Has Covid19 Affected Global Agricultural Trade? Lessons from an Econometric Assessment of Outbreak Incidence Rates, Policy Response and Lockdowns

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JEL Classification: F14, F13, Q17, Q18

Keywords: COVID-19, Coronavirus, Agricultural and Non-Agricultural Trade, Pandemics, Trade Shocks

Abstract: This paper empirically examines the effects of Covid19 on global agriculture trade. Global agricultural trade, which increased at the end of 2020, has been described as being resilient to the pandemic; however, the precise quantitative implications are not clear. We use recently available, full calendar year 2020 data to estimate the ex-post agricultural trade impacts of the Covid19 outbreak, policy response by governments, and the *de facto* quarantine lockdown effect using a monthly reduced-form gravity-based equation of product-line trade flows. Our investigation finds that while agricultural trade remained quite stable through the pandemic, the sector as a whole has not gone unscathed. First, we estimate that Covid19 reduced overall agricultural trade by 5-10%, on average; two-three times smaller in magnitude than the estimated trade effects of Covid19 on non-agricultural trade. Second, we find sharp differences across commodities. In particular, we find that non-food items (hides & skins, ethanol, rubber, cotton) were more severely impacted by the pandemic; however, the majority of food and bulk commodity sectors experienced an insignificant or in a few cases a positive impact from the pandemic. Third, examining the effect across markets, we find mixed evidence that lower-income and least developed countries trade flows were more sensitive to the pandemic effects. Finally, we found evidence that trade flows had adjusted to the disruptions over time, however pandemic effects were still persistent to the end of 2020. Findings from this study provide learning lessons to which dimensions of our global agricultural supply chains are most resilient and most vulnerable to major global shocks.

This Draft: March 2021.

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1. INTRODUCTION

"COVID-19 caused a global recession whose depth was surpassed only by the two World Wars and the Great Depression over the past century and a half."
World Bank, Global Economic Prospects (2021)

In 2020, the Covid19 pandemic challenged the global economy, spreading to nearly every country and region, decreasing and shuttering economic activity, and threatening the lives of the world's most vulnerable populations. While Covid19, caused by the novel coronavirus, or SARS-CoV-2, was first diagnosed in December 2019 in China's Hubei province, the pandemic has continued to grip the world economy well into 2021. As of this writing, there have been more than 115 million Covid19 cases worldwide, with 2.5 million deaths according to data provided by John Hopkins University Covid19 Dashboard.[1]

Experience with similar diseases (i.e. SARS, MERS, H1N1) reveals that while the human costs can be significant, the large economic toll is due to the preventive behavior of individuals and the transmission control policies of governments (Brahmbhatt and Dutta, 2008). In response to the pandemic, many national governments imposed lockdowns, stay-at-home orders, and the promotion of remote business and education activities to thwart the spread of Covid19. These policies led to significant, although somewhat temporary, economic damage by discouraging large gatherings and outright closures of non-essential businesses including restaurants, bars, shopping centers, and attractions. Service and tourism industries have been particularly hard hit. For example, the year-over-year percentage change in weekly airline traffic plunged well over 50 percent for most industrialized nations in 2020 compared to 2019.[2] Evidence suggests that lockdowns have worked to slow the spread of Covid19 but at considerable economic costs (Fajgelbaum et al. 2020; Antras, Redding and Rossi-Hansberg 2020).

As the introductory quotation implies, the world economy suffered an immediate and significant global recession. For example, unemployment burgeoned in just a few weeks from less than 5 percent to nearly 15 percent as firms laid off or furloughed workers, and second quarter U.S. GDP estimates showed a contraction of 9.5%. By March 5, 2020, the majority of the world's top multinational firms had revised their earnings forecasts for fiscal year 2020 and nearly three-quarters of the top 100 firms issued warning statements concerning the impact of Covid-19 on their business (UNCTAD, 2020).[3] The World Bank (2021) forecasts global gross domestic product (GDP) could shrink over 4.3 percent in 2020 due to the impacts of Covid19.[4]

Since the crisis began in China – often considered the "world's factory" – arguments have been raised in favor of breaking up global value chains and reshoring production closer to home on the grounds that it is dangerous – from both an economic and public health perspective – to be so dependent on imports (Baldwin and Evenett 2020). Food security has

[1] See https://coronavirus.jhu.edu/map.html
[2] Flight data provided by Statista: https://www.statista.com/statistics/1104036/novel-coronavirus-weekly-flights-change-airlines-region/
[3] See also individual reports on Apple Inc. and Airbus in New York Times (2020) and The Economist (2020)
[4] It should be noted that prior outlooks forecasted a larger contraction in GDP. In June 2020, the World Bank forecasted a 5.2 percent decline in global GDP growth; the International Monetary Fund (IMF 2020) projected a 4.2 percent decline.

also been impacted, (cite FAO, World Bank). The Economic Research Service estimates that 75 million more people could become food insecure due to Covid19 (ERS, 2021). However, as countries have learned to manage the crisis, GDP forecasts for global economic growth in 2021 and 2022 have become more optimistic with forecasts of five and 4 percent growth, respectively (World bank 2021).

In April of 2020, concerns grew over trade with the WTO forecasting declines in the value of global trade of -8.1%, -16.5% and -20.4% under a V- (optimistic), U- (less optimistic), and L-shaped (pessimistic) set of economic recovery scenarios (WTO 2020). Actual ex-post data for the end of the 2020 calendar indicate that these initial forecasts were pessimistic. In aggregate, global trade is down 6 percent in 2020 for most countries that have completed 2020 customs reporting.[5] However, global trade in food and agricultural products has been relatively stable experiencing a 2 percent growth in 2020. As discussed later, the smaller impact of the pandemic on global agricultural trade is related to several factors including a low-income elasticity of food demand, shipping channels that do not require substantial human interaction (i.e. bulk commodities), and the essential nature of the industry that many governments declared. Indeed, the WTO (2020) describes agricultural trade during the Covid19 pandemic as a "story of resilience" and one of the few "bright spots" in the world economy.

While descriptive analysis may give some insights on the changes of trade, simple year-over-year changes masks underlying factors occurring across commodities and markets. Covid19 is a multifaceted demand and supply shock that has impacted agricultural production and demand in unique and unprecedented ways. Economic assessment is further clouded by other confounding factors including ongoing animal disease challenges related to African Swine Fever (ASF) in pork and swine production, burgeoning feed demand by China related to a faster than expected recovery of the hog herd, policy changes such as the U.S.-China Phase 1 trade agreement, an ongoing dispute between China and Australia affecting food and agricultural products, and other factors. While global agricultural trade was up overall in 2020, it is unclear to what extent Covid19 has affected trade flows. Providing and early look at the association between trade and Covid-19 indicators while isolating the pandemic effect from other observable policy factors is a key empirical objective this paper.

This article provides a comprehensive *ex post* quantitative assessment of the impacts of Covid19 on food and agricultural trade. Specifically, we develop a monthly structural gravity-based model of bilateral agricultural and non-agricultural trade and econometrically assess different dimensions of the global pandemic effect. We examine the extent to which lockdowns, mobility restrictions and case incidence and death rates affect bilateral trade in 2020 relative to the pre-pandemic era using higher frequency monthly data and detailed agricultural product sectors to account for the rapidly changing pandemic on economic outcomes and differences in underlying requirements of product distribution. Because the governmental response to the pandemic was heterogeneous and many countries experienced at least two surges of Covid19 infection spikes (i.e., spring and summer), we leverage variation in country-specific mobility restrictions and national lockdown stringency to identify trade

[5] Countries that have not reported complete (i.e. full year) trade statistics include Saudi Arabia, Jordan, Panama, Nicaragua, Botswana, and Brunei Darussalam.

impacts. To the best of our knowledge, this study is the first to systematically quantify the differential impacts of the pandemic on agricultural versus non-agricultural trade.

To preview the results, we unpack various components of the Covid19 pandemic effect on trade. We first examine the impacts of the overall agricultural sector and compare it to quantified impacts on non-agricultural sector and further decompose export supply vs import demand disruptions. Second, we disaggregate impacts across product-types and stratify which products were mostly harshly affected by the pandemic as well as identifying which areas were unaffected or even benefited from its indirect effects. Third, we illustrate the differential impact of the pandemic across different regions and country income classification, highlighting in particularly the more sever impacts on low-income and least developed countries. Finally, our analysis examines dynamics of the pandemic and the role of confounding factors such as the ongoing, pre-pandemic U.S.-China trade tensions and subsequent phase one purchase commitments that could otherwise plague identification of the pandemic effect.

2. EXTANT LITERATURE ON COVID19 AND AGRICULTURAL MARKETS

A number of studies have started to investigate the impacts of the Covid19 pandemic on agricultural markets. Gupta et al. (2020) use weekly financial transaction data collected from households residing in rural India to estimate the impacts of India's Covid19 lockdown on household income, food security, welfare, and access to local loan markets. The authors find that in the month immediately after India's lockdown announcement, weekly household local income fell by 88 percent compared to long-term averages and an additional 63 percent reduction in remittances. In response to reduced earnings, rural Indian households substantially reduced meal portions and consumed fewer food items. Baker et al. (2020) find a substantial increase in household spending in the United States immediately following the news of Covid-19, which was then quickly followed by a sharp decrease. Dang, Huynh, and Nguyen (2020) study the impact of Covid-19 on the different income groups in six industrialized countries (China, Italy, Japan, South Korea, the United Kingdom, and the United States). Their results suggest the pandemic has no impacts on household income losses across income quintiles, but Covid-19 had a noticeable impact on household savings. Beckman and Countryman (2020) find that the market effects due to Covid-19 have had a larger effect on the overall U.S. economy than the share of agriculture in the economy during the initial outbreak of COVID-19. However, shocks to nonagricultural markets outweigh the impacts from agriculture by a factor of three. Fajgelbaum et al. (2020) show that spatial lockdowns achieve substantially smaller income losses than uniform, across-the-board lockdowns using detaile commuting in NYM and Soeul, South Korea.

Fewer studies have investigated the impacts of Covid-19 on international trade. Mallory (2020) analyzed early 2020 monthly data and found that beef and pork markets were temporarily impacted by lower exports during the initial onset of Covid19, whereas grains and oilseeds markets were not affected. Maliszewska, Mattoo and van der Mensbrugghe (2020) simulated the potential impact of COVID-19 on GDP and trade, using the World Bank's Envisage general equilibrium model. They find that the baseline global pandemic scenario sees GDP

falling by 2 percent below the world benchmark, 2.5 percent for developing countries, and 1.8 percent for industrial countries. In an amplified pandemic scenario in which containment is assumed to take longer, the simulated declines are nearly 4 percent below the benchmark. Friedt and Zhang (2020) estimate that the pandemic reduced Chinese exports by 40–45% during the initial wave. The authors estimate that China's domestic supply shocks contributed about 10–15 percent of the total reduction in Chinese exports, while international import demand shocks reduced the propensity of countries' purchases of Chinese exports by only 5–10 percent. Kejzar and Velic (2020) characterize the impacts of COVID-19 on supply chains by accounting for the stages of production in terms of the relative upstream or downstream position of an industry. Arita, Grant and Sydow (2021) provide a preliminary assessment of the impacts on agricultural trade using quarterly country-level data on imports of agricultural and non-agricultural commodities. This work builds off this analysis by using a more rigorous bilateral estimation framework across disaggregated agricultural commodities with a nearly complete set of international trade statistics for 2020.

While these studies have shed considerable light on the trade impact of Covid19, many were conducted ex ante, or ex post using the first few months of available 2020 data. Moreover, a cleaner identification of the pandemic on agricultural trade must be placed in context: in 2018-2019 trade was already slowing down due to escalating political tensions, lower economic growth prospects,[6] and the 2018-2019 "trade war" which began with a series of unilateral policy actions by the US against China and other trading partners (Grant et al 2021).[7] In 2020, the U.S. and China signed the Phase One Trade Agreement which includes significant increases in Chinese imports of U.S. products.

3. COVID19, AGRICULTURAL MARKETS, AND GLOBAL TRADE TRENDS

In this section, we provide an overview of the implications of Covid19 on agriculture markets and trade. In particular we summarize the latest trade data and document the main stylized facts and trends pre and during the global pandemic. The pandemic has impacted economic activity in many ways, as people have become sick and died, stayed home under government orders, or voluntarily, and lost their jobs and work time. Food and agricultural production and trade was often considered an essential industry for national security in the U.S. and many other countries, which meant agricultural producers, wholesalers, retailers, and distributors of food products were able to stay on the job throughout production, processing and distributional activities for domestic and international sales (Chenarides, Manfredo and Richards 2020). This compares to non-agricultural trade much of which is trade in intermediate inputs and parts and components. However, as Yaffe-Bellany and Corkery (2020) and Lusk, Tonsor and Shulz (2020) note, the shuttering of service and tourism industries such as restaurants, hotels, bars, entertainment attractions, and schools left some producers with very few buyers for more than half of their output. Thus, the Covid19 pandemic is a complicated

[6] See the International Monetary Fund (October 2019).

