Resilience of global and local value chains to the Covid-19 pandemic: Survey evidence from vegetable value chains in Senegal

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Abstract
In this paper we descriptively investigate the Covid-19 pandemic’s early impact on the fruit and vegetable supply chain in Senegal, using trade statistics and survey data collected through online questionnaires and telephone interviews with smallholder farmers, agro-industrial companies, agricultural workers, traders, importers, and consumers. Our results point to major differences in how Covid-19 and containment measures disrupt supply chains between the modern export-oriented supply chain that is centered around a few large vertically integrated agro-industrial companies, and the more traditional domestic-oriented supply chain with a large number of smallholder farmers and informal traders—with the former being more resilient to the Covid-19 shock. We show that both the modern and the traditional supply chain innovate to cope with the Covid-19 containment measures. While our study is subject to some limitations, our findings bring nuance in the debate on the resilience of the food system to the pandemic, and have important policy and research implications toward international trade, social safety measures, and food and nutrition security.

KEYWORDS
Africa, food security, international trade, shocks, supply chain innovations

JEL CLASSIFICATION
Q12, Q13, Q17, Q18

1 INTRODUCTION

The 2020 worldwide Covid-19 pandemic is expected to have severe economic consequences, with a projected contraction of the global economy of 3% (IMF, 2020). Countries in Sub-Saharan Africa (SSA) are expected to be most severely affected, with a simulated drop in Gross Domestic Product of almost 9% (Laborde et al., 2021). The expected global recession is anticipated to result in increased global poverty: the number of additional people in extreme poverty is estimated to be nearly 150 million, of which 80 million would be in SSA (Laborde et al., 2021). Food prices are expected to rise or become more volatile than usual (Ali et al., 2020; Laborde et al., 2020; Reardon et al., 2020; RPCA, 2020) and food insecurity expected to worsen substantially as a result of Covid-19 (Ali et al., 2020; Laborde et al., 2021).

This paper provides an early and descriptive assessment of the consequences of the Covid-19 pandemic on the fresh fruit and vegetable (FFV) supply chain in
Senegal. The recent literature puts forward that the Covid-19 shock and subsequent imposed measures may affect production, supply, and availability of food through disruptions in international trade, through reduced on-farm labor supply, and through related productivity and output decreases (Laborde et al., 2021; Vos et al., 2020). We elaborate on these channels of effects and conceptually discuss how effects may differ across food supply chains with diverse characteristics. We rely on survey data collected through online questionnaires and telephone interviews with different types of stakeholders in FFV supply chains, and on available trade statistics, to empirically describe how FFV supply chains in Senegal have been affected by the pandemic. Our study adds microeconomic empirical evidence to the rapidly emerging literature on the impact of Covid-19 on food systems in developing countries. The specific case of FFV supply chains in Senegal is relevant because an export-oriented modern supply chain and a more traditional domestic supply chain coexist, and because the country is both an exporter and importer of fresh produce (Van den Broeck et al., 2017, 2018). Because of the importance of FFV such as onion and tomato in the local diet in Senegal, effects on FFV chains matter for food and nutrition security in the country. Moreover, our study brings some insights in the broader but scarce literature on the resilience of food supply chains to adverse shocks (Falkowski, 2015; Jacobi et al., 2018; Kangogo et al., 2020; Leat & Revoredo-Giha, 2013; Reardon & Zilberman, 2018; Vroegindewey & Hodobod, 2018).

The remainder of the paper is structured as follows. In the next section we provide a conceptual discussion on the resilience of diverse food supply chains to the Covid-19 shock, and its implications for the Senegalese FFV supply chains. In section three we first provide background information on the Covid-19 situation and related measures in Senegal, and on the different FFV production and marketing seasons in the research area. Next, we describe our data collection methods, data analysis, and limitations of our study. We present our descriptive results in section four and discuss these in section five.

2 | CONCEPTUAL DISCUSSION

2.1 | Supply chain resilience to Covid-19 pandemic

Based on recent literature (Vos et al., 2020), we can identify three channels of effects through which the Covid-19 pandemic affects food supply chains. A first effect is through disruptions in international trade, stemming from an increase in trade costs due to restrictions in international mobility and quarantine measures, or stemming from trade policy measures, such as export taxes and bans, in response to the crisis. A second effect is through a decline in on-farm labor, stemming from workers being unwilling or unable to work due to containment risk and various containment measures, leading to reductions in land productivity and declining agricultural output. A third effect is through a decline in productivity and farm output, caused by disruptions in distribution channels and in the provision of capital inputs and services. Effects likely differ with the type of product, and the structure and organization of supply chains.

