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# Gravity of Covid-19

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## Abstract

In this study, we analyze the impact of the Covid-19 pandemic on bilateral trade using monthly data from January to June 2020. Imports of the OECD member states are analyzed using a structural gravity model of trade estimated with the Poisson pseudo maximum likelihood estimator. The analysis is conducted for total imports and for fruit and vegetables. Our findings show a significantly negative impact of the pandemic on both import measures, which is more pronounced for the perishable goods than for aggregate imports.

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# 1 Introduction

One year after the outbreak of the pandemic, the cumulative number of Covid-19 cases worldwide reached 83 million, with a death toll of 1.8 million attributed to the corona virus (World Health Organisation, 2020). To help prevent transmission, countries across the globe have adopted various containment measures, including lockdowns, travel restrictions and border closures. These unprecedented measures collapsed international transport and trade activities worldwide, making future developments very uncertain (UNCTAD, 2020). The literature documents similar adverse impacts on trade as a result of the outbreaks of Severe Acute Respiratory Syndrome (Keogh-Brown & Smith, 2008), Ebola (Abban, 2020) and the swine flu (Rassy & Smith, 2013).

The Covid-19 pandamic has a negative impact on both the supply and demand sides of the economy. The supply shock emanates from the under-utilization of the production capacity – factory closures, workers staying home, reduction in labor supply, travel bans, border closings – that reduces exports particularly in severely hit sectors in the most impacted nations (Baldwin & Weder di Mauro, 2020; Maliszewska, Mattoo, & Van Der Mensbrugghe, 2020). The pandemic has hindered business activity and restricted the movement of goods and services, thus, adversely affecting global trade and the global supply chain (Baldwin & Tomiura, 2020).

The distortions in the supply chain caused by the pandemic are particularly important for perishable goods. The requirement of additional certificates to cross borders translates into delays that are more detrimental for perishable goods than non-perishables. Moreover, social distancing, creates difficulties for export and import inspections that can exacerbate the delays along the supply chain (OECD, 2020). Together with the risks and uncertainties related to the sale of perishable products, with low storage capacity and major production losses, all this makes perishable goods more vulnerable (Junior et al., n.d.).

Similarly, the Covid-19 pandemic has eroded aggregate demand mainly due to the reduced purchasing power. As industries are inter-connected, the reopening of a fully or partially closed business depends on the reopening of the related businesses, including retailers, distributors and suppliers (Balla-Elliott, Cullen, Glaeser, Luca, & Stanton, 2020). McKibbin and Fernando (2020) point out to the decline in aggregate demand and distorted consumption patterns associated with the situations of panic among consumers and producers.

A burgeoning literature has developed on the economic impact of the Covid-19 pandemic (Abiad, Arao, & Dagli, 2020; Baldwin & Weder di Mauro, 2020; Brodeur, Gray, Islam, & Bhuiyan, 2021; Chetty, Friedman, Hendren, Stepner, et al., 2020). Covid-19 caused a huge dip in global trade, mainly through the resulting supply and demand shocks (Gruszczynski, 2020); however, the net effect of such external and unexpected shocks on imports and exports is unclear (del Rio-Chanona, Mealy, Pichler, Lafond, & Farmer, 2020). Despite the substantial disruption in international trade amid Covid-19, there are only few studies that explain the bilateral trade impact of the pandemic using a gravity model

framework. For instance, using monthly data for 68 countries, Barbero, de Lucio, and Rodríguez-Crespo (2021) finds that the negative impact of Covid-19 is more pronounced for trade flows between members of free trade agreements, particularly in the case of high income countries. Similarly, Hayakawa and Imai (2021) analyses exports flows of medical products between January 2019 and August 2020 using a sample of 35 reporting countries and 250 partner countries. The findings show that an increase in Covid-19 stringency measures reduces bilateral exports, though such effects become minimal when exporting to countries with closer political, economic, and geographical ties. In another study, the adverse Covid-19 effect was found for both exporting and importing countries (Hayakawa & Mukunoki, 2021); nevertheless, effects in importing countries tend to become trivial since July 2020. Also using a gravity model of trade applied to Commonwealth countries over the period from January 2019 to November 2020 Khorana, Martínez-Zarzoso, and Ali (2021) find that a surge in the COVID-19 cases in low-income importing countries reduced Commonwealth exports. The current study contributes to the existing literature by assessing the impact of Covid-19 on bilateral aggregate trade vis-à-vis the trade of perishable goods, i.e. fruit and vegetables.

# 2 Econometric Estimation

Using the gravity model of trade, the present study estimates the impact of Covid-19 on bilateral imports of the OECD member states from 101 exporting countries over the period January–June 2020. Data on imports are taken from the TRADE MAP database of the International Trade Centre. Similarly, the traditional gravity variables – namely distance, contiguity, and colony – are taken from the CEPII database. These variables are commonly included in the gravity equation to account for time invariant country-pair factors that facilitate or hinder trade flows. The information on economic integration agreements (EIAs) is borrowed from Mario Larch's Regional Trade Agreements Database from Egger and Larch (2008). Bilateral trade is expected to be higher if the countries are members of an economic integration agreement.