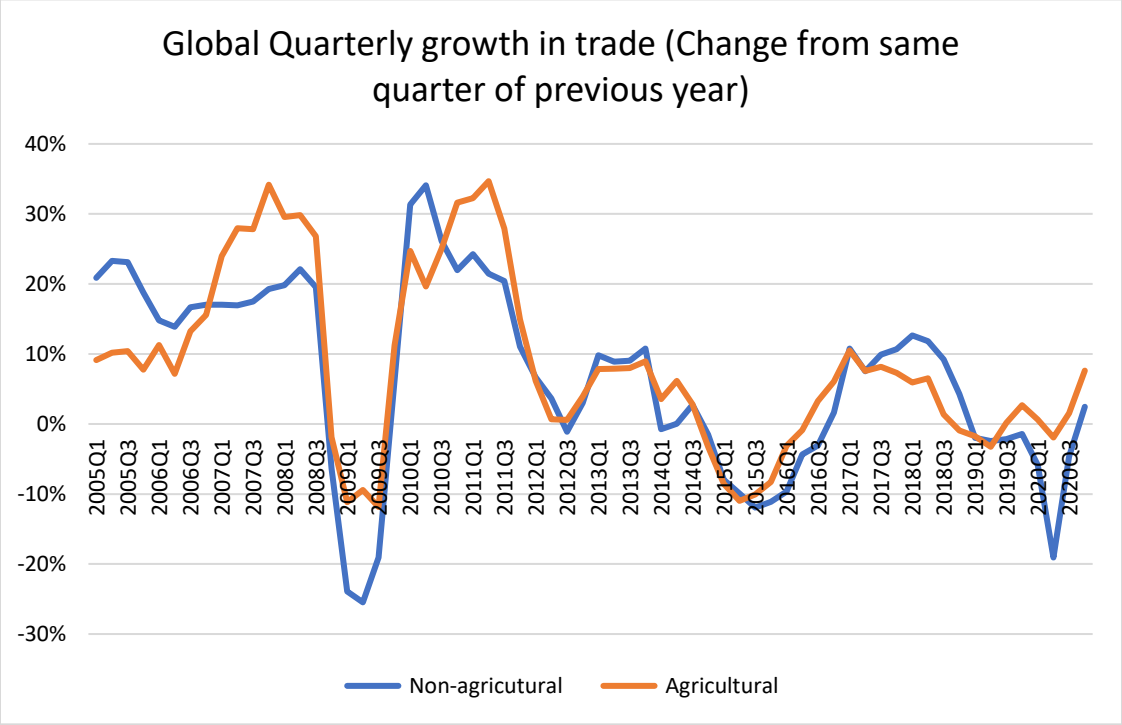
[7] In 2018 alone, the US increased tariffs on a total of 12,043 products covering $303 billion of its annual imports (Fajgelbaum *et al*., 2020). While several affected countries filed complaints with the WTO, many retaliated with tariffs on a total of 8,073 products covering $127 billion of annual US exports (Amiti *et al*. 2019).

event because it affects both aggregate demand and supply and is dependent on the nature of the industry, the exposure of workers to illness (Luckstead et al. 2020), and the ability of supply chains to adapt to sharp changes in the way final products are consumed (i.e., food at home).

3.1 Covid19 trade disruption not historically large

Disruptions to food and agricultural trade resulting from economic, natural, or trade policy induced shocks are not new. Figure 1 plots the quarterly percent change from the same quarter in the previous year of global agricultural and non-agricultural trade from 2005Q1 through 2020Q4. Figure 2 presents monthly values of global agricultural and nonagricultural trade during the 2018-2020 period. Several sharp declines in trade standout. First, the Great Recession of 2007-2009 marked the most significant collapse in trade with global manufacturing (agricultural) trade plummeting almost 30 (20) percent (Figure 1). However, the economic expansion period that followed was one of the longest on record. From 2009Q3 through 2014Q4, global agricultural and non-agricultural trade growth remained positive (the exception being 2012Q3 for non-agricultural trade). Second, beginning in 2015, world trade experienced a significant slowdown; commodity prices fell from their recent highs, the U.S. dollar appreciated, and the International Monetary Fund (IMF) lowered its forecast for global economic growth (see also UNCTAD, 2016). These global macro factors led to a slowdown in global trade, with U.S. and global agricultural exports falling more than 10 percent, a steeper contraction than currently observed under COVID-19 (Figure 1). Third, in 2018, a trade dispute between the United States and China and several other trading partners led to a significant escalation in applied tariffs and a resulting decline in agricultural and merchandise trade (Crowley 2019; Bown 2018; Bown 2019; Amiti et al. 2019; Grant et al. 2021). However, even though China, EU, Canada, Mexico, Turkey and India became engulfed in a trade dispute with the U.S., global agricultural and non-agricultural quarterly trade growth fell only slightly below zero, beginning in 2019Q1.

Figure 1. Global Growth in Global Agricultural and Non-Agricultural Trade

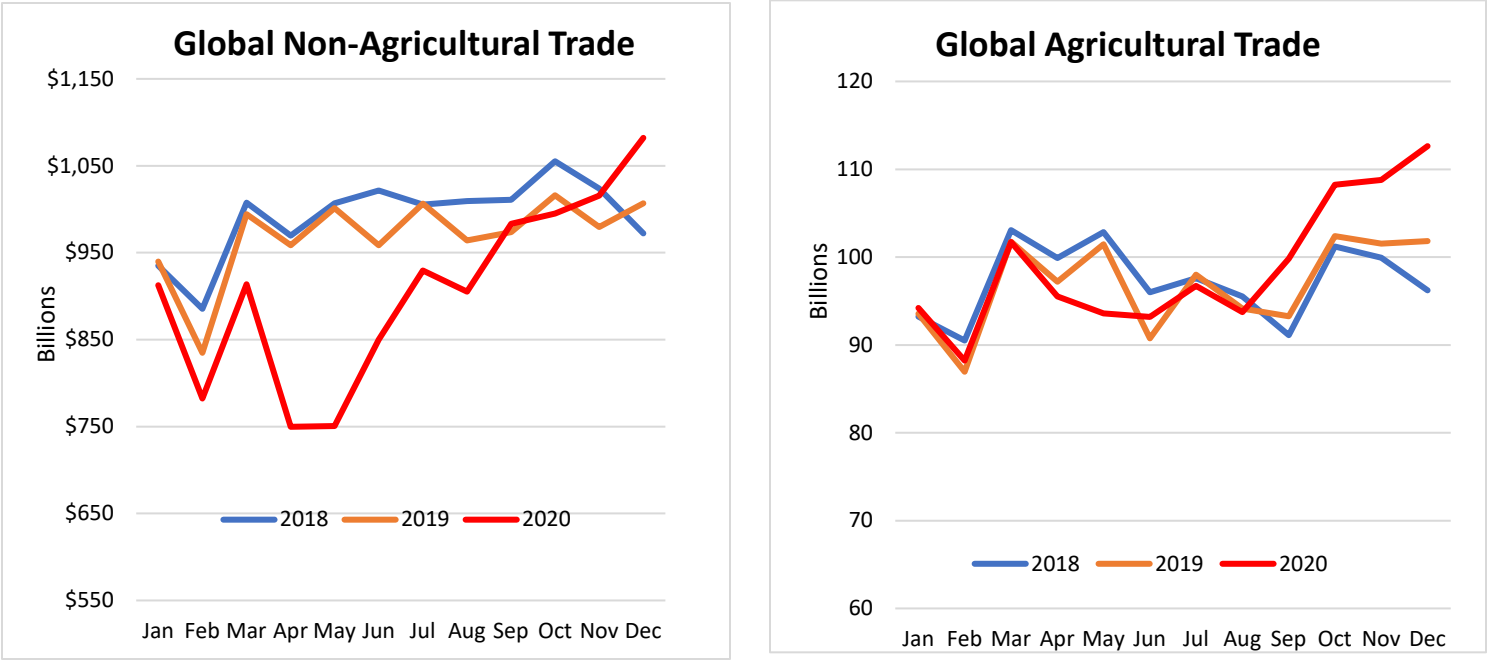


Data: TDM. Agricultural trade includes all HS codes defined under USDA's BICO definition of Agricultural and Agricultural related goods. Non-agricultural trade includes all other HS codes.

3.2 Agricultural Trade relatively stable under Covid19

Agricultural trade under covid19 has been relatively stable. Global agricultural trade fell two percent in 2020Q2 during the initial wave of Covid19 infections and lockdowns; however, food and agricultural trade rebounded significantly during 2020Q3 and 2020Q4 and ended the year up 2%. On the other hand, non-agricultural trade experienced the second largest contraction in global trade since 2005 under the Covid19 pandemic in 2020Q2. Non-agricultural trade subsequently experienced a strong recovery in Q3 and Q4, however still remained down by over 6% by the end of 2020. The smaller impact on agricultural trade may reflect the relatively lower income elasticity of food demand, particularly for staple food items, and the structure of the agricultural global value chains which is less fragmented than manufacturing and other merchandise trade. Additionally, agricultural trade, which occurs more substantially through bulk marine shipments, is likely to be less susceptible to disruption to transport restrictions in other sectors that require more human interaction (WTO, 2020b). Nevertheless, despite realizing a 2% growth, the year-over-year change is too simplistic of a metric to conclude that agricultural trade has gone unscathed by Covid19, as it masks underlying changes occurring at the disaggregate product line level as well as ongoing confounding factors independent of the global pandemic.

Figure 2. Non-agricultural trade plunges in 2020; agricultural trade stable

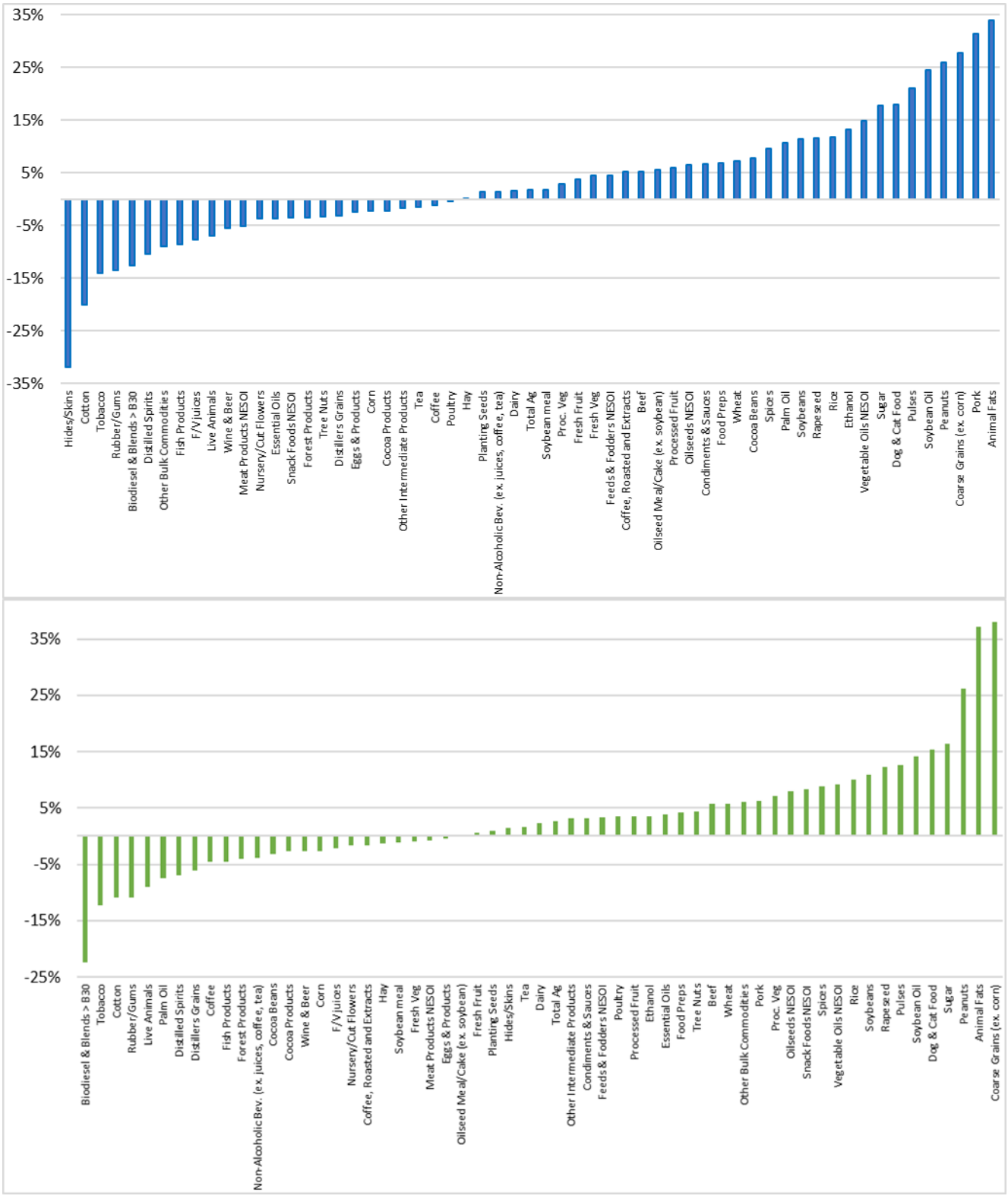


Data: TDM. Agricultural trade includes all HS codes defined under USDA's BICO definition of Agricultural and Agricultural related goods. Non-agricultural trade includes all HS codes.