Reardon, Bellemare, et al. (2020) draw a distinction between traditional, transitional, and modern food supply chains: the size of production and distribution units, the capital-intensity of operations, the level of vertical coordination, the length of the chains, and its level of integration in international markets increase from traditional over transitional to modern supply chains. The resilience to the Covid-19 pandemic might differ substantially between these supply chains (Reardon, Bellemare, et al., 2020; Reardon & Swinnen, 2020). As traditional and transitional supply chains are less integrated in international markets on the output side and oriented more toward production for domestic markets, they might be less affected by international trade disruptions. Traditional and transitional food supply chains typically include a mix of small-scale family farms and medium-sized production units, and small to medium-sized traders. While small farms and trading enterprises use more labor-intensive production and distribution methods, they often rely mainly on family labor. This might make them less vulnerable to Covid-19 induced reductions in labor availability. Yet, even family labor might become unavailable, for example, due to illness of family members or inability of family members to return from places of temporary migration to the family farm. Medium-sized enterprises might be hit harder by reduced labor availability as they rely more intensively on hired labor, whose availability is more severely affected by containment measures and mobility restrictions. Disruptions in the provision of capital inputs and in distribution channels might more severely affect transitional supply chains and medium-sized production units because of more capital-intensive production methods, a more pronounced commercial orientation and more distant market outlets in these chains. Small farms in traditional supply chains might be less affected through this channel if they sell produce in local village markets. Yet, traditional supply chains include poor farmers, who might revert to food-first strategies when the risk related to commercial production increases due to disruptions in distribution channels. Moreover, poor farmers may not be able to overcome short-term losses or reduced farm...
incomes, and, hence, may be forced to sell land or nonland assets, jeopardizing future production.

Modern supply chains, being more complex and highly integrated in international markets, are likely to be impacted by international trade disruptions or a possible global recession. The consequences of the Covid-19 pandemic could be massive for export and import enterprises when borders close, trade costs soar, or demand for export goods decreases. Vos et al. (2020) and Laborde et al. (2020) predict effects through this channel to be most severe for developing countries with a strong dependence on international trade, such as most African countries. Arouna et al. (2020) specifically point to a large impact in the West-African rice supply chain, that heavily depends on imports. Modern supply chains include large-scale and agro-industrial companies that rely on more capital-intensive production methods, which makes them more vulnerable to supply chain disruptions. High-value supply chains of fresh produce and produce of animal origin are particularly vulnerable to disruption in distribution channels because of the high perishability of these products. Yet, a higher level of vertical coordination and a better organization of exchange in these supply chains might reduce this vulnerability. Mobility restrictions and containment measures might be biased toward less formal ways of transport and more personal ways of exchange, and thereby affect spot market transactions of small traded volumes (in traditional supply chains) more than agreed transactions of larger volumes (in modern supply chains). Further, large-scale agro-industrial companies rely on hired labor, unskilled as well as skilled labor. A Covid-19 induced reduction in the availability of labor might be specifically harmful for these companies, especially for labor-intensive production as is the case in vegetable supply chains (Hobbs, 2020; Minten et al., 2020), and especially in case agro-industrial companies heavily depend on migrant labor. While modern supply chains might be more severely affected by Covid-19 triggered disruptions, the more capitalized companies in these chains might be better able to overcome short term losses, and might be better able to respond to shocks and mitigate the impact through innovations (Reardon & Swinnen, 2020).

2.2 Fruit and vegetable supply chains in Senegal

Two FFV supply chains coexist in Senegal: (1) a modern, vertically coordinated, high capital- and labor-intensive supply chain, producing for both the export and the domestic market, and (2) a traditional, high labor-/low capital-intensive, domestic supply chain. The structure of the FFV supply chain in Senegal, drawing a distinction between the export and the domestic market, and the traditional and the modern supply chain, is depicted in Figure 1. At the upstream end, the traditional supply chain is dominated by smallholder farmers. The most common way produce reaches the domestic market is through a web of small to medium-scale itinerant traders or “bana-banas” and small wholesalers who buy produce at the farmgate or at rural assembly markets and transport it to larger urban wet markets (in Dakar, Touba, Saint-Louis) or to more remote regions in the South of the country. Within urban areas, smaller (street) retailers, grocery shops, and the food services industry source produce from these wet markets. Also, for consumers, at the downstream end of the supply chain, wet markets are the main FFV outlet. While the domestic FFV supply largely remains traditional, some modernization is ongoing. At the upstream end of the domestic supply chain a few medium- and large-scale agro-industrial companies entered the market in the last decade. They mainly supply the domestic market through medium-scale, well-organized traders, and wholesalers. In addition, since a few years modern supermarket chains—such as Auchan and Casino—are spreading in Senegal’s cities, especially in Dakar. They offer a wide range of fresh products at competitive prices, and attract customers of various social backgrounds, not exclusively the more affluent. Nevertheless, the market share of these supermarkets is still much smaller than the traditional wet markets. FFV imports are controlled by a small number of importing companies, almost all located in Dakar. Imported produce (mostly onions, potatoes, carrots, and garlic) reach wet markets and consumers throughout the country by means of the “bana-bana” traders. The modern export supply chain is organized around a few large capital-intensive agro-industrial companies who produce, process, and export produce. Contract farming with smallholder farmers exists for mangoes (and a little bit for green beans) but the overall trend of the past 15–20 years in the export supply chain is toward greater consolidation, industrialization, and complete vertical integration of production and export. Export companies mainly sell directly to overseas importers, but in recent years, when prices in the domestic market are favorable due to seasonal import bans, they also sell to domestic traders and local supermarkets.

