardia citricarpa in fruit tissues. *Plant Disease* 90, no. 1:1419-1424.

Agricultural Research Council. 2020, May 15. Umlindi report Issue 2020-05.

Agrihub. 2020. Export statistics. https://www.agrihub.co.za/login/.

Animal Feed Manufacturing Association. 2020. Chairman's report 2019/2020. https://www.afma.co.za/download/chairmans-report-2019-20/?wpdmdl=8529&refresh=60224dbb191941612860859

Bank of International Settlements (BIS). 2019. Triennial Central Bank Survey. https://www.bis.org/statistics/rpfx19_fx.pdf.

Battersby, J. 2020. South Africa's lockdown regulations and the reinforcement of anti-informality bias. *Agriculture and Human Values. May* 11: 1.

Baudoin, M., C. Vogel, K. Nortje, and M. Naik. 2017. Living with drought in South Africa: lessons learnt from the recent El nino drought period. *International Journal of Disaster Risk Reducation* 23: 128–137.

Boin, A., et al. 2003. Critical infrastructures under threat: learning from the anthrax scare. *Journal of Contingencies and Crisis Management* 11, no. 3: 99–104.

Bureau for Food and Agricultural Policy (BFAP). 2012. Farm Sectoral Determination: An analysis of agricultural wages in South Africa. Pretoria.

Bureau for Food and Agricultural Policy. 2013. Impact of possible European Union Market Closure to South African Citrus. BFAP. Pretoria.

Bureau for Food and Agricultural Policy. 2016. Policy brief on the 2015/2016 drought. https://www.bfap.co.za/wp-content/uploads/2018/11/BFAP_Drought-Policy-Brief_5-February-2016.pdf.

Bureau for Food and Agricultural Policy. 2020. BFAP Baseline Agricultural Outlook https://www.bfap.co.za/category/baseline/.

Businesstech. 2020. South Africa's take home pay shock – here's how much money people took home in June. https://businesstech.co.za/news/wealth/420736/south-africas-take-home-pay-shock-heres-how-much-money-people-took-home-in-june/.

Citrus Growers Association of South Africa. 2019. CGA annual report. https://c1e39d912d21c91dce811d6da9929ae8.cdn.ilink247.com/ClientFiles/cga/CitrusGowersAssociation/Company/Documents/CGA%20Annual%20Report%202019%20v6%20FINAL.pdf.

Chadwick, J. 2019. SA Won't give up its fight against the EU's intransigence towards citrus products. Daily Maverick. https://www.dailymaverick.co.za/article/2019-01-08-sa-wont-give-up-its-fight-against-the-eus-intransigence-towards-our-citrus-products/.

Delport, M., Louw, M., Davids, T., Vermeulen, H. and Meyer, F. 2017. Evaluating the demand for meat in South Africa: an econometric estimation of short-term demand elasticities. *Agrekon* 56, no. 1: 13–27. DOI: https://doi.org/10.1080/03031853.2017.1286249

Department of Agriculture, Land Reform, and rural Development (DALRRD). 2020. Abstract of Agricultural Statistics. https://www.dalrrd.gov.za/Portals/0/Statistics20and20Economic20Analysis/Statistical20Information/Abstract%202020_organized.pdf.

European Commission Plant Health and Animal Safety. 2020. Interceptions of harmful organisms in imported plants and other objects. https://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt/interceptions_en

Fana, W. 2020. Fruit is ripe but farmers have to contend with COVID-19, labour shortages. City Press. https://www.news24.com/citypress/news/fruit-is-ripe-but-farmers-have-to-contend-with-covid-19-labour -shortages-20200519.

Ferrer, B. 2020. Citrus sales surge as pandemic spurs demand for Vitamin C rich foods. Food Ingredients First. https://www.foodingredientsfirst.com/news/citrus-sales-surge-as-pandemic-spurs-demand-for-vitamin-c-rich-foods.html.

Freshplaza. 2020. Maersk sends refrigerated containers to South Africa. https://www.freshplaza.com/article/9212164/maersk-sends-refrigerated-containers-to-south-africa/#:~:text=Integrated%20container%20logistics%20company%2C%20Maersk,among%20Maersk%20and%20Safmarine%20customers.

Freshplaza. 2020. Spain: Agriculture and its seasonal workers, the new victims of COVID-19 rebound. https://www.freshplaza.com/article/9233268/spain-agriculture-and-its-seasonal-workers-the-new-victims-of-covid-19-rebound/

Genis, A. 2018. Oranges and labour ers: The potential for job creation in the citrus sub-sector of South Africa, Working Paper 54. PLAAS, UWC: Cape Town.

Gouse, M. 2014. Labor impacts. In: Socio-economic considerations in biotechnology regulation, 189-200. Springer, New York, NY, 2014.

Greyling, J.C., and P. Pardey. 2019. Measuring maize in South Africa; The shifting structure of production during the twentieth century, 1904–2015. *Agrekon* 58, no. 1: 21–41.

International Trade Council (ITC). 2020. Trademap database. www.trademap.org. (accessed July 10, 2020).