3.3 Uneven changes in agricultural trade

While overall aggregate changes in agricultural trade have been generally stable, there are sharp differences at the country and regional level. Figures 3 and 4 present the percentage change in 2020 trade flows relative to 2019 across product sector categories (Figure 3) and trading countries (Figure 4). Figure 3 illustrates that products used to make higher end goods such as hides & skins, cotton, rubber, and nursery are among the sectors that saw the largest contraction

Figure 3. Percentage Changes in Value (top panel) and Volume (bottom panel) of Product Sector Global Trade Flows



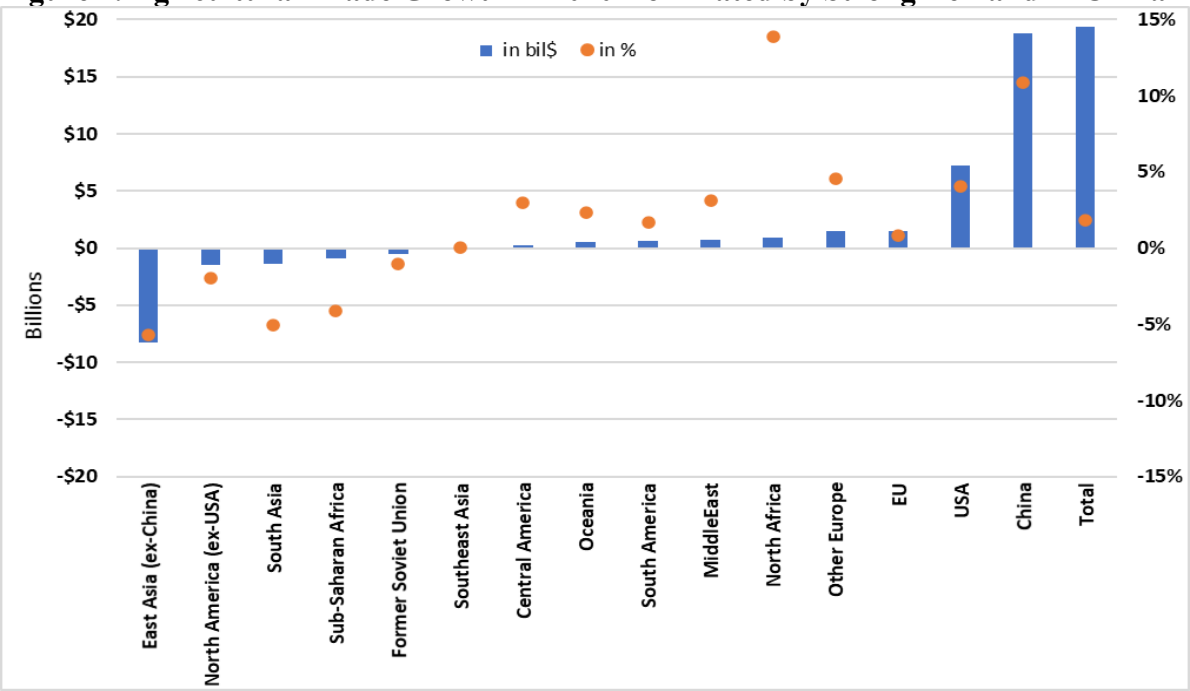
Notes: Authors calculations from Trade Data Monitor.

in trade during the Covid19 pandemic. These sectors are more likely to have a higher income elasticity of demand and thus are relatively more susceptible to aggregate demand shocks and lockdowns. Retail sales of clothing and textiles plummeted as clothing and apparel stores closed, weaker demand for retail purchases due to stay at home orders, and lower incomes as unemployment increased or workers became furloughed. Secondly, there is a clear dichotomy between food products more likely to be consumed at home versus those being consumed away from home. For example, trade in sectors characterized by high restaurant or food away from home consumption, such as seafood, poultry, and beef products (Brinkley and Liu 2019), have declined globally. In comparison, trade in staple products such as cereal grains and protein crops, which are more likely to be consumed at home or serve as intermediate inputs for processing, has increased. Finally, the role of workers falling ill at meat packaging plants and plant closures in the United States, Brazil and other major meat exporting countries was also expected to weigh on exports due to temporary supply disruptions (Lusk, Tonsor and Shulz 2020). However, on an annual basis Figure 3 illustrates that beef, poultry and especially pork increased significantly compared to 2019 trade values.

3.4 Other Agricultural Trade Shocks occurring in 2020: Record China Import Demand, ASF, Policy Changes

Finally, when examining year-over-year changes in trade, it is important to recognize that there are additional trade shocks that have occurred outside Covid19. Simple year over year changes indicate that pork and oilseeds have experienced among the highest growth in 2020, an increase unrelated to Covid19, but driven by ASF that has ravaged herd populations in China, Asia, and other sectors of the world. China, which prior to ASF, consumed almost half the world's pork supply, has faced severe supply shortfalls (being more than 20% down since 2018), and has imported record amounts of pork, raising global prices.

Figure 4. Agricultural Trade Growth in 2020 Dominated by Strong Demand in China



Source: Authors calculations from Trade Data Monitor

As China's pig herd recovered and was further consolidated into more grain-fed operations, China's import demand for grains and oilseeds grew substantially with soybean imports increasing $4 billion. Corn and coarse grain imports also surged that may have been driven by tightening of corn stocks; wheat imports also increased as China has shifted some of the wheat grains to feed. The U.S.-China Phase One agreement may also have supported further imports with tariff exemptions and liberalization of barriers on many key import sectors.

China in fact drives much of the overall observed global growth in 2020. Figure 4 above shows that of the $20 billion increase in global agricultural trade in 2020, China accounted for over 95% of that growth. Thus, simple observed changes in global growth in 2020 is likely to be confounded. Outside of China most markets experienced relatively weak or negative growth. East-Asia (excluding China) and North America (excluding U.S.) stand out in particular.

4. ECONOMETRIC APPROACH AND DATA

4.1 Econometric Model

Descriptive analysis suggests that agricultural trade has been generally stable under Covid19. However, most of this assessment has relied on simple year-over-year changes that ignores confounding natural (i.e., ASF) and policy-induced (i.e., U.S.-China Phase one) factors. To isolate the effect of Covid19, we employ a monthly panel data model of disaggregated product-line bilateral trade relationships introduced by Grant et al. (2021), Fagejlbaum et al. (2020), and Carter and Steinbach (2020) who investigated the impacts of the 2018-2019 trade war on manufacturing and agricultural product-line trade controlling for pre-trends, seasonality and naturally higher and lower trade flows between country-pairs (i.e., U.S.-China soybean vs. U.S.-China beef trade). Because Covid19 impacted countries differently and government responses to the pandemic varied, we exploit variation in country-and-month-specific indicators to estimate the (partial) direct trade effects of the pandemic-induced shock using a theoretically consistent model of bilateral trade flows at the product level as presented by Yotov et al. (2018) and Yotov et al. (2016), and Peterson et al. (2013) but with the addition of a monthly dimension as an additional source of within-year variation specific to many agricultural commodity exports.

Head and Mayer (2014), Peterson et al. (2013), and Baldwin and Taglioni (2006) provide formal derivations of the gravity equation at the product line. The gravity model used here is not fully structural as in Anderson and Yotov (2016) and Yotov et al. (2016) in conditional or full endowment general equilibrium (GE). By design, the full GE gravity setup requires intra-national trade flows (i.e., trade with self) which is nearly impossible to obtain across months within years. Thus, our results are consistent with best practices to estimate partial direct effects also advocated by Yotov et al. (2016) and Grant et al. (2021).

Denote exporting (importing) countries as *i* (*j*) and products, months, and years as *k*, *m*, and *t*, respectively. Using monthly panel data from January 2016 through December 2020 of bilateral-product-month relationships (*ijkm*), our baseline estimating equation to quantify the trade effect of Covid19 on agricultural and non-agricultural exports is:

$$(1) \qquad X_{ijmt} = exp\{\mu_{ijm} + \pi_{it} + \varphi_{jt} + \xi_{kt} + \gamma_1 \, Cov19_{imt} + \gamma_2 \, Cov19_{jmt}\} + \varepsilon_{ijmt}$$

where, *exp* denotes the exponential function, X_{ijkmt} is the value of bilateral trade between exporting country *i*, importing country *j*, product group *k*, month *m* (*m = 1, 2, … 12*), and year *t* (*t = 2016, 2017, … 2019, 2020*). Equation (1) contains a comprehensive set of exporter-importer-product-month specific fixed effects[8], μ_{ijmk}, designed to absorb all time-invariant product-and-month specific bilateral trade cost or natural trading partner effects.[9] Such trade cost factors include existing non-tariff measures (see Grant and Arita 2017; Ning and Grant 2019), transportation costs (i.e. distance), existing free trade agreements (i.e., U.S.-Korea, China-Australia, etc.), bilateral applied tariffs, time-invariant natural, cultural and geographical factors, as well as within-year seasonality of supply and demand of product *k*. In addition to μ_{ijmk}, we also include importer-year (φ_{jt}), exporter-year (π_{it}), and product-year (ξ_{mt}) fixed effects, which are time varying, but not bilateral-specific, to control for changes in a country's overall inward or outward multilateral agri-food trade resistance (*it*, *jt*) and year-to-year fluctuations in global commodity prices (*kt*) or shifts in agricultural trade patterns.

The effect of Covid19 is captured from both the export and import side. $Cov19_{imt}$ ($Cov19_{jmt}$) is an exporter-month-year (importer-month-year) specific Covid19 variable designed to capture the influence of cases, deaths, lockdowns and mobility impacts on an exporter's (importer's) trade with all partners. Covid19 is a complicated multifaceted shock and there is no single indicator that can reflect the entirety of its impact. Thus, we employ a battery of indicators attempting to capture different elements of its trade effect discussed in the data section.

As suggested by Santos Silva and Tenreyro (2006; 2010; 2011), we adopt the Poisson-Pseudo-Maximum Likelihood PPML estimator because it retains the multiplicative theoretical structure of structural gravity type models (equation 1). It is also robust to unknown patterns of heteroskedasticity and allows the dependent variable to remain in levels (as opposed to logarithms) permitting the inclusion of zero trade flows in estimation. Zero trade flows are key in the context of assessing trade policy or pandemic-induced trade shocks at the product level, and for cases of thinner trade relationships among least developed economies for exports of certain processed food products. If the reason for zero trade is related to the Covid19 pandemic in certain months, then omission of zero trade flows creates the classic sample selection bias leading to underestimation of trade impacts.

[8] In their sensitivity analysis, Grant et al 2021, ran different degrees of fixed effects, with some specifications not including the full set of dummies (exclusion of jt, kt, or mt). Results of their finding were generally robust to the different sets of fixed effects; however the full set was viewed as being the most exhaustive in absorbing unobserved effects that would otherwise show up in the error term, and thus forms the basis of our estimations here. Estimations using a smaller set of fixed effects are available upon request.

[9] For example, U.S.-Canada, U.S-Mexico trade in many product lines is naturally higher than many other country-pairs in the model because of shared border, language, cultural and institutional similarities between USMCA/NAFTA partners. If we instead tried to leverage variation between country-pairs in the model for identification, we would miss the important fact that there are pre-existing trends and trade relationships that are specific to country-pair-product and month (i.e., US exports of soybeans to China peak in the post-harvest fall season, whereas Brazilian soybean exports are counter-seasonal and peak in the U.S.'s spring planting season).