In line with the general conceptual discussion above, we hypothesize that traditional supply chain actors—such as smallholder farmers, small informal traders, and wet market vendors—might be more affected when labor and product markets are disrupted. Especially mobility restrictions might hinder traditional supply chain continuity, because of its inherent poor organization and dependence on public transport. Modern supply chain actors—such as large-scale export companies and traders—might be more affected through international market disturbances, as
3 | METHODS

To describe the implications of the Covid-19 pandemic on the FFV supply chain in Senegal, we rely on a before–after comparison informed by the course of events in terms of Covid-19 measures in Senegal. This is not perfect and limited by the seasonality in FFV production. We first give some background information on these issues, and then describe the methods and associated limitations.

3.1 | Background

Until October 30th, 2020, Senegal has reported 15,605 positive Covid-19 cases and 323 deaths. The first confirmed Covid-19 case reported on March 2nd, 2020 triggered a range of policy measures to prevent the spread of the virus. On March 23rd, 2020 the state of emergency (l’état d’urgence) was declared, followed by a range of other measures (Table 1). Transport was significantly restricted, both between and within regions and cities, wet markets were regularly closed for not complying with the rules or for complete sanitation, and shops were required to limit opening hours. The government started to relax some measures to reopen the economy as of May 12th, 2020, even though the total number of cases continued to rise. Since the beginning of September 2020, less than 50 new cases are reported each day and the total number of infected people is decreasing fast. Except from face masks and distancing measures which remain mandatory in shops, public places, and transport, all other restrictions have been removed. Since the beginning of the Covid-19 crisis in Senegal, both the government and international institutions promised financial and food aid. In March 2020, the Senegalese government created a Response and Solidarity Fund “Force Covid-19” to deal with the impact of Covid-19. The fund is planned to be endowed with 1,000 billion FCFA (approximately 1.5 billion euros) through state and donor funding. A food aid distribution operation was launched to help 1 million vulnerable households and the state declared to pay the energy bills (electricity and water) of almost 1 million households.

The main FFV production zones in Senegal are: (1) the Niayes region, a long and narrow coastal area stretching between Dakar and Saint-Louis, and (2) the Senegal River region in the North of the country. These two zones produce FFV for the domestic market, mostly tomatoes and onions, and for the export market, mostly (cherry) tomatoes, green beans, and mangoes. For the most important horticultural crops, an overview of different export,
TABLE 1  Covid-19 measures in Senegal

| Date       | Measure                                                                                   |
|------------|--------------------------------------------------------------------------------------------|
| Installment of measures                      |                                                                                           |
| 14/03/2020 | Closure of schools and universitiesPublic events are forbidden                            |
| 16/03/2020 | Suspension of all in and outbound flights from western Europe                             |
| 20/03/2020 | Closure of airspace                                                                       |
| 23/03/2020 | Declaration of state of emergency                                                          |
|            | Installment of curfew                                                                      |
|            | Regional transport restrictions                                                             |
|            | Creation of solidarity fund                                                                |
| 24/03/2020 | Interurban transport restrictions                                                           |
| 17/04/2020 | Face masks mandatory in public administration services, private sector services,          |
|            | commercial places and on all types of transportation                                       |
| Relaxation of measures                        |                                                                                           |
| 12/05/2020 | Relaxation of curfew                                                                      |
|            | Markets and shops can open for 6 days a week                                               |
|            | Reopening of weekly markets                                                                |
|            | Religious and educational events allowed                                                   |
| 04/06/2020 | Suspension of interregional travel restrictions                                           |
| 07/06/2020 | Suspension of interurban transport restrictions                                            |
| 15/06/2020 | Resume domestic air travel                                                                  |
| 30/06/2020 | Suspension of curfewSuspension of state of emergency                                       |
| 15/07/2020 | Resume international air travel (land and sea borders remain closed until further notice) |
| 23/09/2020 | Suspension of passenger limitation on public transport                                     |

Source: Senegalese government website (https://www.sec.gouv.sn/).

FIGURE 2  Timeline of horticultural production seasons and period of data collection. (Source: authors’ construction) [Color figure can be viewed at wileyonlinelibrary.com]

import, and domestic harvest and marketing seasons are presented in Figure 2. The main FFV export season runs from December to the end of April, when there is a large demand for off-season vegetables in the EU. From June to August there is a second, but smaller peak of mango exports. Domestic production of vegetables is seasonal as well but differs by crop and by region. The main harvesting season takes place from February to May, when the bulk of onion, potato, carrot, and tomato production reaches the domestic market, and prices often drop. Later in the
year, during the *hivernage* or rainy season, mangoes and watermelons are widely available, in addition to onions and other vegetables from a smaller second harvest season. Imports of FFV are concentrated in the period August to January, when domestic production is low. Since 2003 the Senegalese government implements seasonal import bans and other trade restrictions for onion, potato, and carrot to boost domestic production and protect it from relatively cheap, but high-quality imports from Europe (David-Benz & Seck, 2018). The timing of these seasonal import bans largely coincides with the main domestic harvest season, from end of January, until end of August or beginning of September.

