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Globalization and infectious diseases: Evidence on the reproduction rate of the COVID-19 pandemic

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Abstract

In this paper we investigated the impact of globalization on infectious diseases and found that export values contributed greatly to the reproduction rate of the COVID-19 outbreak. We collected the number of new cases and deaths from the Worldometer and trade data from the International Trade Center. Our sample covered more than 100 countries. In addition, we applied the epidemiology model, namely the SIR model, to relate globalization to the infection rate. Our results indicated that high export values contributed to high infection rate, especially among high income countries. Finally the impacts were not identical across sectors: they ranged from positive in some sectors to insignificant and even negative in others.

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1 Introduction

Economists have traditionally argued that income is a contributing factor to health improvement (Pritchett and Summers, 1996; Lynch et al., 2004). Marmot (2002) suggested that economic growth resulted in improved material conditions such as sanitary facilities. It also created greater health awareness. It is then not surprising that globalization, often touted as an important factor in raising income across countries, is considered to be positively related to health. Indeed, Bhagwati (1998) argued that health, particularly in developing countries, would be improved as a result of globalization as more medical technologies crossed borders and patients sought care in better or lower cost facilities in other countries. This line of argument is supported by subsequent studies (Dollar, 2001; Levine and Rothman, 2006; Owen and Wu, 2007).

Recent evidence has raised the question whether the income-health relationship is monotonic (Case and Deaton, 2017). Globalization was shown to cause some profound but unpredictable changes in ecological, biological and social conditions (Saker et al., 2004). In addition, the distributional effect of globalization also played a significant role (Lee, 1999). As a result, the spread of infectious diseases is most likely one of the most health effects of globalisation (Newcomb, 2003).

In this paper we investigated the impacts of globalization on a novel disease, the COVID-19 outbreak. This outbreak is perhaps one of the greatest global crisis since World War Two, affecting 210 countries and territories around the world (Worldometers, 2020; UNDP, 2020). This virus has been prolific because of its high reproduction rate, the number of infection transmitted by a single patient. Our research question then is: *Does globalization explain the reproduction rate of the COVID-19 pandemic?*

By applying an epidemiology model called the SIR model, we were able to relate the reproduction rate to the international economic activities, measured by trade volumes. Admittedly these activities resulted in more interactions was an important condition for a high reproduction rate. In order to calculate the reproduction rate, we needed to estimate the number of people tested positive with the virus. Since this number was underestimated by the number of reported cases, we had to revise this number based on the number of deaths. Our principal data came from the Worldometers which reported the number of daily cases and deaths in over 100 countries.

Our analysis identified three important results. First, more international trade in goods resulted in more cases. For every 1 billion USD increase in export value in 2019, the infection rate increased by 0.85 basis points. Second, this impact was more pronounced in high income countries. Arguably the economy in these countries is more interconnected that involves a high number of social and economic interactions. Finally, we provided evidence that not all trades contributed the same way to the spread of the disease. Certain types of trade seemed to curb the spread or had no significant impacts on it.

In addition to the literature that links globalisation and infectious disease discussed above, our paper contribute to a growing literature that investigates the reproduction rate of the novel COVID-19 outbreak. Zhao et al. (2020) estimated the reproduction rate to be 2.2 to 3.5 in the early phase of the outbreak in China while Shim et al. (2020) estimated it to be 1.5 in Korea. Some studies linked natural conditions to this parameter (Luo et al., 2020). To our knowledge, we are the first to analyse the impact of a socio-economic factor on the reproduction rate of this novel disease.

Our paper is organized as follows. In the next Section we presented the model that guided our empirical analysis. Section III presents the data while Section IV discusses our results. The concluding remarks are contained in Section V.

2 Model

Follow the literature on epidemiology (for instance, Anderson and May, 1991 or more recently Wang et al., 2020) we applied the SIR model by dividing the population into two groups of people: susceptible (S) and infectious (I). We have $S_t + I_t = Pop_t$. In each period, new infections occurred from the interactions between susceptible and infected individuals, as follows:

$$dI/dt = R\frac{S}{N}I \tag{1}$$

Arguably human interactions resulted from economic and social activities. In our context, international trade in goods was an important part of economic activities. Put more formally, the reproduction rate R was expressed as a function of exports X:

$$R = \alpha * X \tag{2}$$

The parameter α is the extent to which globalization affected the reproduction rate via trading activities. From Equation (1) we have:

$$\frac{\partial dI/dt}{\partial X} = \alpha\frac{S}{N}I > 0 \tag{3}$$

The equation above yields the following regression:

$$\Delta I_{it} = \beta_0 + \beta_1 * X_i + \epsilon_{it} \tag{4}$$

What we were interested in was the sign of the coefficient β_1. In particular, globalization increased (decreased) the number of new infections if β_1 was positive (negative).