4.2 Data

Monthly bilateral exports from January 2016 through December 2020 reported by 93 countries to 207 importing markets are retrieved from Trade Data Monitor.[10] Appendix A provides a list exporting and importing countries. The sample includes 57 agricultural and related product groups as defined by USDA's Bulk, Intermediate and Consumer-Oriented products (see Appendix B). Thus, an observation comprises a country pair, BICO product, month, and year. We also collect aggregate non-agricultural trade data from the same source. Given the over 5,000 HS6-digit product codes comprising non-agricultural products we first separate agricultural trade and then aggregate all non-agricultural products into a single sector. While this likely mask some of the pandemic's effect on individual manufacturing sectors (i.e., vehicles and parts, aircraft, electronics), it does give us a benchmark comparison from which to judge the agricultural trade effects.

Covid19 indicators are collected from the following sources:

i. Direct outbreaks: increase in the number of coronavirus cases or deaths reported in importing country *j* and exporting country *i* per million people (John Hopkins University), monthly, 2020.

ii. Policy Response: Oxford Policy Stringency Index in importing country *j* and exporting country *i*. The Oxford COVID-19 Government Response Tracker (OxCGRT) systematically collects information on several different common policy responses that governments have taken to respond to the pandemic on 18 indicators such as school closures and travel restrictions. It now has data from more than 180 countries. The Oxford Stringency Index ranges from 0-100. These data are available at: https://www.bsg.ox.ac.uk/research/research-projects/covid-19-government-response-tracker

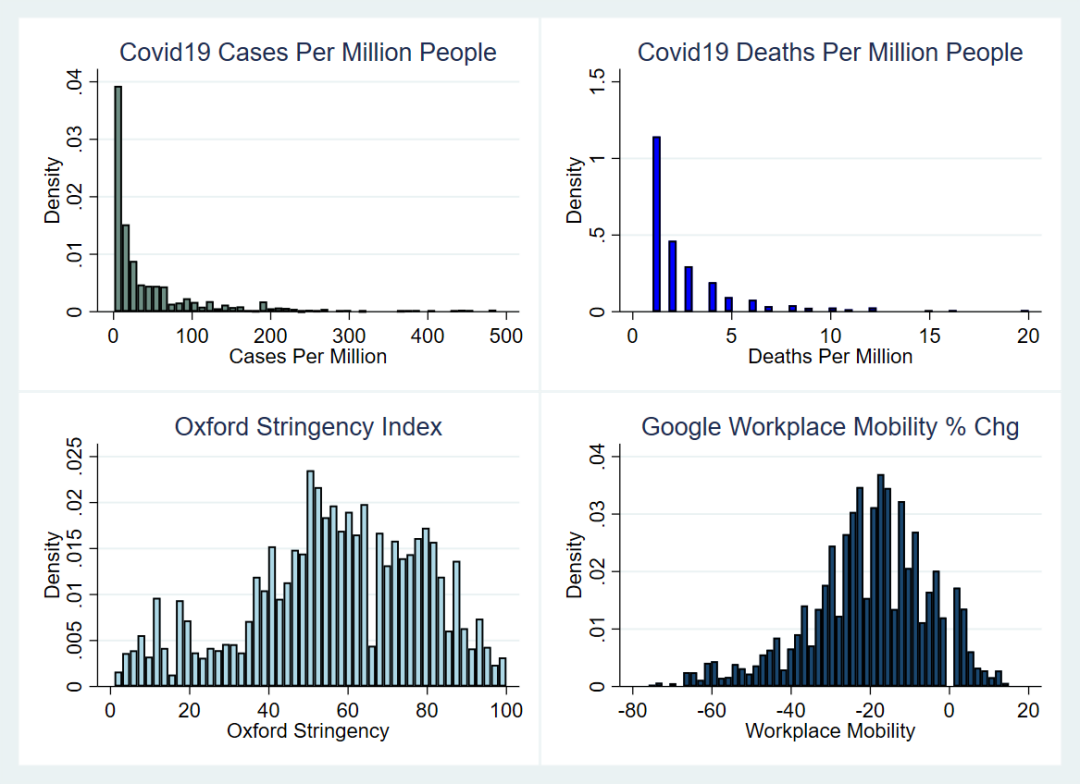
iii. De facto lockdown effect: Community Mobility indicator in importing country [deviation from pre-covid baseline] using workplace and retail people traffic are retrieved from Google Mobility data, available at: https://www.google.com/covid19/mobility/

Figure 5 presents the distribution of Covid19 cases and death rates per million residents, the Oxford policy stringency index and Google's workplace mobility indicator. The mean of Covid19 cases per million residents is 56 with a median of 15. Andorra, Belgium, Luxembourg and Montenegro experienced Covid19 cases greater than 800. These more extreme cases incidences occurred in October and November of 2020. Mean deaths per million residents is 2.8 with a median of 2 and a maximum of 26. Andorra, Belgium, Luxembourg, Czech Republic, San Marino, and Slovenia all experienced deaths rates per million residents above 15, which occurred in March, April and November 2020. The government lockdown stringency index as reported by Oxford University has a mean of 56 and a median of 58 a minimum of 1 and a

[10] Trade Data Monitor data are available by subscription at https://tradedatamonitor.com/. Export reported information was selected relative to import reported information, since the former has arguably less data lag between transaction (time when trade sale occurred) and covid19 events. We also tested import reported information and found the results consistent with the export reported information.

maximum of 100 (100 indicates complete lockdown). Ten countries imposed lockdown stringencies that exceeded 90 on the index: Argentina, Azerbaijan, Guatemala, Honduras, India, Jordan, Philippines, Serbia, the State of Palestine, and Slovenia. Interestingly, China which was often highlighted by the media as imposing strict lockdown measures was not on the top-10 list. China's highest Oxford policy reading was 80 and it imposed this level of stringency for 4 out of 12 months in 2020 (i.e., duration). By comparison, Argentina's reading of 100 on the Oxford indicator was imposed only in April of 2020.

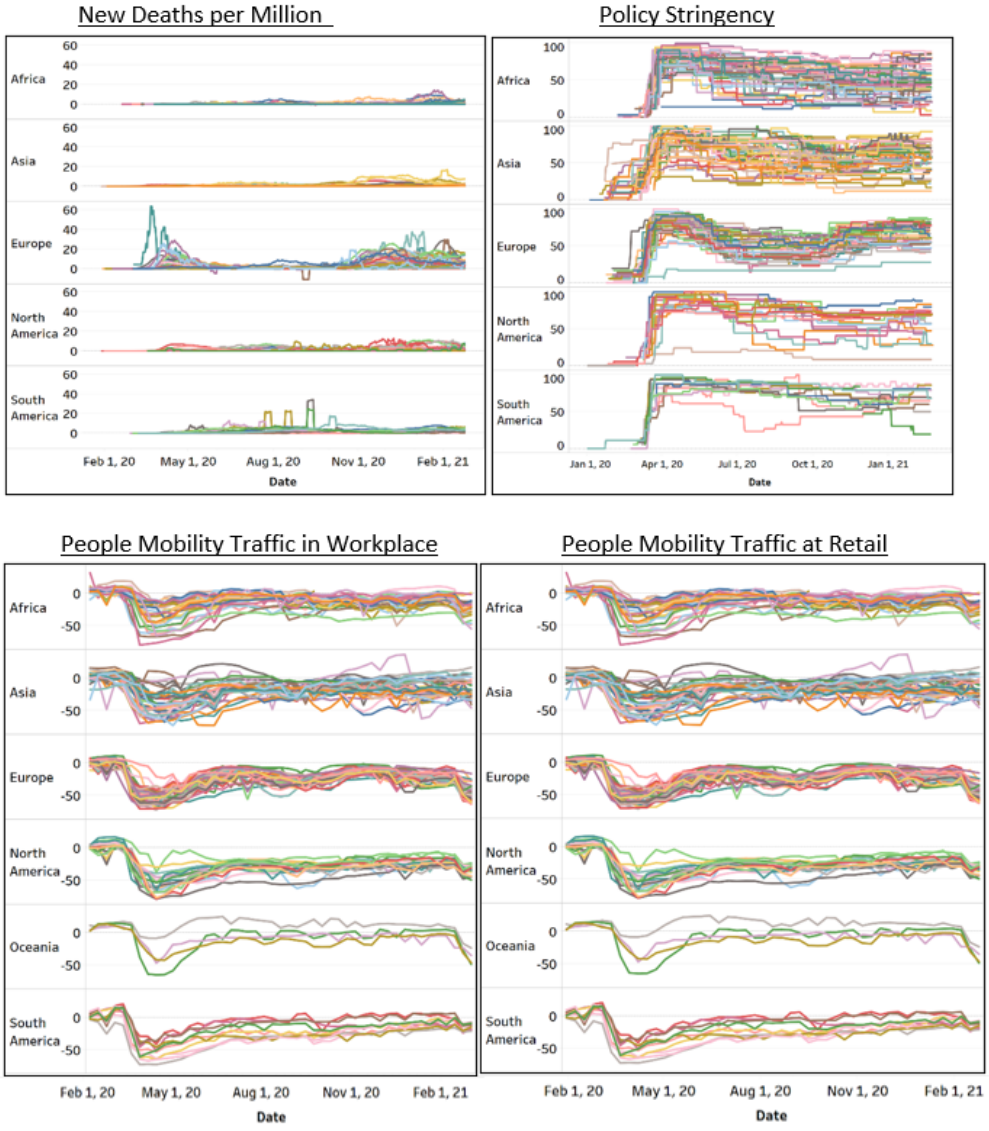
Figure 5. Distribution of Covid19 Cases, Deaths, Lockdown and Mobility, March 2020 to December 2020



Source: Authors calculations from John Hopkins, Oxford and Google

Figure 6 takes a closer look at Covid19 Deaths, Lockdowns and Google mobility at the regional level: Africa, Asia, Europe, North America, and South America. Each individual color lined represents a different country within the continent. For presentation purposes the figure only labels the continent. The top left panel indicates significant variation in Covid19 rates across continents, countries and markets; there is also substantial intertertemporal variation with different waves apparent for some countries. The Oxford policy stringency indices also display intertemporal variation—with strong surges during the 2nd quarter as Covid19 became a pandemic. There is also cross-country variation as some countries, such as in Asia, were quicker to control the pandemic. The *de facto* level of quarantines as measured by the google workplace and retail mobility data displays similar movements with policy stringency; however there is variation in dynamics between the trends.

Figure 6. Deaths, Policy Stringency and Google Mobility Across Regions.



Data: death rates-John Hopkins University, Policy Stringency-Oxford, Workplace and Retail Mobility-Google.

5. ECONOMETRIC RESULTS

The econometric results are presented according to different dimensions and components of how covid19 has affected trade. Subsection one reports the overall sector level effects of Covid19 on non-agricultural and agriculture. The second subsection presents the disaggregated effects on individual agricultural trade values and volumes. The third subsection examines the impacts across regions focusing in particular how trade between low income and least developed countries were affected. In the fourth subsection we address timing and dynamics of trade estimates.

5.1 Estimated sector level effects of Non-agricultural vs. Agricultural Trade

What is the effect of Covid19 on global trade in 2020, holding other factors constant? Table 1 presents the sector level effects for both the value of non-agricultural and agricultural trade along different components of the pandemic effect[11]. All estimations include bilateral-month (ijm), importer-year (it), exporter-year (jt), and month-year (mt) fixed effects; since the estimates are performed at the overall sector level, product level fixed effects are not included and all errors are clustered along the ijm dimension[12].

Columns 1-4 report the estimated direct effect of the outbreak. The insignificant or small size of the coefficients suggests a very limited direct effect of the pandemic. For agricultural trade, a significant effect is found only on the death counts reported by the import country. The coefficients in column 4 implies that each additional fatality per million people due to covid19 is associated with a 0.02% reduction in monthly agricultural trade. In our sample, the average number of new covid19 deaths reported per a month, averaged across all countries was 27. Applying our estimated coefficient on death counts to this average indicates that the direct covid19 death counts reduced agricultural trade on average by -0.5% throughout 2020. For non-agricultural trade, the direct covid19 effect for death counts is significant on both the exporter and importer side; however, the average effect implied by our coefficient estimates amounts to only 1.1% reduction. The effect on case counts is largely negligible.

The stronger effect of the pandemic is more likely to be driven not by the direct health impact, but the policy response and voluntary quarantining of individuals. The next set of columns supports this. Columns 5 and 6 reports the estimated impact of policy response. For non-agricultural trade, the size of the coefficients are significantly negative on both the exporter and importer side. A 1% increase in an importer's policy restrictiveness due to Covid19 leads to reduction of agricultural trade of 0.2%. In 2020, the average import countries' policy index was elevated to 52%. Applying our estimated coefficient to this average indicates that the average agricultural trade flow was reduced by -10% due to national policy responses. Similar to the direct effect, policy restrictions on the importer side were also negatively significant for agricultural, but not significant on the export side. The results may suggest that Covid19 effect may be factored in more significantly through the import demand channels rather than export supply. In contrast, exporter's policy response to Covid19 is found to be much stronger for non-agricultural trade, which could be attributed to the more vulnerable supply chains occurring in non-agricultural trade, which are typically longer and more complex than agricultural supply chains.