### 3.2 Data collection and analysis

We use primary survey data complemented with secondary data on international FFV trade flows to and from Senegal. Monthly trade statistics, available until June 2020, are sourced from the International Trade Center’s TradeMap (ITC Trade Map, 2020). We collected primary survey data from all relevant actors in the FFV supply chain in Senegal, including farm and agro-industry workers, smallholder farmers, traders (bana-banas, and small and larger wholesalers), medium and large-scale agro-industrial companies, importers, and consumers (Table 2). Data were collected from mid-April to mid-June 2020, using both phone interviews and self-administered online questionnaires. Two trained local enumerators implemented phone interviews with workers, smallholder farmers, traders, and importers. In addition, agro-industrial companies and importers were directly contacted to fill in an online survey. Consumer interviews were conducted online as well, on a voluntary basis by the respondents themselves using Qualtrics software. The consumer survey was promoted both on social media (through various Facebook groups) and by email within the social and professional networks of local partners. For most actor groups contact details were sourced from the authors’ previous data collections in the two main FFV producing areas in Senegal, the Niayes region and the Senegal River Delta region, and sometimes complemented with additional contacts obtained through snowball sampling or various online sources.

All surveys started with a common demographics section, followed by multiple actor-specific sections. We enquired about food consumption (consumers) and food insecurity\(^1\) (consumers and workers); labor (workers, smallholder farmers, and agro-industrial companies); agricultural inputs (smallholders farmers and agro-industrial companies); and prices and transactions (smallholder farmers, agro-industrial companies, and traders), among other issues. Questions were built around the declaration of the state of emergency (*l’état d’urgence*) on March 23rd, allowing us to compare the situation before and after the start of the Covid-19 crisis.

We use descriptive statistics to highlight the early consequences of Covid-19 on the Senegalese FFV supply chain by focusing consecutively on effects at the level of international trade, production, consumption, and domestic trade. We believe that our sample of smallholder producers, traders, agro-industrial companies, and importers is representative to capture the situation of the FFV export and import chains in Senegal as well as the domestic FFV chain that originates from the two main horticultural regions in the country. Our sample of workers is somewhat biased toward agro-industry workers while hired workers on smallholder farms are underrepresented (5 out of the 51 interviewed workers). Our data allow to reveal how farms have been affected through Covid-19 induced changes in labor availability but do not allow to draw conclusions on the implications for hired workers. We have a more

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\(^1\) We measure food insecurity with the Household Food Insecurity Access Scale (HFIAS) developed by the Food and Nutrition Technical Assistance (FANTA) program of USAID (Coates et al., 2007)
problematic bias in the consumer sample, including mostly highly educated urban consumers. Hence, we cannot draw conclusions on changes at the consumption side of the FFV supply chains in Senegal or on the food and nutrition security implications of changes in the FFV supply chain.

3.3 | Limitations

Agriculture is inherently seasonal. As we do not have access to time-series agronomic and socioeconomic data to correct for seasonal variation, we must interpret the results with some caution. We are not able to completely disentangle Covid-19 related impacts from seasonal variation. The first months of the Covid-19 crisis ran parallel to the end of the export season (except for mango) and the harvesting season of vegetables for the domestic market. During this harvesting season, domestic supply of onion, potato, and other vegetables increases and prices often decrease. In the interpretation of our results, we need to take into account that quantities are likely to increase and prices likely to decrease in the period after the declaration of the state of emergency because of seasonal variation, and thus that observed changes cannot always be attributed to Covid-19 impacts.

To compare the situation before and after the declaration of the state of emergency, we use recall questions. While recall questions are commonly used in surveys, they are prone to bias as the accuracy of respondents’ memories cannot be controlled for. One the one hand, our data might suffer from recall bias as we ask for very specific transactions that date back to up to four months before the survey. Such details might be hard for respondents to remember accurately. On the other hand, bias might still be limited. Several scholars indicate that there is little proof of recall bias for cash crops that are harvested over short periods of time at specific moments of the year (Beegle et al., 2012; Carletto et al., 2013). In our case, events are recalled that happened a maximum of four months before the survey, the recall period is linked to a very specific and important event that everybody is aware of (the installment of the state of emergency), and the survey asks for quantitative information about the production and marketing of high value cash crops and other important aspects of respondents’ daily life—which may refresh respondents’ memory. In addition, our analysis relies on a comparison of events right before and right after the state of emergency. If recall bias in the data runs in the same direction for the two sets of events, the comparative analysis may partially reduce bias in the data.

While online surveys and phone interviews allowed us to rapidly collect relevant data from a large variety of actors in the supply chain (during lockdown or otherwise), both the quantity and quality of such data are limited, as these methods are prone to some weaknesses (Alvi et al., 2020; Himelien et al., 2020). In order to not fatigue and “lose” respondents, we kept the online surveys and telephone interviews short (i.e., 10–15 min). The resulting survey data as well as the analysis are hence not very detailed. This remote data collection was only possible owing to an extensive research experience in the FFV sector in Senegal. This is important as not knowing the research area or not being able to experience the local situation firsthand, could lead to difficulties in collecting data and in bias in interpreting data and statistical results. Knowing the FFV sector in Senegal very well, we are confident about the robustness of the data collection, analysis, and interpretation. In addition, the secondary trade statistics we use are limited as well, as they do not yet cover a large enough period of time after the start of the pandemic to be able to observe changes in trends in the medium to long run.