In the context of a zoonotic disease such as the COVID-19 outbreak, the reproduction rate has received particular attention (Liu et al., 2020, Luo et al., 2020, Shim et al., 2020). Indeed, if the rate is higher than 1 we will have an exponential growth of the new cases. We can only contain the outbreak if this rate is less than 1. As we argue that globalization could be an important factor to explain the reproduction rate, we estimated the sensitivity of the reproduction rate to export values as:

$$\frac{\partial^2 dI/dt}{\partial(IS/N)\partial X} = \alpha \tag{5}$$

The equation above yields the following regression:

$$\Delta I_{it} = \beta_0 + \beta_1(I_tS_t) + \beta_2X_i + \beta_3(I_tS_t)X_i + \epsilon_{it} \tag{6}$$

where i indicates countries and t indicates time (month). The coefficient of interest is $\beta_3 = \alpha$.

2.1 How globalization results in the pandemic across countries?

One particular question is whether in some countries (e.g. high income countries vs. middle and low income countries) the diseases became more infectious due to the rapid increase of trading activities. We tested this hypothesis by expanding Regression (6) as follows:

$$\begin{aligned}\Delta I_{it} = \beta_0 + \beta_1(I_tS_t) + \beta_2X_i + \beta_3(I_tS_t)X_i + \beta_4GDPpc_i + \beta_5(I_tS_t)GDPpc_i \\ + \beta_6X_iGDPpc_i + \beta_7(I_tS_t)X_iGDPpc_i + \epsilon_{it}\end{aligned} \tag{7}$$

2.2 The sectoral impacts of trade

There was some evidence that the current corona virus was the second zoonotic corona virus after SARS-CoV (WHO, 2020). A zoonotic virus has a natural animal origin. As a result, the trading of some sectors, especially fresh animal trading could have some health impacts (Huynen, Martens and Hilderink, 2005, Seimenis, 2008). In our context we expanded the function f:

$$f(X) = (\Sigma_f \alpha_f X_f) \tag{8}$$

The sensitivity of the reproduction rate to export that we estimated in Regression (6) was therefore the average effect across sectors. The richness of our data allowed us to analyse in depth the sectoral impacts of trade as follows:

$$\Delta I_{it} = \beta_0 + \beta_1(I_tS_t) + \Sigma_f\beta_{2f}X_{if} + \Sigma_f\beta_{3f}(I_tS_t)X_{if} + \epsilon_{ift} \tag{9}$$

In the equation above, β_{if} is the impact of trade in sector f on the reproduction rate.

3 Data

To measure Covid-19 pandemic across countries and months, we used data from Worldometer (www.worldometers.info) on the infected people and death. The data reported the number of Covid-19 situations in more than 100 countries from February 2020 to April 2020. We also used the value of trade in good in all sectors and in certain categories reported by International Trade Centre (ITC) from January 2019 to February 2020.

One problem when counting the number of infected people and susceptible people was that there were infected people who had not been tested and therefore were not counted in the number of confirmed cases. We followed Jombart et al. (2020) to estimate the number of cases based on the number of reported deaths. Their estimates depended on the values of two critical parameters, case fatality rate (CFR) and the reproduction number (R). We adopted their "average" scenario where CFR = 2% and R = 2 which gives similar results to a number of settings. According to this scenario, a single death corresponded to an average of 276 cases.

We reported the number of revised cases in Figure 1. In this figure, the number of estimated cases and the populations of the corresponding countries were in log terms. The red line is the 45 degree line to help us compare the number of estimated cases against the population. We can see that the countries who are worst hit by the pandemic, as of April 2020, are the high income countries such as the United States, Italy, Spain, France and United Kingdom. Relative to the number of reported cases that we had, the number of estimated cases was inflated by a factor of 170 on average. This factor was more conservative than what was estimated by Imai et al. (2020) for the cases in Wuhan.

Futhermore we extracted the data on Population, GDP per capita, GNI per capita from the World Development Indicators. The latest figure for Population was in 2018. According to the World Bank classification, low-income economies were defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,025 or less in 2018; lower middle-income economies were those with a GNI per capita between $1,026 and $3,995; upper middle-income economies were those with a GNI per capita between $3,996 and $12,375; high-income economies are those with a GNI per capita of $12,376 or more. We applied this classification in our paper.