Columns 7 and 8 report the de-facto lockdown effect of the Covid19 using the Google mobility indicators. Coefficients for the level of workplace mobility on the exporter side and retail mobility on the import side are positive for both non-agriculture and agriculture. A 1%

[11] Appendix C reports results showing the estimated impacts in terms of volumes vs values with product level fixed effects.

[12] Estimates for agriculture were performed with product level fixed effects (using BICO codes). Results were largely robust and are available upon request.

decrease in the level of workplace mobility for an exporter relative to the periods prior to Covid19, led to a 0.4% reduction in non-agricultural trade and a 0.16% reduction in agricultural trade. In our sample the average level of workplace traffic fell by 17.8%; retail traffic by 19.1%. Applying these averages to the estimated coefficients implies and a 6% reduction in the average agricultural trade flow. In comparison the lockdown effect is about twice as large for non-agricultural trade.

Table 1. Estimated Impact of Covid19 on Value of Trade: Non-agricultural Trade vs Agricultural Trade

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Non-Ag	**Ag**	**Non-Ag**	**Ag**	**Non-Ag**	**Ag**	**Non-Ag**	**Ag**	**Non-Ag**	**Ag**
VARIABLES	value	value	value	value	value	value	value	value	value	value
Covid Cases per million_Exporter	0.0000***	0.0000								
	(0.00)	(0.00)								
Covid Cases per million_Importer	0.0000	-0.0000*								
	(0.00)	(0.00)								
Deaths per Mil_Exporter			-0.0002**	-0.0000					0.0001*	-0.0000
			(0.00)	(0.00)					(0.00)	(0.00)
Deaths Per Mil_Importer			-0.0002**	-0.0002***					0.0000	-0.0001*
			(0.00)	(0.00)					(0.00)	(0.00)
Oxford Policy Stringency_Exporter					-0.0045***	-0.0004			0.0000	0.0002
					(0.00)	(0.00)			(0.00)	(0.00)
Oxford Policy Stringency_Importer					-0.0014***	-0.0020***			0.0007*	0.0001
					(0.00)	(0.00)			(0.00)	(0.00)
Google workplace mobility_Exporter							0.0040***	0.0016***	0.0044***	0.0010**
							(0.00)	(0.00)	(0.00)	(0.00)
Google retail mobility_Importer							0.0025***	0.0014***	0.0030***	0.0013***
							(0.00)	(0.00)	(0.00)	(0.00)
Observations	560,288	494,400	550,098	485,309	558,093	492,792	753,584	644,922	496,991	440,651

Estimated with PPML. Includes ijm, it, jt, mt, fixed effects. Standard errors are in parentheses and robust to clustering on ijm. * and ** denote statistical significance at the ten and five percent levels, respectively. Estimated on monthly data from Jan 2016, to Dec. 2020. The average partial Covid19 effect on bilateral trade applies the estimated coefficient on the case, death count, policy stringency and/or mobility index at the mean level of the indicator in 2020. Agricultural trade includes all HS codes defined under USDA's BICO definition of Agricultural and Agricultural related goods. Non-agricultural trade includes all HS codes. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices.

Columns 9 and 10 report the results estimating all components jointly. We recognize that these variables may exhibit significant multicollinearity and thus several of the individual efficeints lose significance. Similar to the previous columns we find that the estimated effect is larger for non-agricultural than agricultural trade (twice as large). Separately, the Covid19 effect seems to be more significantly inflicted on the import demand side for agricultural trade whereas for non-agricultural trade it appears to be impacted more severely on the supply side.

Finally, it is of interest to note the differences implied by the econometric findings relative to the simple year over year changes reported in the previous section. While simple year over

year changes find global agricultural trade was up +2%, our overall estimations are negative and significant. We find an approximate impact on the range of a 5-10% reduction in agricultural trade as predicted by the model due to Covid19 direct and indirect factors. While this quantitative impact is 2-3 times smaller than non-agriculture, it provides evidence that agricultural trade was not entirely resilient. Our findings also provide empirical support that policy restrictions and de facto lockdowns imposed by the importer are the main channels of trade loss.

5.2 Which commodities where most severely impacted by Global Pandemic?

In addition to strong contrast of Covid19 impacts between the agriculture vs non-agriculture sectors, the earlier descriptive analysis also suggested very sharp differences within the agricultural sector. To identify how Covid19 effects vary, we perform estimations at the commodity level employing finely defined product groups defined by USDA agricultural and agricultural-related (BICO) product groups (appendix B details the HS codes for each group). There are a total of 57 of these groups defined within the USDA agricultural and agricultural related BICO scheme. For these sets of estimations we estimate the joint effect of Covid19, including direct (death counts per million), policy response (Oxford Policy Stringency), and de facto lockdown (Google mobility) on both the importer and exporter side.[13] Case counts are not included in this specification due to the weak significance of these results found within the overall agricultural sector.

Table 2 shows the estimation results, across individual commodities. The findings indicate very diverse Covid19 effects. In some commodities we find very large and significant negative effects whereas others are significant or even positive effects. By component we find that 25% of the commodities suffered a negative effect from the direct (death counts) impact of the pandemic, 54% from the policy response, and 39% from the de facto lockdown effect. In contrast, about 10% of the commodities are found to have experienced a positive impact from the Covid19, likely through demand shifting. Notably a slight majority of commodities (55-60%), were not found to be significantly effected by the pandemic.

Figure 7 attempts to stratify the impacts of the pandemic across scenarios. It employs the coefficient estimates in Table 2 and applies a one standard deviation shock to each of the Covid19 effects (death counts, policy response, and de facto lockdown), and quantifies the resulting impact by commodities. The results are sorted from lowest to highest average impact. The non-food related commodities are found to have suffered the highest impacts. Hides and skins (-24% lockdown impact), ethanol (-16% lockdown impact), cotton (-11% policy response), cut flowers (-9% policy response) suffer among the most severe disruptions. Higher value food products—beef, seafood, pork, and other meat products are found to have been significantly negatively impacted.

It is interest to note how are econometric results differ from simple year over year changes in other commodities. We note that our estimates have indicated pork bilateral trade, has been on average reduced by -2 to -3% due given a 1 standard deviation sized shock in policy response and de-facto effect. This stands in strong contrast to the over 20% increase in global growth as shown through simple year over year changes presented in section 2.3 which is driven by

[13] Estimations were also performed for individual sets of covid19 indicators and are available upon request.

African Swine Fever, not Covid19. Rapeseed, which experienced a 11% increase in global increase in 2020, largely on confounding supply side shocks, is found to be insignificantly impacted by Covid19 in terms of the direct and indirect effects. Our estimation thus is able to effectively disentangle the covid19 effect for these commodities. Soybeans is found to have a significant positive effect for policy response. This could be attributed to increased demand driven by China's recovering herd size and thus reflecting a possible limitation in our approach to completely isolate the Covid19 impact—however the effect is insignificant in terms of death counts and de facto lockdown effect. For beef trade, which had increased in 2020 relative to 2019—our results found a 6% decline, which is consistent with the supply chain disruptions that have occurred through major beef producers throughout the world.

We find that for many of the grains and oilseeds, prepared and processed foods there is a relatively small or insignificant effect. The stratification of estimated impacts seems to generally align with what we know from the literature on income demand elasticities. Non-food related products are typically found to be the most sensitive to income shocks, followed by higher value meat and specialty products, then staple grains and oilseeds. Consistent with the simple year over year changes, rice—a perennial staple food item, increased 4% given a one standard deviation direct and lockdown shock.

We also estimated the impact of Covid19 on volume of trade. By focusing on volumes we control for commodity price changes and isolate the impacts in terms of real changes in shipments. However, we do note that our estimations on values does include month-time fixed effects which controls for seasonality and price effects. Results are reported in Appendix D. The results are largely consistent with the estimations performed on values and roughly similar in magnitude.

Table 2. Product level estimates on Value of Agricultural Trade

	1. Direct Effect			2. Policy Response			3. Lockdown		
Product-Group	Deaths per Mil_Export	Deaths Per Mil_Importer	Obs	Oxford Policy Stringency	Oxford Policy Stringency	Obs	Google workplace mobility_Expor	Google retail mobility_Importer	Obs
AnimalFats	0	0	76,142	0.002	-0.002	78,051	0.005	0.002	82,228
Beef	0	-0.001***	116,020	-0.001	-0.002*	118,557	0.002	0.005***	145,598
BiodieselBlends	0	0	25,187	-0.002	-0.005	25,995	-0.007	0.006**	27,767
ChocolateCocoaProducts	-0.000**	0	211,421	0	-0.002***	215,637	0.001	0.001**	251,375
CoarseGrainsexcorn	0	-0.001	78,087	0.006	-0.014***	80,311	-0.006	-0.001	89,451
CocoaBeans	0	0.001	34,732	-0.007*	0.002	35,853	0.002	-0.001	37,674
CoffeeRoastedExtracts	0.000**	0	167,572	0.002**	-0.001	171,734	-0.001	-0.001	199,910
CoffeeUnroasted	0.000**	0	83,748	-0.001	-0.001	86,240	0.009***	-0.001	92,736
CondimentsSauces	0.000*	0	184,663	0	-0.001***	188,779	-0.002**	0.001*	221,402
Corn	0	0	59,471	0.005	-0.004	61,164	0.022***	0.003	70,369
Cotton	-0.001	-0.001	38,100	-0.006	-0.007**	39,296	-0.002	0.010***	42,987
DairyProducts	0	0	220,479	0.002***	-0.001	225,336	-0.001*	0	275,983
DistilledSpirits	-0.001***	0	166,756	-0.001	-0.003**	170,772	0.007***	0.003***	202,595
DistillersGrains	0	-0.001	13,665	0	0.002	14,124	-0.013	0.001	16,033
DogCatFood	0	0	105,254	-0.002*	0	107,947	0.001	-0.001*	117,768
Eggs	0	0	80,181	-0.001	-0.002**	82,153	0	0.001	97,560
EsentialOils	0	-0.001**	184,414	-0.002	-0.003*	188,919	0.005*	0.005***	216,760
Ethanol	0	-0.001***	68,702	-0.005*	-0.004	70,566	0.016***	0.002	80,332
FeedsFoddersNESOI	0	0	173,986	-0.001	-0.002***	178,237	0.002	0.001	199,229
FishProducts	0	-0.000***	227,709	-0.002***	-0.003***	232,835	0.003***	0.003***	271,701
FoodPreps	0	0	303,781	0	-0.001**	309,756	0.001	0	382,626
ForestProducts	0	0	310,180	-0.002**	-0.001	316,452	0.005***	0.003***	380,261
FreshFruit	0	0	159,241	-0.001	0.001	162,735	0.001	0.001**	185,434
FreshVegetables	0	0	133,451	0	0.001	136,375	-0.002	0	151,219
FruitVegetableJuices	0	0	169,014	0	0	172,922	-0.001	0	200,736
Hay	-0.001**	0	37,533	0.002	-0.001	38,703	0.004	0.001	42,469
HidesSkins	0	0	62,204	-0.008***	-0.006***	64,000	0.024***	-0.002	69,537
LiveAnimals	0.000*	0	80,024	0.002	0	82,126	-0.002	-0.002	95,458
MeatProductsNESOI	-0.000*	-0.000***	137,202	-0.002***	-0.003***	140,241	0.003***	0.001***	164,945
NonAlcoholicBev	0	0	158,127	-0.001	-0.001	161,849	-0.001	0.001*	193,836
Nurseryflowers	-0.001***	-0.001***	141,315	-0.003***	-0.003***	144,396	0.001	0.004***	159,582
OilseedMeal	0	0.001**	58,379	-0.001	0.003	60,090	0.007*	-0.001	65,416
OilseedsNESOI	0	0	121,014	-0.003**	-0.005**	124,142	0.011**	-0.001	136,655
OtherBulkCommodities	0	0	110,573	0.003*	-0.001	113,770	0.004	0.002	122,999
OtherIntermediateProducts	0	0	287,332	-0.001	-0.001*	293,298	0	0.001*	348,556
PalmOil	-0.001	-0.001	57,463	-0.004	-0.003	58,884	0.010*	0.002	68,484
Peanuts	0	0	41,250	-0.001	-0.005*	42,379	0.007	0.001	44,553
PlantingSeeds	0	0.000*	134,570	0.003***	0	138,217	0.002	-0.002***	155,879
Pork	0	-0.000**	102,010	-0.001	-0.002*	104,276	0	0.003***	127,781
Poultry	0	-0.001***	115,777	-0.002**	-0.001	117,952	0.001	0.004***	151,049
ProcessedFruit	0.000***	0	221,671	-0.001	0	226,548	0.001	0	258,467
ProcessedVegetables	0	0	215,209	-0.002***	0	219,558	-0.001	0.001	254,164
Pulses	0	0	112,846	0.001	0.001	115,679	0.001	-0.003	132,515
Rapeseed	-0.001	-0.001	22,038	-0.006	-0.001	22,815	0.004	0.004	25,206
Rice	0.001***	0	103,652	0.004	0.002	105,938	0.005	-0.004**	123,450
RubberAlliedGums	-0.001	0	86,263	0.001	-0.002**	88,931	0.009***	0.003**	94,948
SnackFoodsNESOI	-0.000***	0	228,688	-0.001	-0.002***	233,145	0.003***	0.001*	278,045
Soybeanmeal	-0.001	0	47,411	0.003	-0.003	48,867	-0.002	-0.001	54,474
SoybeanOil	0.002***	-0.001	50,114	0.006	0.001	51,769	0	0.003	59,455
Soybeans	0.001	0	36,038	0.023**	-0.005	37,193	0.002	-0.001	39,170
Spices	0.000*	0	161,451	-0.003**	0	165,348	0.005*	-0.002*	187,933
SugarsSweeteners	0	0	190,663	0.003**	-0.007***	194,986	0.007***	0.001	226,545
Tea	0	0	151,292	-0.004***	-0.001	155,269	0.009***	-0.001	176,436
Tobacco	0	-0.001*	58,329	-0.005*	-0.003	59,444	-0.006	0	64,246
TreeNuts	0	0	153,088	-0.003**	-0.003**	156,798	-0.012***	0.003	180,071
VegetableOilsNESOI	0	0	219,697	0.001	-0.001	224,838	-0.001	0	260,656
Wheat	-0.001**	0	47,211	-0.002	-0.001	48,599	-0.003	0.001	57,168