4 | RESULTS

4.1 | International trade

The start of the Covid-19 crisis coincides with the end of the main FFV export season in Senegal and with the low-season for FFV imports (Figure 3). FFV export volumes during the first half of 2020 are very similar to preceding years. While exports in April 2020 are 11% lower than in April 2019, they are still higher than exports in April 2016 and 2017. FFV import volumes of March and April 2020 are less than half compared to those in March and April 2019, but already in February 2020, before Senegal was hit by the Covid-19 crisis, imports were substantially below those of the preceding year. Moreover, FFV imports in this period are influenced by irregular import bans in Senegal. The trade data show no clear indication of major implications for FFV trade volumes in the first months of the crisis. Also available trade statistics for agricultural inputs do not show major changes in imported agricultural inputs in this period (ITC Trade Map, 2020).

The majority of surveyed export-oriented agro-industrial companies continued their export activities but do indicate to export smaller volumes since the

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2 See for example recent studies by Bernard et al. (2017); Hirvonen et al. (2021).

3 See for example the papers of Colen et al. (2012); Fabry et al. (2020); Feyaert et al. (2020); Maertens et al. (2011); Maertens, Minten & Swinnen (2012); Maertens & Swinnen (2009); Van den Broeck & Maertens (2017); Van den Broeck et al. (2016, 2018) and Van Hoyweghen et al. (2020).
Covid-19 crisis because of a declining demand from their overseas clients. Only a few smaller companies temporarily suspended all export activities. Three-fourths of the interviewed importers did not import FFV since mid-March 2020, which more likely relates to the end of their import season, and possible import bans, than to the Covid-19 crisis. Import and export companies that continued international trade activities experienced delays in transactions and in transport by air cargo, as well as by boat or truck. Smaller companies point to more severe customs procedures and commercial restrictions in the European Union, hindering their export activities.

### 4.2 Production

At the supply side of the FFV chains, the Covid-19 pandemic and containment measures in Senegal may affect production activities through changes in the allocation and productivity of land, labor, and capital inputs. We consecutively discuss these effects.

Large export-oriented companies indicate to not have changed their production area, nor their crop mix of fruits and vegetables targeted to the international market. Yet, the majority of smaller companies indicate to have reduced the size of their FFV production area, by 50%–75%, because of the crisis. Also, smallholder FFV farmers producing for the domestic market, drastically decreased their FFV production area. The summary statistics in Table 3 indicate that 25% of the interviewed farmers left land completely fallow during the hot dry season, for which preparation more or less coincides with the start of the Covid-19 crisis. Only 15% of the farmers in our sample actually started new horticultural production in the months after the declaration of the state of emergency (while during the cold dry season, 83% of the sampled farmers grew FFV and allocated on average 1.65 ha to this). These farmers use on average 0.59 ha for FFV production while they indicate they

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**TABLE 3** Land allocated to horticultural production for three growing seasons

|                                | Mean    | Mean hypothetical scenario without Covid-19 | Number of farmers |
|--------------------------------|---------|---------------------------------------------|-------------------|
| Total land (ha)                | 4.44    |                                             | 102               |
| Left land fallow (1/0)         | 0.25    |                                             | 102               |
| **Land under production (conditional on producing in particular season)** |         |                                             |                   |
| Cold dry season (ha)           | 1.65    |                                             | 85                |
| Hot dry season (ha)            | 0.59    | 1.10                                        | 15                |
| Rainy season (ha)              | 0.65    | 0.91                                        | 41                |

Source: authors’ derivation from smallholder farmer survey data.

*Respondents were asked about the size of the land they would have allocated to horticultural crops, if the Covid-19 pandemic would not have taken place.

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**FIGURE 3** Evolution of fruit and vegetable exports and imports, in million kg, in Senegal, 2016–2020. Fruits and vegetables include the following product categories: 07 (edible vegetables and certain roots and tubers) and 08 (Edible fruits and nuts) (Source: ITC Trade Map, accessed October 2020) [Color figure can be viewed at wileyonlinelibrary.com]
would have allocated on average 1.1 ha under normal circumstances. Also, for the rainy season, farmers seem reluctant to cultivate horticultural crops. Only 40% of the farmers intend to allocate land to horticultural crops during the rainy season, with an average planned acreage of only 0.65 ha. Almost one-fifth of the farmers who will not grow horticultural crops, are planning to grow groundnuts or staple crops such as millet. This is in line with evidence on shock-driven shifts away from perishable cash crops to less perishable and staple crops in SSA (Salazar-Espinoza et al., 2015). The observed land allocation changes could have important repercussions on the availability of fresh produce in domestic markets and for own consumption by rural households, which may result in food and nutrition security impacts in the medium run.