Data on Covid-19 are retrieved from Our World in Data portal. The incidence of the pandemic in a country can be measured in terms of the cumulative number of Covid-19 cases. However, this measure is affected by the testing capacity of a country. Therefore, we opted for number of deaths due to Covid-19. To account for country size, we normalized the number of deaths caused by the pandemic by the total population of the country. Thus, the variable $\text{Covid}_{it}$ ($\text{Covid}_{jt}$) measures the number of confirmed deaths per million inhabitants per month due to the virus in the exporting (importing) country. In order to keep the zero values of this variable after logarithmic transformation, we add 1 to the number of monthly deaths. An additional variable is included, $\text{DNoCovid}_{ijt}$, which takes a value of one if there were no deaths in a given month, and zero otherwise. This approach yields an unbiased estimation for the full sample (Battese, 1997). Note that $\text{DNoCovid}_{ijt}$ is a country-pair

specific time variant variable. Thus, we expect $\delta_1 < 0$, $\delta_2 < 0$ and $\delta_3 > 0$ in Equation (1).

$$\begin{aligned}\text{Imports}_{ijt} = \exp\big(&\alpha_i + \beta_j + \gamma_t + \delta_1 \ln \text{Covid}_{it} + \delta_2 \ln \text{Covid}_{jt} + \delta_3 \text{DNoCovid}_{ijt} \\ &+ \delta_4 \ln \text{Distance}_{ij} + \delta_5 \text{Contiguity}_{ij} + \delta_6 \text{Colony}_{ij} + \delta_7 \text{EIA}_{ij}\big)\epsilon_{ijt} \end{aligned} \tag{1}$$

In Equation (1) the trade effect of Covid-19 is estimated separately for the exporting and importing countries. This specification does not include exporter-time and importer-time fixed effects as they would absorb the variables of interest. Next, we re-formulate the target variable as $\text{Covid}_{ijt} = \text{Covid}_{it} \times \text{Covid}_{it}$ to capture the impact of Covid-19 on bilateral imports. As the variable $\text{Covid}_{ijt}$ is country-pair specific and time variant, it allows for a more rigorous statistical estimation through the inclusion of exporter-time, importer-time and country-pair fixed effects, as given in Equation (2) below.

$$\text{Imports}_{ijt} = \exp\big(\alpha_{it} + \beta_{jt} + \gamma_{ij} + \delta_1 \ln \text{Covid}_{ijt}\big)\epsilon_{ijt} \tag{2}$$

Finally, the trade impact of Covid-19 is analyzed across the income levels of exporting countries. Based on the World Bank's classification, we formulated two dummy variables: $\text{HighIncome}_i$ takes a value of one when the exporter is a high income or upper-middle income country, and zero otherwise; and $\text{LowIncome}_i$ denotes lower-middle income and low income exporting countries.

$$\begin{aligned}\text{Imports}_{ijt} = \exp\big(&\alpha_{it} + \beta_{jt} + \gamma_{ij} + \delta_1 \ln \text{Covid}_{ijt} \times \text{Highincome}_i \\ &+ \delta_2 \ln \text{Covid}_{ijt} \times \text{Lowincome}_i\big)\epsilon_{ijt} \end{aligned} \tag{3}$$

For the estimation of the three equations, we applied Poisson pseudo maximum likelihood estimator which is appropriate in the case of zero trade and heteroscedasticity (Silva & Tenreyro, 2006, 2011).

# 3 Results and Discussion

The results presented in Table 1 show a negative and statistically significant effect of Covid-19 on bilateral imports. The effect is negative for the variables $\text{lnCovid}_{it}$ and $\text{lnCovid}_{jt}$, whereas it is positive for the variable $\text{DNoCovid}_{ijt}$. In particular, the results indicate that incidence of Covid-19 in the exporter but not in the importer is having a significant impact on aggregate imports of the OECD (similar to the results in Khorana et al. (2021) for a global sample of countries). However, in case of the fruit and vegetables imports, the impact of Covid-19 incidence in both the exporter and importing countries is statistically significant. The signs of other gravity variables are as expected.

Table 1: Trade effect of Covid-19: Estimations of Equation (1)

| | Total Imports | | Fruit & Vegetable Imports | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| $\ln\text{Covid}_{it}$ | −0.044*** | −0.039*** | −0.016** | −0.014* |
| | (0.010) | (0.010) | (0.008) | (0.008) |
| $\ln\text{Covid}_{jt}$ | −0.011 | −0.007 | −0.033** | −0.029* |
| | (0.013) | (0.012) | (0.016) | (0.016) |
| $\text{DNoCovid}_{ijt}$ | | 0.152** | | 0.167** |
| | | (0.066) | | (0.078) |
| $\ln\text{Distance}_{ij}$ | −0.498*** | −0.500*** | −0.831*** | −0.832*** |
| | (0.040) | (0.040) | (0.104) | (0.104) |
| $\text{Contiguity}_{ij}$ | 0.569*** | 0.568*** | 0.638*** | 0.638*** |
| | (0.097) | (0.097) | (0.198) | (0.198) |
| $\text{Colony}_{ij}$ | 0.270*** | 0.272*** | 0.510** | 0.510** |
| | (0.098) | (0.098) | (0.245) | (0.245) |
| $\text{EIA}_{ij}$ | 0.198*** | 0.197*** | 0.566*** | 0.565*** |
| | (0.038) | (0.038) | (0.107) | (0.107) |
| $N$ | 22,206 | 22,206 | 22,206 | 22,206 |

Notes: Robust country-pair clustered standard errors are given in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1. Fixed effects for exporter, importer and time are included but not reported for the sake of brevity.