*Estimated with PPML. Includes ijm, it, jt, mt, fixed effects. Standard errors are in parentheses and robust to clustering on ijm. * and ** denote statistical significance at the ten and five percent levels, respectively. Estimated on monthly data from Jan 2016, to Dec. 2020. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices.*

Figure 7. Covid19 trade impact across commodities

Product-group	1. Direct Effect (Deaths per million)	2. Policy Response (Oxford Stringency)	3. Lockdown (Google Workplace and Retail Mobility)
HidesSkins	0%	-22%	-24%
Corn	0%	0%	-22%
Ethanol	-7%	-7%	-16%
RubberAlliedGums	0%	-4%	-11%
OilseedsNESOI	0%	-12%	-11%
DistilledSpirits	-5%	-5%	-10%
Cotton	0%	-11%	-10%
CoffeeUnroasted	2%	0%	-9%
Tea	0%	-6%	-9%
ForestProducts	0%	-3%	-9%
SugarsSweeteners	0%	-6%	-7%
FishProducts	-2%	-7%	-6%
BiodieselBlends	0%	0%	-6%
Beef	-3%	-3%	-6%
EsentialOils	-6%	-4%	-5%
MeatProductsNESOI	-3%	-8%	-5%
Nurseryflowers	-5%	-9%	-4%
Poultry	-3%	-3%	-4%
SnackFoodsNESOI	-1%	-3%	-3%
Pork	-2%	-2%	-3%
FreshFruit	0%	0%	-1%
ChocolateCocoaProducts	-1%	-3%	-1%
AnimalFats	0%	0%	0%
CoarseGrainsexcorn	0%	-22%	0%
CocoaBeans	0%	-11%	0%
CoffeeRoastedExtracts	1%	3%	0%
DairyProducts	0%	3%	0%
DistillersGrains	0%	0%	0%
DogCatFood	0%	-3%	0%
Eggs	0%	-4%	0%
FeedsFoddersNESOI	0%	-4%	0%
FoodPreps	0%	-2%	0%
FreshVegetables	0%	0%	0%
FruitVegetableJuices	0%	0%	0%
Hay	-5%	0%	0%
LiveAnimals	2%	0%	0%
NonAlcoholicBev	0%	0%	0%
OilseedMeal	3%	0%	0%
OtherBulkCommodities	0%	5%	0%
OtherIntermediateProdu	0%	-2%	0%
PalmOil	0%	0%	0%
Peanuts	0%	-8%	0%
ProcessedFruit	1%	0%	0%
ProcessedVegetables	0%	-3%	0%
Pulses	0%	0%	0%
Rapeseed	0%	0%	0%
Soybeanmeal	0%	0%	0%
SoybeanOil	9%	0%	0%
Soybeans	0%	34%	0%
Spices	2%	-5%	0%
Tobacco	-3%	-7%	0%
VegetableOilsNESOI	0%	0%	0%
Wheat	-6%	0%	0%
CondimentsSauces	1%	-2%	2%
PlantingSeeds	2%	5%	2%
Rice	4%	0%	4%
TreeNuts	0%	-8%	12%

Notes: Impact applies cofficients estimated in Table 2 to a one standard deviation shock of each covid19 indicator. One standard deviation is approximately equivalent to: Death counts-50 people per million, Oxford policy stringency-15%, and Google Mobility-10%.

5.3 Were developing and least developing ag trade flows more vulnerable to the Pandemic?

Concerns have been raised that Covid19 may disproportionally affect low income and least developed countries compared to high income countries who are better integrated into global value chains. Thus, low income countries may be more vulnerable to supply chain disruptions. Further on the demand side, low income countries spend a much larger share of their household budgets on food and are thus their purchases are more sensitive to income changes that may be caused by Covid19. Table 3 performs the estimations according to selected subsamples which partition the data into income groups defined by the World Bank. Low income groups are defined as countries with a GNI per capita of less than $4k , Middle income countries $4k-$12.5, and high income >$12.5k.

The results in Table 3 report varying degrees of significance across the different specifications. Overall the differences across Covid19 indicators and income groups tends to be mixed. For example, the de facto level of lock down for the importing country, which tends to carry the strongest effect, is generally larger for trade within low-income countries relative to trade within high-income countries. For example, a one standard deviation increase of the lockdown effect leads to a 5% reduction in low-income to low-income agricultural exports but only 3% for high-income to high income trade. However the effects on policy response is a mixed. Low-income to middle-income agricultural exports but low-income to low-income agricultural exports are non-significant.

Table 3. Impact of Covid19 on value of agricultural trade, by income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Level of Income	Low-Low	Low-Mid	Low-High	Mid-Low	Mid-Mid	Mid-High	High-Low	High-Mid	High-High
Deaths per Mil_Exporter	-0.0001	0.0002	-0.0001**	0.0000	0.0002	-0.0002***	0.0000	-0.0000	-0.0000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Deaths Per Mil_Importer	-0.0001	-0.0003**	-0.0001**	-0.0000	-0.0002**	-0.0001***	-0.0003***	-0.0003***	-0.0003***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	184,546	194,227	255,460	241,435	249,147	297,309	319,875	325,724	358,712

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Level of Income	Low-Low	Low-Mid	Low-High	Mid-Low	Mid-Mid	Mid-High	High-Low	High-Mid	High-High
Oxford Policy Stringency_Exporter	-0.0003	0.0002	-0.0009***	-0.0015***	-0.0006	-0.0010***	0.0005	0.0002	-0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Oxford Policy Stringency_Importer	-0.0010	-0.0034***	-0.0002	-0.0011**	-0.0023***	-0.0005	-0.0029***	-0.0026***	-0.0023***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	187,726	196,301	260,341	244,291	251,287	302,026	325,672	330,953	365,253

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Level of Income	Low-Low	Low-Mid	Low-High	Mid-Low	Mid-Mid	Mid-High	High-Low	High-Mid	High-High
Google workplace mobility_Exporter	0.0026**	0.0025***	0.0017***	0.0026***	0.0033***	0.0018***	0.0008*	0.0010**	0.0012***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Google retail mobility_Importer	0.0022***	0.0010	0.0008***	0.0015***	0.0011**	0.0010***	0.0019***	0.0017***	0.0015***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	289,913	251,152	318,745	346,947	308,473	364,132	449,892	427,673	467,559

*Estimated with PPML. Includes ijm, it, jt, mt, fixed effects. Standard errors are in parentheses and robust to clustering on ijm. * and ** denote statistical significance at the ten and five percent levels, respectively. Estimated on monthly data from Jan 2016, to Dec. 2020. Agricultural trade includes all HS codes defined under USDA's BICO definition of Agricultural and Agricultural related goods. Product groups defined by BICO codes. Income groups defined by World Bank Classification. High income countries have GNI per capita >$12.5k, Middle income $4k-$12.5k, and Low Income <$4k. (1) Low-low means low-income country exports to low-income country, (2) low-mid means low-income country exports to middle-income country, and the rest of the columns follow accordingly. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices.*

5.4 Has trade at the end of 2020 showing signs of recovery?

We also examine some dynamics of the covid19 effect during different periods of the pandemic. To estimate this, we split up the estimates according to different quarters throughout 2020 and perform the estimations on both the non-agricultural and agricultural sector. Table 4 reports the results estimates. Columns 1-3 report the results for estimation of the number of deaths. The direct effect is very limited and weak for both non-agricultural and agricultural trade. Columns 4-6 report the policy response. We find a very significant negative Covid19 effect under Q2. This effect is however much lower for Q3 and Q4. We also find that the de facto impact is most severely felt under Q2 and lessens for Q3 and Q4. The joint effect also finds the same trend.

We note that in some cases the effect is not only due to changes in the severity of Covid19 indicators; but also attributed to an attenuation of the Covid19 effect across time. For instance, we can see in the policy response, the estimated coefficients or elasticity lessens from Q2 to Q4. We observe some similar lessening for the de-facto coefficients, however to a lesser degree. The effects suggests that trade and supplly chains may have learned to adjust to both the policy response and lockdown factors of Covid19 following initial disruption.

Table 4. Effects of Covid19 on Value of Non-Agriculture Trade by Quarter

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Quarter	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4
Deaths per Mil_Exporter	-0.0004***	-0.0008***	-0.0004***							0.0001	-0.0003**	0.0001
	(0.00)	(0.00)	(0.00)							(0.00)	(0.00)	(0.00)
Deaths Per Mil_Importer	-0.0004***	-0.0004*	0.0001							-0.0002*	-0.0001	0.0002**
	(0.00)	(0.00)	(0.00)							(0.00)	(0.00)	(0.00)
Oxford Policy				-0.0066***	-0.0047***	-0.0053***				0.0000	-0.0000	-0.0000
Stringency_Exporter				(0.00)	(0.00)	(0.00)				(0.00)	(0.00)	(0.00)
Oxford Policy				-0.0033***	-0.0010**	0.0002				-0.0013*	0.0008*	0.0001
Stringency_Importer				(0.00)	(0.00)	(0.00)				(0.00)	(0.00)	(0.00)
Google workplace							0.0046***	0.0038***	0.0058***	0.0057***	0.0037***	0.0069***
mobility_Exporter							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Google retail							0.0036***	0.0028***	-0.0000	0.0023***	0.0029***	0.0016**
mobility_Importer							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	269,982	270,795	267,231	280,408	280,966	277,591	377,960	378,595	374,499	244,319	244,913	241,589

Effects of Covid19 on Value of Agriculture Trade by Quarter

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Quarter	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4
Deaths per Mil_Exporter	-0.0000	0.0000	0.0000							0.0001	0.0001	-0.0000
	(0.00)	(0.00)	(0.00)							(0.00)	(0.00)	(0.00)
Deaths Per Mil_Importer	-0.0002***	-0.0004**	-0.0002*							-0.0001	-0.0001	-0.0000
	(0.00)	(0.00)	(0.00)							(0.00)	(0.00)	(0.00)
Oxford Policy				-0.0012***	-0.0004	-0.0004				0.0020***	0.0008	0.0000
Stringency_Exporter				(0.00)	(0.00)	(0.00)				(0.00)	(0.00)	(0.00)
Oxford Policy				-0.0024***	-0.0017**	-0.0021**				-0.0000	-0.0004	-0.0000
Stringency_Importer				(0.00)	(0.00)	(0.00)				(0.00)	(0.00)	(0.00)
Google workplace							0.0026***	0.0023***	0.0024***	0.0043***	0.0026***	0.0014
mobility_Exporter							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Google retail							0.0012***	0.0011***	0.0006	0.0009*	0.0009	0.0008
							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	237,977	238,163	235,525	247,517	247,527	245,162	323,281	323,814	320,767	216,309	216,452	214,024

*Estimated with PPML. Includes ijm, it, jt, mt, fixed effects. Standard errors are in parentheses and robust to clustering on ijm. * and ** denote statistical significance at the ten and five percent levels, respectively. Estimated on monthly data from Jan 2016, to Dec. 2020. Agricultural trade includes all HS codes defined under USDA's BICO definition of Agricultural and Agricultural related goods. Non-agricultural trade. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices.*

6. CONCLUSION

This article conducted a comprehensive one-year ex post econometric assessment of the Covid19 pandemic on global agricultural trade. Given the multifaceted nature of the pandemic's effect on domestic markets and global supply chains (farm gate, processing, distribution, labor, and retail sales and final consumption locations), summarizing the pandemic's overall impact is challenging. However, several empirical findings are apparent as it relates to pandemics and agricultural and non-agricutlural trade.