Jansen, C. 2019. Crisis at South Africa's harbours affecting citrus exports. Freshplaza. https://www.freshplaza.com/article/9123535/crisis-at-south-africa-s-harbours-affecting-citrus-exports/

Liverpool-Tasie, L.S.O., T. Reardon, and B. Belton. 2020. "Essential non-essentials": COVID-19 policy missteps in Nigeria rooted in persistent myths about African food value chains. Applied Economic Perspectives and Policy. Published online Dec28 2020. https://doi.org/10.1002/aepp.13139.

Leahy, E. 2020. Citrus Sales still booming during coronavirus. Fruitnet. http://www.fruitnet.com/eurofruit/article/181595/citrus-sales-still-booming-during-coronavirus.

Meyiwa, A., and M. Chasomeris. 2020. South Africa's port doctrine: dilemmas and the way forward. *Maritime Studies* 2020, no. 19: 179–191. https://link.springer.com/article/https://doi.org/10.1007/s40152-020-00166-2.

Meintjies, F. 2020. South African citrus shows resilience. Fruitnet. http://www.fruitnet.com/eurofruit/article/182405/south-african-citrus-shows-resilience.

National Income Dynamics Study (NIDS) – Coronavirus Rapid Mobile Survey (CRAM). 2020. NIDS-CRAM Wave 1 Questionnaire data. https://www.datafirst.uct.ac.za/dataportal/index.php/catalog/NIDS-CRAM

Netherlands Department of Agriculture. 2020. Spain citrus fruit and the coronavirus domino effect. https://www.agroberichtenbuitenland.nl/actueel/nieuws/2020/03/05/spain-citrus-fruits-and-the-coronavirus-domino-effect.

Organisation for Economic Cooperation and Development (OECD). 2020. OECD Economic Outlook – The world economy on a tightrope. http://www.oecd.org/economic-outlook/june-2020/.

Paterson, G. 2020. COVID-19 fastracks online shopping in South Africa. https://themediaonline.co.za/2020/05/covid-19-fastracks-online-shopping-in-south-africa/.

Phakhati, B. 2020. Is COVID-19 fueling a growing demand for SA's lemons? Business Day. https://www.businesslive.co.za/bd/national/2020-04-20-is-covid-19-fuelling-a-growing-demand-for-sas-lemons/.

Reardon, T., A. Heiman, L. Lu, C.S.R. Nuthalapati, R. Vos, and D. Zilberman. 2021. "Pivoting" by food industry firms to cope with COVID-19 in developing regions: e-commerce and "co-pivoting" delivery-intermediaries. *Agricultural Economics* 52, no. 3. doi:https://doi.org/10.1111/agec.12631.

Reardon, T., and D. Zilberman. 2018. Climate smart food supply chains in developing countries in an era of rapid dual change in agrifood systems and the climate. In *Climate smart agriculture: building resilience to climate change*, eds. L. Lipper, N. McCarthy, D. Zilberman, S. Asfaw, and G. Branca, FAO and Springer: Series on Natural Resource Management and Policy, 52, 335–351.

SAMIC (South African Meat Industry Company). 2018. Executive director: annual report. http://samic.co.za/wp-content/uploads/2019/08/Annual-Report-2018-updated-v5.pdf.

Smoley, R. 2020. The coronavirus and citrus demand. Blue Book Services. https://www.producebluebook.com/2020/04/27/the-coronavirus-and-citrus-demand/.

South African Government. 2020. Disaster Management Act (Act No. 57 of 2002). Regulations issued in terms of section 27(2)() of the disaster management act. Gazette number: 43107. 18 March 2020.

South African Grain Information Service (SAGIS). 2020. Supply and demand estimates. https://www.sagis.org.za/sd_marketing_year.html.

South African Reserve Bank (SARB). 2007. Annual economic report. https://pmg.org.za/committee-meeting/8608/

Stats SA. 2017. Living Conditions of Households in South Africa: an analysis of household expenditure and income data using the LCS 2014/2015. Statistical release P0310. Pretoria: Statistics South Africa Available at: http://www.statssa.gov.za/publications/P0310/P03102014.pdf.

Statistics South Africa. 2020. Quarterly Labour Force Survey – Quarter 1 2020. http://www.statssa.gov.za/publications/P0211/P02111stQuarter2020.pdf.

Truter, M. 2010. Epidemiology of citrus black spot disease in South Africa and its impact on phytosanitary trade restrictions. Phd Thesis. University of Pretoria.

Vermeulen, H. 2020. A balanced food basket approach to monitor food affordability in South Africa. Doctoral dissertation. University of Pretoria.

Wagner, S.M., and C. Bode. 2006. An empirical investigation into supply chain vulnerability. *Journal of Purchasing and Supply Management* 12, no. 6: 301–312.

Wagner, S.M., and N. Neshat. 2010. Assessing the vulnerability of supply chains using graph theory. *International Journal of Production Economics* 126, no. 1: 121–129.

Zestfruit. 2019. Crisis at SA harbors affecting the citrus industry. http://www.zestfruit.co.za/2019/07/13/crisis-at-sa-harbours-affecting-citrus-industry/