Table 2 presents the estimates corresponding to Equation (2) and (3) , where the variable Covid-19 is constructed as a country-pair variable. The impact of Covid-19 on trade is found to be negative and significant, for both total imports and fruit and vegetables. The table also shows the impact of Covid-19 for low income and high income countries. The results indicate that whereas the effect is not statistically different between groups for total imports, it is for imports of fruit and vegetables, being significantly higher for high income countries.

Table 2: Trade effect of Covid-19: Estimations of Equation (2) and (3)

| | Total Imports | | Fruit & Vegetable Imports | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| $\ln\text{Covid}_{ijt}$ | −0.022** | | −0.079*** | |
| | (0.010) | | (0.025) | |
| $\text{DNoCovid}_{ijt}$ | 0.163** | 0.163** | 0.056 | 0.062 |
| | (0.078) | (0.077) | (0.088) | (0.088) |
| $\ln\text{Covid}_{ijt} \times \text{HighIncome}_i$ | | −0.022* | | −0.098*** |
| | | (0.011) | | (0.028) |
| $\ln\text{Covid}_{ijt} \times \text{LowIncome}_i$ | | −0.022* | | −0.055** |
| | | (0.012) | | (0.026) |
| $N$ | 21,972 | 21,972 | 15,046 | 15,046 |

Notes: Robust country-pair clustered standard errors are given in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1. Exporter-time, importer-time and country-pair fixed effects are not reported for the sake of brevity.

The overall results indicate that the fruit and vegetables sector is particularly vulnerable to outbreaks in the importing countries. The impact on this sector is crucial, and unless coordinated action is taken, supply chains will be distorted. The main concerns in this regard is the sustainable supply of food items at a stable price. With the higher incidence of Covid-19 pandemic, countries adopt more stringent measures, which in turn results into higher costs along the supply chains. Such new costs are due to many factors, including the inefficiency caused by the necessary social distancing in orchards and pack-houses, increases in logistical costs due to trucks returning empty to their base, additional safety measures, and delays (OECD, 2020). These additional costs inflate the food prices. In this context, Espitia, Rocha, and Ruta (2020) argue that export restrictions could drive up the average price of food by almost 50 percent. They further explain that such a rise is driven by products like fresh fruit and vegetables, whose import demand is much less elastic vis-à-vis specific producers, leading to higher price increases when they are hit by a supply shock.

Clearly the effects will differ between countries. For example, Canada relies heavily on seasonal imports of fresh products from the United States and Mexico, whereas the United States is a net importer of Canadian beef and cattle. As the pandemic passes the one-year mark, assessments of the supply-side effects will need to consider the vulnerability to international trade disruptions of the food categories for which Canada is a net importer. Efforts to maintain relatively frictionless cross-border trade in agri-food products during the Covid-19 pandemic are critical. This includes steps to mitigate any risk of inspection-related disruptions for imported fruit and vegetable from the United States and Mexico.

Net importers are therefore exposed to risks on the supply side. Export restrictions implemented by key commercial partners and disruptions in production and logistics chains may affect them directly in the short run, whereas a spiral of rising food prices would afflict them indirectly. At the opposite end of the spectrum, net exporters are exposed to risks on the demand side. Rising costs and obstacles along the trade routes will negatively affect

them in the short run. Whereas in the medium run, the impact will depend on the dynamics of global demand and export prices, against the backdrop of a looming global recession.

# 4 Conclusions

Our analysis presents empirical evidence of the negative impact of Covid-19 on OECD imports, particularly focusing on perishable products. As some OECD countries import fruit and vegetables mostly from developing countries, the decline in trade would on the one hand adversely affect smallholder growers in the exporting countries. On the other hand, consumers in the importing countries would have to pay higher prices. In order to mitigate the negative effects of the pandemic, it should be recommendable to eliminate tariffs and other artificial trade barriers on food imports and on the imported inputs required for the production of fruit and vegetables. In the same way, trade facilitation initiatives focused on strengthening electronic infrastructure would minimize human contact and contribute to reduce trade cost. Furthermore, access to protective material by all fresh produce workers along the supply chains should be guaranteed on a priority basis. This analysis could be informative for governments and help them to consider and select national priorities for action. More critically, it can help to build a road-map for a more sustainable and resilient global economy. Policymakers should encourage domestic production of essential goods, including fruit and vegetables, in order to increase resilience and to reduce dependence on imports from other countries. These actions could be done with the help of industrial policies and could be crucial to overcome potential future disruptions on the global value chains, which could be originated by unexpected environmental and/or health shocks.

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