Smaller agro-industrial companies and the majority of smallholder farmers (80.4%) indicate to face important restrictions to hire workers. Mobility restrictions make it difficult for agricultural workers to commute. Moreover, workers are scared, either to be caught and fined for breaking mobility regulations or to become infected at the workplace or during commuting. Larger agro-industrial companies report no problems with the supply of labor. These companies overcome worker constraints by investing in protective masks and gloves, in training on sanitary measures, in creating conditions for social distancing between workers in the field and in processing units, and in a larger or more frequent commuter bus service capacity for their workers—a service that many large companies offer to attract workers. Nevertheless, in all agro-industrial companies the demand for labor reduced because activities reduced, particularly in conditioning stations. This reduction ranges from 20% to 90% of the normal workforce across the companies. Extra social protection laws put in place by the government, prohibit employers to lay-off or dismiss workers during the period of Covid-19 containment (except in case of gross negligence). Yet, many agro-industry employees are casual day-to-day laborers (Maertens, 2009; Van den Broeck et al., 2017) for whom such protection laws might be less effective. Our data show that 66% of the sampled agro-industry workers were employed both before and after the declaration of the state of emergency, but 45% of them work less frequently than before the declaration, and that only 29% of those workers who stopped working since the declaration indicate the crisis to be the main cause. Moreover, we find no changes in wages and contracts of workers since the start of the crisis.

Access to agricultural inputs such as seeds and agrochemicals is a major constraint for smallholder farmers. In general, 82% of the sampled smallholders indicate that since the declaration of the state of emergency they encounter problems to buy inputs, mainly because of mobility restrictions (90.5%), closed shops (45.2%) and lower availability of vendors (15.5%), or increased input prices (10.7%). Also, cash constraints play a role for smallholder farmers. The large majority (75.9%) of farmers who did not start a new growing season in the months after the declaration and more than half of the farmers (57.4%) who are not planning to produce FFV in the main rainy season, indicate to lack cash to buy the necessary inputs (seeds, fertilizer, etc.). Also, smaller agro-industrial companies face problems accessing inputs. They indicate that both national and international suppliers of inputs reduced or stopped their activities, and that mobility restrictions inhibit an adequate input supply. Two companies specify a price increase of agricultural inputs, while another company reports the use of an expensive emergency air freight shipment of inputs that were depleted in the local market. The largest agro-industrial companies however, do not experience input related problems because they have enough input stocks, because they have direct buying relations with international input dealers, or because they are able to switch between input suppliers in case of delivery problems. In general, agro-industrial companies report to have input stocks to work at full capacity for three up to 16 weeks, with larger stocks in larger companies.

### 4.3 Consumption

Our data, despite not being representative for the downstream segment of the supply chain, do suggest that the demand for FFV reduced since the start of the Covid-19 crisis in Senegal. Figure 4 shows that 14% of sampled consumers consume less meals per day since the crisis. Figure 5 shows that diets changed: 29% of consumers indicate to have reduced the amount of rice consumed, 41% reduced vegetable consumption, and 47% reduced fruit consumption–15% reduced fruit consumption to a large extent. These figures point to important Covid-19 induced changes in consumption but likely severely underestimate these changes. Our sample is biased toward urban and highly educated respondents, who are more likely to have a lower income elasticity and a lower price elasticity of food consumption, especially for more expensive food categories such as fruits and vegetables. Changes toward less FFV in diets might be much more pronounced among less affluent consumers. A reduction in local demand for FFV is confirmed by data from supply side actors, including smallholder farmers, traders, and agro-industrial companies.

### 4.4 Domestic trade

With the declaration of the state of emergency, the Senegalese government restrained the activity of (and
sometimes even closed) local wet markets to contain the spread of the virus. Moreover, they imposed transportation restrictions within and between regions, cities, and urban–rural axes. In doing so, they cut off consumer, producers, and traders from their usual FFV sales outlets. The results show that the likelihood of consumers to buy fruits and vegetables in local wet markets reduced by 8 percentage points since the declaration of the state of emergency (Figure 6) and the likelihood of smallholder farmers to sell produce in village and town markets reduced by 58 and 30 percentage points, respectively (Figure 7). We find that in rural markets, FFV trade is more likely to happen at the farm gate, while urban consumers increase shopping online.

The large majority of traders indicate that the emergency measures make it very difficult (if not impossible) to transport produce between and within regions, while this is the main way of living for traders. This is confirmed by smallholder farmers, who reduce FFV sales to traders and other intermediaries (Figure 8). Figure 9 documents how the volumes that traders commercialize decreased in the two weeks after the declaration of the state of emergency (compared to the two weeks before): purchase volumes dropped from 7.3 to 4.9 tons, and sales volumes from 6.7 to 4.4 tons on average. As we expect traded volumes at the start of the harvest season to increase, these differences are likely underreporting Covid-19 related trade reductions.

Figures 10 and 11 depict producer sales prices, and trader sales and purchase prices, before and after the start of the Covid-19 crisis. There is a significant decrease in producer and trade prices after the declaration of the state of emergency. As we expect prices to decrease when produce arrives in bulk on the market at the start of the harvest season, it is difficult to attribute the observed price reductions completely to the impact of Covid-19. However, the markup of traders does not change. The reduced income reported by traders is mainly driven by the lower volumes and increased cost of transportation, caused by closed markets and mobility restrictions. Smallholder farmers indicate that the lack of decent storage for their perishable products forces them to sell at an inferior price. Traders have a much better access to storage facility, which likely contributes to the stable markup of traders.