1. Holding other factors constant, our estimates suggest that Covid19 reduced overall agricultural trade by 5-10%; an effect two-three times smaller than non-agricultural trade.
2. For agriculture trade, the negative impacts of the pandemic seem to be manifested more on the demand side as opposed to export supply.
3. Sharp differences in impacts occur across agriculture commodities. Non-food items (hides & skins, ethanol, rubber, cotton) suffered the steepest trade losses; however, the majority of the sectors experienced an insignificant trade effect of the pandemic, while a few commodities experienced a positive impact likely due to demand shifts for staple products caused by the pandemic (e.g. rice).
4. We find limited and mixed evidence that low income and least developed economy trade flows were more vulnerable to the Covid19 shock, although future research should investigate this effect for key individual commodities of export interest to low income nations.
5. Finally, we found evidence that trade flows had adjusted to Covid19 disruptions over time; however pandemic effects continued to persist through the end of 2020.

Covid19 is a once in century shock to the global economy. While this black swan event is both unprecedented and unique in terms of its effects, the findings summarized above offer useful lessons about how agriculture fares through a major disruption.

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Appendix Tables and Figures

Appendix A. List of countries in dataset

Exporters			Importers			
Albania	India	Senegal	Afghanistan	Ecuador	Liberia	Saudi Arabia
Argentina	Indonesia	Serbia	Albania	Egypt	Libya	Senegal
Australia	Ireland	Singapore	Algeria	El Salvador	Lithuania	Serbia
Austria	Israel	Slovakia	Andorra	Estonia	Luxembourg	Sierra Leone
Bahrain	Italy	Slovenia	Angola	Ethiopia	Macao	Singapore
Belarus	Japan	South Africa	Argentina	Fiji	Madagascar	Slovakia
Belgium	Jordan	South Korea	Armenia	Finland	Malaysia	Slovenia
Belize	Kazakhstan	Spain	Australia	France	Maldives	Somalia
Bolivia	Kenya	Sri Lanka	Austria	French Polynesia	Mali	South Africa
Bosnia	Kosovo	Sweden	Azerbaijan	Gabon	Malta	South Korea
Botswana	Latvia	Switzerland	Bahamas	Gambia	Mauritania	Spain
Brazil	Lithuania	Taiwan	Bahrain	Georgia	Mauritius	Sri Lanka
Brunei	Luxembourg	Thailand	Bangladesh	Germany	Mexico	Sudan
Bulgaria	Macao	Turkey	Belarus	Ghana	Moldova	Swaziland
Canada	Madagascar	Ukraine	Belgium	Greece	Mongolia	Sweden
Chile	Malaysia	United Kingdom	Benin	Guatemala	Montenegro	Switzerland
China	Malta	United States	Bolivia	Guinea	Morocco	Syria
Colombia	Mauritius	Uruguay	Bosnia	Haiti	Mozambique	Taiwan
Costa Rica	Mexico	Zambia	Botswana	Honduras	Myanmar	Tajikistan
Cote d'Ivoire	Montenegro		Brazil	Hong Kong	Namibia	Tanzania
Croatia	Morocco		Brunei	Hungary	Nepal	Thailand
Cyprus	Mozambique		Bulgaria	Iceland	Netherlands	Togo
Czech Republic	Myanmar		Burkina Faso	India	New Zealand	Trinidad and Tobago
Denmark	Namibia		Cambodia	Indonesia	Nicaragua	Tunisia
Ecuador	Netherlands		Cameroon	Iran	Niger	Turkey
Egypt	New Zealand		Canada	Iraq	Nigeria	Turkmenistan
El Salvador	Nicaragua		Chile	Ireland	North Macedonia	Uganda
Estonia	North Macedonia		China	Israel	Norway	Ukraine
Ethiopia	Norway		Colombia	Italy	Oman	United Arab Emirates
Finland	Pakistan		Congo (DROC)	Jamaica	Pakistan	United Kingdom
France	Panama		Congo (ROC)	Japan	Panama	United States
Georgia	Paraguay		Costa Rica	Jordan	Papua New Guinea	Uruguay
Germany	Peru		Cote d'Ivoire	Kazakhstan	Paraguay	Uzbekistan
Ghana	Philippines		Croatia	Kenya	Peru	Venezuela
Greece	Poland		Cuba	Kuwait	Philippines	Vietnam
Guatemala	Portugal		Cyprus	Kyrgyzstan	Poland	Yemen
Honduras	Qatar		Czech Republic	Laos	Portugal	Zambia
Hong Kong	Romania		Denmark	Latvia	Qatar	Zimbabwe
Hungary	Russia		Djibouti	Lebanon	Romania	
Iceland	Saudi Arabia		Dominican Republic	Lesotho	Russia	

Appendix B. BICO Sectors as Defined by USDA

BICO Product Category	BICO Aggregate Sector	HS6-digit Codes Comprising BICO Sectors
Coarse Grains	BULK	100200, 100290, 100300, 100390, 100400, 100490, 100700, 100790, 100820, 100829, 100840, 100850, 100860, 100890
Cocoa Beans	BULK	180100
Coffee (raw/unroasted)	BULK	090112, 090111
Corn (not for seed)	BULK	100590
Cotton	BULK	140420, 520100
Gums	BULK	130190, 400110, 400121, 400122, 400129
Oilseeds	BULK	120300, 120400, 120600, 120710, 120720, 120729, 120730, 120740, 120750, 120760, 120791, 120792, 120799
Other Bulk	BULK	100810, 100830, 121210, 121291, 121292, 121293, 140190, 140200, 140210, 140290, 140291, 140299, 140300, 140310, 140390, 140490, 400130, 500100, 500200, 530110, 530121, 530129, 530130, 530210, 530290, 530310, 530390, 530410, 530490, 530500, 530511, 530521, 530590, 530591, 530599
Peanuts/Groundnuts	BULK	120210, 120220, 120241, 120242
Pulses	BULK	071310, 071320, 071331, 071332, 071333, 071334, 071335, 071339, 071340, 071350, 071360, 071390
Rapeseed	BULK	120500, 120510, 120590
Rice	BULK	100610, 100620, 100630, 100640
Soybeans	BULK	120190
Tobacco	BULK	240110, 240120, 240130
Wheat	BULK	100110, 100119, 100190, 100199
	BULK	
Alcohol	CONSUMER	220290, 220291, 220299, 220300, 220410, 220421, 220422, 220429, 220430, 220510, 220590, 220600, 220810 ,220820, 220830, 220840, 220850, 220860, 220870, 220890
Beef	CONSUMER	020110, 020120, 020130, 020210, 020220, 020230, 020610, 020621, 020622, 020629, 021020 ,160250
Biodiesel	CONSUMER	382600
Cheese	CONSUMER	040610, 040620, 040630, 040640, 040690
Cocoa products	CONSUMER	180310, 180320, 180400, 180500, 180610, 180620, 180631, 180632, 180690
Coffee (roasted/processed)	CONSUMER	090121, 090122, 090140, 090190, 210110, 210111, 210112, 210130
Condiments	CONSUMER	210310, 210320, 210330, 210390, 220900
Dairy (excl. Cheese)	CONSUMER	040110, 040120, 040130, 040140, 040150, 040210, 040221, 040229, 040291, 040299, 040310, 040390, 040410, 040490, 040500, 040510, 040520, 040590, 170210, 170211, 170219, 190110, 210500, 350110, 350190, 350220, 350710, 980210
Eggs	CONSUMER	40700, 40711, 40719, 40721, 40729, 40790, 40811, 40819, 40891, 40899, 350210, 350211, 350219, 350290
Ethanol	CONSUMER	220710, 220720
Food Preparations	CONSUMER	190120, 190190, 190211, 190219, 190220, 190230, 190240, 190300, 190410, 190420, 190430, 190490, 190590, 210410, 210420, 210690
Fresh Fruit	CONSUMER	080300, 080310, 080390, 080430, 080440, 080450, 080510, 080520, 080521, 080522, 080529, 080530, 080540, 080550, 080590, 080610, 080710, 080711, 080719, 080720, 080810, 080820, 080830, 080840, 080910, 080920, 080921, 080929, 080930, 080940, 081010, 081020, 081030, 081040, 081050, 081060, 081070, 081090
Fresh Vegetables	CONSUMER	070110, 070190, 070200, 070310, 070320, 070390, 070410, 070420, 070490, 070511, 070519, 070521, 070529, 070610, 070690, 070700, 070810, 070820, 070890, 070910, 070920, 070930, 070940, 070951, 070952, 070959, 070960, 070970, 070990, 070991, 070992, 070993, 070999

Fruit/Vegetable Juice	CONSUMER	200911, 200912, 200919, 200920, 200921, 200929, 200930, 200931, 200939, 200940, 200941, 200949, 200950, 200960, 200961, 200969, 200970, 200971, 200979, 200980, 200981, 200989, 200990
Nursery	CONSUMER	060110, 060120, 060210, 060220, 060230, 060240, 060290, 060299, 060310, 060311, 060312, 060313, 060314, 060315, 060319, 060390, 060410, 060420, 060490, 060491, 060499
Other Meat	CONSUMER	20410, 20421, 20422, 20423, 20430, 20441, 20442, 20443, 20450, 20500, 20680, 20690, 20810, 20820, 20830, 20840, 20850, 20860, 20890, 21090, 21091, 21092, 21093, 21099, 41000, 50400, 160100, 160210, 160220, 160290, 160300
Petfood	CONSUMER	230910
Pork	CONSUMER	020311, 020312, 020319, 020321, 020322, 020329, 020630, 020641, 020649, 021011, 021012, 021019, 160241, 160242, 160249
Poultry	CONSUMER	020710, 020711, 020712, 020713, 020714, 020721, 020722, 020723, 020724, 020725, 020726, 020727, 020731, 020732, 020733, 020734, 020735, 020736, 020739, 020741, 020742, 020743, 020744, 020745, 020750, 020751, 020752, 020753, 020754, 020755, 020760, 160231, 160232, 160239
Processed Fruit	CONSUMER	080410, 080420, 080620, 081110, 081120, 081190, 081210, 081220, 081290, 081310, 081320, 081330, 081340, 081350, 081400, 121230, 200600, 200710, 200791, 200799, 200811, 200820, 200830, 200840, 200850, 200860, 200870, 200880, 200891, 200892, 200893, 200897, 200899
Processed Vegetables	CONSUMER	071010, 071021, 071022, 071029, 071030, 071040, 071080, 071090, 071110, 071120, 071130, 071140, 071151, 071159, 071190, 071210, 071220, 071230, 071231, 071232, 071233, 071239, 071290, 071410, 071420, 071430, 071440, 071450, 071490, 121294, 121299, 200110, 200120, 200190, 200210, 200290, 200310, 200320, 200390, 200410, 200490, 200510, 200520, 200530, 200540, 200551, 200559, 200560, 200570, 200580, 200590, 200591, 200599
Snack Food	CONSUMER	170410, 170490, 190510, 190520, 190530, 190531, 190532, 190540
Spices	CONSUMER	090411, 090412, 090420, 090421, 090422, 090500, 090510, 090520, 090610, 090611, 090619, 090620, 090700, 090710, 090720, 090810, 090811, 090812, 090820, 090821, 090822, 090830, 090831, 090832, 090910, 090920, 090921, 090922, 090930, 090931, 090932, 090940, 090950, 090961, 090962, 091010, 091011, 091012, 091020, 091030, 091040, 091050, 091091, 091099
Tea	CONSUMER	090210, 090220, 090230, 090240, 090300, 210120
Tree Nuts	CONSUMER	080110, 080111, 080112, 080119, 080120, 080121, 080122, 080130, 080131, 080132, 080211, 080212, 080221, 080222, 080231, 080232, 080240, 080241, 080242, 080250, 080251, 080252, 080260, 080261, 080262, 080270, 080280, 080290, 200819
Distiller Dried Grains (DDGs)	INTERMEDIATE	230330
Essential Oils	INTERMEDIATE	330111, 330112, 330113, 330114, 330119, 330121, 330122, 330123, 330124, 330125, 330126, 330129, 330130, 330190, 330210
Fats	INTERMEDIATE	020900, 020910, 020990, 150100, 150110, 150120, 150190, 150200, 150210, 150290, 150300, 150500, 150510, 150590, 150600, 151610
Fodder	INTERMEDIATE	121300, 121410, 230210, 230220, 230230, 230240, 230250, 230310, 230320, 230670, 230800, 230810, 230890, 230990
Hay	INTERMEDIATE	121490
Hides & Skins	INTERMEDIATE	410110, 410120, 410121, 410122, 410129, 410130, 410140, 410150, 410190, 410210, 410221, 410229, 410310, 410320, 410330, 410390, 430110, 430120, 430130, 430140, 430150, 430160, 430170, 430180, 430190
Meal	INTERMEDIATE	120890, 230500, 230610, 230620, 230630, 230640, 230641, 230649, 230650, 230660, 230690
Other Intermediates (i.e., flours, yeasts, saps, waxes, hairs)	INTERMEDIATE	050210, 050290, 050300, 050510, 050590, 050610, 050690, 050790, 051000, 051110, 090130, 110100, 110210, 110220, 110230, 110290, 110311, 110312, 110313, 110314, 110319, 110320, 110321, 110329, 110411, 110412, 110419, 110421, 110422, 110423,