The large majority of smallholder farmers (80%) indicate that they have experienced increased postharvest losses since the declaration of the state of emergency. Due to a lack of storage capacity and the perishability of produce, disruptions and delays in transactions stemming from containment measures, result in losses at the farm gate. Only 10% of sampled traders report an increase in losses, which likely relates to their access to storage (78.5% of traders have access). The same holds for the importers and agro-industrial companies who do not report increased losses. Still, almost all importers indicate to have sold large shares of their produce at inferior prices, half of the export companies report longer storage periods than usual, and some companies sold export quality produce on the domestic market or donated produce to food aid programs in order not to waste it.

The results show that the crisis has stimulated innovations in the supply chain, as depicted by the red arrows on Figure 2. To adapt to the new reality, traders, and to a limited extend also smallholder farmers, increasingly use online platforms for the marketing of their products (Figure 12), and urban consumers increasingly rely on online shopping. These platforms reduce the need of traders to travel the country, and the number of face-to

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4 Differences significant at the 1% significance level.
5 We enquired about sales and purchase prices of the crop that contributes most to their revenue. These are mainly onions and bell peppers for smallholder farmers, and onions, bell peppers and potatoes for traders.
6 We use two-sided t-tests. Significant at the 10% significance level for producer sales prices, and at the 1% significance level for trader purchase and sales prices.
-face encounters, as they are able to link up with potential suppliers and buyers, and agree on quantities and prices, online. The move toward online buying and selling of FFV presents itself in many different forms and is part of a larger trend of increasing e-commerce (although the market is still assumed small), from informal advertising by small-scale traders and smallholders via different social media channels (Facebook and WhatsApp groups) and specific trading fora\(^7\), to well-built webshops by local small- and medium-sized enterprises (e.g., Niokobok, Yonutol, or Soreetul), and more established international e-commerce platforms (e.g., Jumia or Auchan’s webshop). One online food company experienced a doubling of demand for fruits and vegetables in April 2020 and had

\(^7\)For example: [http://shop.mlouma.com/](http://shop.mlouma.com/) or [www.espaceagro.com](www.espaceagro.com)
to hire 25 people extra to keep up with demand (Reuters, 2020).

5 | DISCUSSION AND CONCLUSION

We find major differences in how Covid-19 and containment measures disrupt supply chains between the modern export-oriented FFV supply chain that is centered around a few large vertically integrated agro-industrial companies, and the more traditional domestic-oriented FFV supply chain with a large number of small producers and traders. In line with the hypotheses of Reardon and Swinnen (2020), the results show that the former is more resilient than the latter. As put forward in the conceptual discussion, this relates to the supply chains’ export- versus domestic-orientation, size of operation, level of vertical coordination and ability to innovate.

First, our data reveal that during the first months of the crisis, the export-oriented supply chain is less severely affected, while the domestic-oriented supply chain is more severely disrupted by the Covid-19 crisis. While we find some anecdotal evidence of reduced overseas demand, and increased transport delays, customs procedures, and commercial restrictions, the majority of the export-oriented companies continued their export activities. Yet, the domestic FFV supply chain has been affected more severely by the containment measures, especially by mobility restrictions and closure of wet markets. Others also document severe supply chain disruptions. Hirvonen et al. (2021) show that vegetable supply chains in Ethiopia were affected by international as well as interregional trade disruptions, resulting in higher prices for farmers usually competing with international and regional imports, and lower prices for farmers usually supplying other regions—and thereby creating winners and losers among domestic farmers. Yet, if global supply chains are more resilient to the Covid-19 shock than domestic supply chains, international trade could contribute to mitigating the short-term global food security impacts of the Covid-19 pandemic (Glauber et al., 2020; Torero, 2020a), in the same way as international trade has been documented to be crucial in limiting the long-term global hunger consequences of climate change (Janssens et al., 2020).

Second, the results show that small-scale enterprises are more severely affected than large-scale enterprises. While both large- and small-scale FFV production is labor-intensive, we find that smallholder farmers are most affected by decreasing availability of on-farm labor. Agro-industrial companies overcome labor availability disruptions by providing protective gear, doubling the number of shifts (halving the number of laborers per shift) and increasing the number of shuttle buses. These findings can be put in perspective to the findings of Minten et al. (2020), who show that smaller vegetable farms in Ethiopia are less affected by the Covid-19 situation.
than medium-sized farms because they rely less on hired labor. Covid-19 disruptions in the availability of farm labor may increase with farm size due to increased use of hired labor (as hypothesized by Reardon, Bellemare, et al. (2020) but decrease again if economies of scale are reached in re-organizing labor to adapt to containment measures. In addition, our findings nuance the hypothesis of a possible inflow of (family) labor due to urban–rural
migration (Reardon et al., 2020). Horticultural regions in Senegal (and other countries) receive migrants from other rural regions with a lower labor productivity (Fabry et al., 2020; Van Hoyweghen et al., 2020). A Covid-19 triggered rural-rural migration in the opposite direction is observed, reducing agricultural labor productivity overall. In addition, labor productivity decreases when access to capital inputs (seeds, agro-chemicals) is disrupted, which is more pronounced on small-scale farms. Qualitative data from local farmer organizations point to similar findings of smallholder farms facing more difficulties in marketing output, hiring labor, and accessing inputs during the state of emergency (IPAR, 2020).

Third, a higher level of vertical coordination plays a role in explaining the resilience of the FFV chains to the Covid-19 pandemic. The low level of organization and the more informal transactions, lead to a larger impact of mobility restrictions in the traditional FFV supply chain. The closure of shops and wet markets impedes smallholders’ access to capital inputs and marketing outlets. As small-scale enterprises do not have the means to invest in stocks of capital inputs or adequate storage facilities, containment measures lead to reduced productivity and increased crop losses. In the modern FFV supply chain, agro-industrial companies and large traders have formal agreements and private transport possibilities, facilitating continued marketing even in a constrained environment. Moreover, large-scale companies have the financial power to invest in stocks of capital inputs and cold storage rooms—a proved supply chain risk mitigating strategy (Sheffi & Rice Jr., 2005)—making them less vulnerable to disruptions in distribution and marketing channels.

Fourth, we find that the export-oriented FFV supply chain in Senegal is more resilient to the Covid-19 shock because of the capacity of large vertically integrated agro-industrial companies to invest and innovate in order to adapt to the measures and continue operations. This is in line with the literature on supply chain innovations emerging from capital-intensive large-scale companies (Jacobi et al., 2018; Reardon et al., 2019; Swinnen, 2007; Swinnen & Maertens, 2007) and on Covid-19 triggered supply chain innovations (Hawkes, 2020; Hobbs, 2020; Pu & Zhong, 2020; Reardon & Swinnen, 2020). We find that agro-industrial companies reorganize labor to overcome mobility restrictions, and adapt to social distancing and sanitation obligations. Yet, the traditional domestic FFV supply chain innovates with increased online marketing. While the seeds were sown for e-commerce before the crisis—through an active promotion by the government and installment of a legal framework (UNCTAD, 2020)—the Covid-19 crisis accelerated its use, owing to the country’s telecom infrastructure and relatively high phone, Internet, and smartphone penetration.8 Similar findings on a Covid-19 induced spread of e-commerce are reported by others (Dou et al., 2020; Hobbs, 2020; Kazeem, 2020; Lal, 2020).

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8 Already in 2017, 10% of the population used the internet to pay bills or shop online (World Bank, 2020).
FIGURE 12  Traders’ use of online platforms for buying and selling fruits and vegetables, before and after the declaration of the state of emergency. Source: authors’ derivation from traders survey data [Color figure can be viewed at wileyonlinelibrary.com]

2020; Leesa-Ngansuk, 2020; Narayanan, 2020; Tandon, 2020). However, these online platforms might not have supported smallholder farmers much to cope with the Covid-19 shock, and might not persistently spread when restrictions ease. The perishability of FFV and the lack of quality standards in Senegal increases consumers’ need to assess product quality firsthand.

Our findings and resultant nuances in the debate—while case-specific for the Senegalese FFV supply chain—have some important policy and research implications. The stronger disruptive impact and the lower resilience found in more traditional food supply chains imply that developing countries will be affected more severely by the Covid-19 crisis. Traditional and transitional food supply chains are most prevalent in the poorest countries, and most important in their domestic food sectors (Feyaerts et al., 2020; Reardon et al., 2019). Especially the disruption of domestic food production and supply, rather than international trade effects, might reduce food availability in poor countries and cause additional food insecurity and hunger in the aftermath of the Covid-19 pandemic. Mitigating this food security impact requires support to domestic food production—for example, through installment of green passage lanes for food products during mobility restrictions—and attention to smallholder farmers in Covid-19 related financial aid programs in developing countries (Laborde et al., 2021; United Nations, 2020). In addition, our observation of a Covid-19 induced shift from high-value FFV production to lower value staple and cash crops among smallholders might imply a reduced availability of more nutritious food, such as fruits and vegetables—as evidenced for Ethiopian consumers by Hirvonen et al. (2020). Consequently, not only the accessibility of FFV is a concern (Harris, 2020), but also its availability may become a concern in the short to medium run (Torero, 2020b)—and likewise, not only food security but also nutrition security may become a concern (Jayawardena & Misra, 2020).

Our study on the early consequences of the Covid-19 pandemic on food supply chains in developing countries is constrained by the limited quantity and quality of data from phone and online surveys. Our study entails further limitations with respect to the difficulty in disentangling inherent seasonal variation and Covid-19 implications, and potential recall bias in the data. Nevertheless, this study brings some important nuances in the debate on the resilience of the food system to the pandemic. Further research remains necessary to reveal longer term implications after Covid-19 triggered restrictions ease, as Dai et al. (2020) did for the case of China.

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