		110429, 110430, 110510, 110520, 110610, 110620, 110630, 110710, 110720, 110811, 110812, 110813, 110814, 110819, 110820, 110900, 121010, 121020, 121110, 121120, 121130, 121140, 121150, 121190, 130211, 130212, 130213, 130214, 130219, 130220, 130231, 130232, 130239, 140410, 151911, 151912, 151919, 151920, 152190, 180200, 210210, 210220, 210230, 210610, 230110, 230700, 350300, 350400, 350510, 350520, 350790, 382311, 382312, 510111, 510119, 510121, 510129, 510130, 510210, 510211, 510219, 510220
Palm Oil	INTERMEDIATE	151110, 151190, 151321, 151329
Seed	INTERMEDIATE	100111, 100191, 100210, 100310, 100410, 100510, 100710, 100821, 120110, 120230, 120721, 120770, 120910, 120911, 120919, 120921, 120922, 120923, 120924, 120925, 120926, 120929, 120930, 120991, 120999
Soy Meal	INTERMEDIATE	120810, 230400
Soy Oil	INTERMEDIATE	150710, 150790
Honey/Sugars	INTERMEDIATE	40900, 170111, 170112, 170113, 170114, 170191, 170199, 170220, 170230, 170240, 170250, 170260, 170290, 170310, 170390
Vegetable Oil	INTERMEDIATE	150810, 150890, 150910, 150990, 151000, 151211, 151219, 151221, 151229, 151311, 151319, 151410, 151411, 151419, 151490, 151491, 151499, 151511, 151519, 151521, 151529, 151530, 151540, 151550, 151560 ,151590, 151620, 151710, 151790, 151800, 152110, 291570, 291615, 292320
Biodiesel	AG RELATED	382600
Forestry	AG RELATED	4401-4421
Fishery	AG RELATED	All under Chapter 3, 50800, 50900, 51191, 1504, 1604, 1605, 230120

Appendix C. Estimated Impact of Covid19 on Agricultural Trade with product group effects : Values vs Volume

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Value	**Volume**	**Value**	**Volume**	**Value**	**Volume**	**Value**	**Volume**	**Value**	**Volume**
VARIABLES	value	value	value	value	value	value	value	value	value	value
Covid Cases per million_Exporter	0.0000***	0.0000**								
	(0.00)	(0.00)								
Covid Cases per million_Importer	-0.0000	-0.0000								
	(0.00)	(0.00)								
Deaths per Mil_Exporter			-0.0000	-0.0000					-0.0000	-0.0001**
			(0.00)	(0.00)					(0.00)	(0.00)
Deaths Per Mil_Importer			-0.0002***	-0.0001					-0.0001***	0.0000
			(0.00)	(0.00)					(0.00)	(0.00)
Oxford Policy Stringency_Exporter					-0.0003	0.0014***			0.0002	0.0025***
					(0.00)	(0.00)			(0.00)	(0.00)
Oxford Policy Stringency_Importer					-0.0020***	-0.0031***			0.0001	-0.0005
					(0.00)	(0.00)			(0.00)	(0.00)
Google workplace mobility_Exporter							0.0015***	0.0046***	0.0009***	0.0035***
							(0.00)	(0.00)	(0.00)	(0.00)
Google retail mobility_Importer							0.0013***	0.0005*	0.0013***	0.0006
							(0.00)	(0.00)	(0.00)	(0.00)
Observations	8,103,927	7,867,905	8,103,927	7,867,905	8,287,412	8,044,391	9,731,967	9,417,002	7,418,663	7,202,455

*Estimated with PPML. Includes ijkm, it, jt, mt, kt, fixed effects. Standard errors are in parentheses and robust to clustering on ijkm. * and ** denote statistical significance at the ten and five percent levels, respectively. Estimated on monthly data from Jan 2016, to Dec. 2020. Covid19 trade impact is calculated as the estimated coefficient of the case, death count, policy stringency or mobility index projected at the mean level of the indicator from Feb to Dec 2020. Agricultural trade includes all HS codes defined under USDA's BICO definition of Agricultural and Agricultural related goods. Product groups defined by BICO codes. All volume data have been converted into metric tons. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices.*

Appendix D. Product level estimates on Volume of Agricultural Trade

	1. Death Incidence Rates			2. Oxford Policy Stringency			3. Lockdown (Google)		
Product-Group	Deaths per Mil_Export	Deaths Per Mil_Importer	Obs	Oxford Policy Stringency	Oxford Policy Stringency	Obs	Google workplace mobility_Expor	Google retail mobility_Importer	Obs
AnimalFats	0	0	75,471	0.003	-0.003	77,370	0.004	0	81,508
Beef	0	-0.001***	115,877	-0.001	-0.003***	118,409	0.002	0.005***	145,175
BiodieselBlends	0	0	24,898	0.001	-0.005	25,715	-0.008	0.006**	27,423
ChocolateCocoaProducts	-0.000**	0	208,712	0	-0.002***	212,847	0.002**	0.001	247,953
CoarseGrainsexcorn	-0.001	-0.001	77,651	0.005	-0.014***	79,868	-0.005	-0.001	88,974
CocoaBeans	0	0.001	34,222	-0.003	0	35,303	-0.001	0.001	36,973
CoffeeRoastedExtracts	0	-0.001**	165,981	0.002**	-0.004*	170,097	-0.003	0.001	197,752
CoffeeUnroasted	0.000**	0	82,490	0	-0.002	84,935	0.008***	-0.001	91,335
CondimentsSauces	0.000*	0	182,143	0.002**	-0.001	186,182	-0.005***	0	218,223
Corn	0	0	59,165	0.006	-0.005	60,847	0.024***	0.002	69,941
Cotton	-0.001	-0.001	36,745	-0.006	-0.007**	37,876	-0.001	0.009***	41,103
DairyProducts	-0.000*	0.000*	218,151	-0.003	0	222,946	0.002	0.001	272,460
DistilledSpirits	-0.001***	0	132,072	0	-0.002**	134,787	0.004**	0.003***	161,182
DistillersGrains	0	-0.001	13,611	0.002	0.002	14,065	-0.007	0.001	15,923
DogCatFood	0	0	104,508	-0.001	0	107,193	0.001	-0.001**	116,999
Eggs	0	0	75,390	-0.001	-0.002	77,245	0.002	-0.002	91,136
EsentialOils	0	0	179,518	-0.002	0.002	183,893	0.001	0.001	210,942
Ethanol	0	-0.002***	53,800	0.004	-0.001	55,198	0.014***	0.001	63,273
FeedsFoddersNESOI	0	0	172,313	0.002	-0.003**	176,537	-0.001	0	196,882
FishProducts	0	0	223,619	-0.002***	-0.001	228,669	0.003***	0.003***	265,097
FoodPreps	0.000***	0	299,053	0.001	-0.001***	304,912	-0.002**	0	376,170
ForestProducts	0	0	293,722	-0.003***	-0.001	299,561	0.006***	0.003***	357,380
FreshFruit	0.000***	0	157,168	0	0.003***	160,613	0.001	-0.002**	182,128
FreshVegetables	0	0	131,147	0	0.003**	134,010	0.007***	-0.004***	147,855
FruitVegetableJuices	0	0	156,415	0.001	0.001	159,835	0.001	0	184,676
Hay	-0.001**	-0.001	37,222	0.003	0	38,390	0.006	-0.001	42,101
HidesSkins	0.001*	0	57,417	-0.001	-0.007***	59,056	0.005*	0.003**	63,993
LiveAnimals	0.001***	0	65,553	0.001	0.001	67,184	0	-0.001	77,345
MeatProductsNESOI	0	-0.000**	136,395	-0.002***	-0.003***	139,405	0.003***	0.001**	163,726
NonAlcoholicBev	0	0	126,424	0	-0.001	129,010	-0.001	0.001	154,390
Nurseryflowers	-0.000**	-0.000***	128,261	-0.002**	-0.003**	131,003	0.001	0.004***	144,581
OilseedMeal	0	0.001**	57,930	0	0.002	59,627	0.005	-0.001	64,813
OilseedsNESOI	0	0	118,873	-0.001	-0.006**	121,926	0.017***	-0.003	133,809
OtherBulkCommodities	0	-0.001**	108,601	-0.003	-0.001	111,745	0.016***	0.004	120,087
OtherIntermediateProducts	0	0	282,459	0.002**	-0.003***	288,339	0	0.001*	341,771
PalmOil	-0.001	-0.001	57,206	-0.004	-0.003	58,602	0.012**	0.002	67,997
Peanuts	0	0	40,676	-0.002	-0.008***	41,776	0.009*	0	43,628
PlantingSeeds	0.001	-0.001*	129,348	0	-0.001	132,826	0.006	-0.003	149,616
Pork	0	-0.000*	101,945	0	-0.002***	104,202	-0.001	0.003***	127,431
Poultry	0	-0.000***	115,185	-0.001	-0.001	117,341	0.003**	0.003***	149,903
ProcessedFruit	0.000***	0	218,665	-0.002	0	216,644	0.001	0.001	250,330
ProcessedVegetables	0	0.000**	212,389	-0.003	0.001	115,222	0.001	-0.001	131,302
Pulses	0	0	112,412	-0.004	-0.001	22,391	0.001	0.002	24,787
Rapeseed	0	-0.001	21,620	0.007**	0.001	105,431	0.003	-0.003**	122,523
Rice	0.002***	0	103,151	0.004*	-0.003**	87,062	0.007**	0.002*	92,988
RubberAlliedGums	0	0	84,451	0.006	0.002	51,444	0.002	0.002	58,940
SnackFoodsNESOI	0	0	226,046	0.003	-0.003	48,726	0	-0.002	54,243
Soybeanmeal	-0.001**	0	47,268	0.021**	-0.004	37,032	0.005	-0.002	38,807
SoybeanOil	0.002***	-0.001	49,791	-0.003**	-0.001	162,815	0.001	0	184,788
Soybeans	0.001	0	35,888	0.006***	-0.009***	191,957	0.012***	0.001	221,962
Spices	0.001***	0	158,987	-0.004***	0	151,949	0.010***	-0.003**	172,140
SugarsSweeteners	0	0	187,684	-0.003	-0.004*	59,477	0.002	0.001	62,633
Tea	0	0	148,026	-0.002	-0.006***	154,729	-0.014***	0.002	176,547
Tobacco	0	-0.001*	58,344	0.001	-0.001	222,019	-0.001	-0.001	256,879
TreeNuts	0	0	151,071	-0.002	-0.001	48,378	-0.003	0.001	56,823
VegetableOilsNESOI	0	0	216,926	-0.001	-0.002**	223,406	-0.001	0.001	254,670
Wheat	-0.001***	0	46,993	0.001	-0.003***	230,382	-0.001	0.001	274,546

*Estimated with PPML. Includes ijm, it, jt, mt, fixed effects. Standard errors are in parentheses and robust to clustering on ijm. * and ** denote statistical significance at the ten and five percent levels, respectively. Estimated on monthly data from Jan 2016, to Dec. 2020. All volume data have been converted into metric tons. Negative effect on trade is implied by a negative sign for cases & death counts and oxford policy stringency and a positive sign for google mobility indices.*