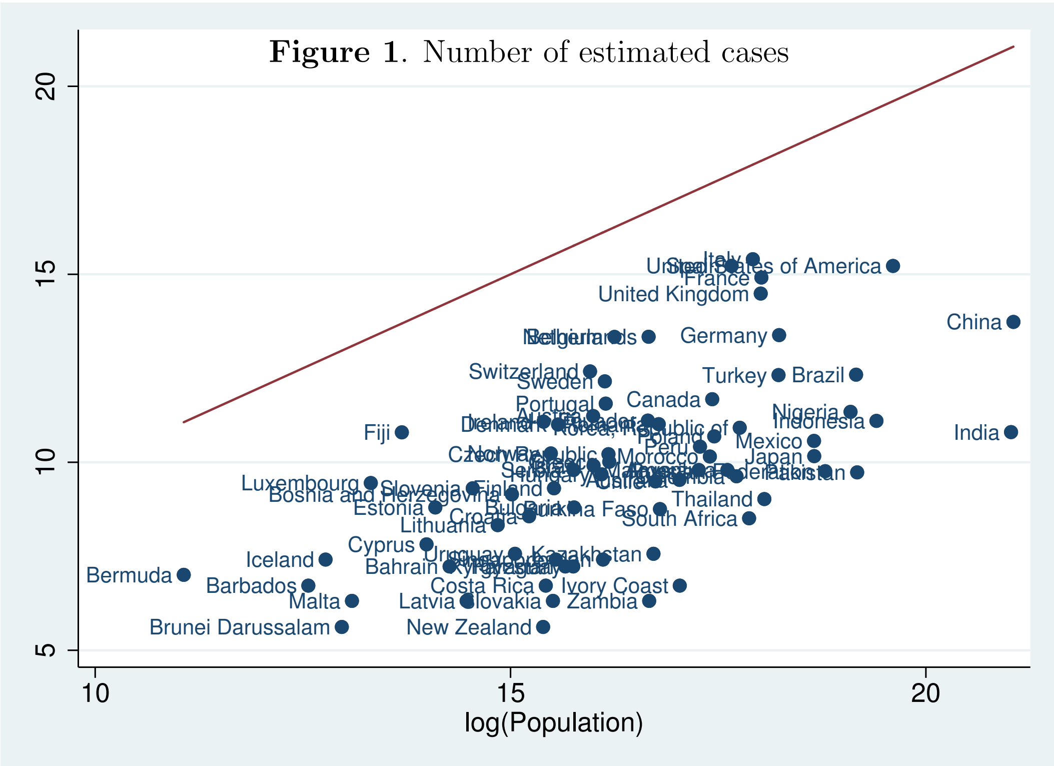
Table 1 presents the summary statistics of our key variables. The total export value indicated the sum of export values over all products exported by one particular country in a particular month. It ranged from 12 millions USD to more than 238 billions USD (China in December 2019) with an average of 18 billions USD. The average of the number of new cases, the number of new deaths, the number of total cases and the number of total deaths reported in a month by a country were 6,609; 383; 10,201 and 558 respectively.

In total we had 75 countries and 3 month data of the pandemic casualties (Feb-2020 to April-2020). Since there were only 2 out of 75 countries (Mozambique and Burkina Faso) that were classified as low income countries, we dropped this category to avoid the multicollinearity problem and put these countries into the low middle income category.

Table 1. Summary statistics

VARIABLES	(1) mean	(2) sd	(3) min	(4) max
Export value ($1 billion USD)	206	395	0	2,499
New reported cases	4,651	19,493	0	245,206
New reported deaths	388.3	1,625	0	12,399
Total reported cases	13,248	43,050	0	434,927
Total reported deaths	415.3	1,699	0	14,792
Population in 2018 (thousands)	74,820	224,500	63.973	1,393,000
GDP per capita in 2018 (USD)	25,963	24,359	499.0	116,640
GNI per capita in 2018 (USD)	24,196	21,735	460	84,410

Figure 1. Number of estimated cases



4 Results

In Table 2 we see that larger the stocks of infected and susceptible people, the higher the number of new infections (Column 1). Also higher export volume seemed to contribute to the number of new infections: every $1 billion USD increase in export value led to nearly 10,000 new infections (Column 2). In Column 3, we see that for every 1 billions USD increase in export value in 2019, the infectious rate increased by 0.8 percentage points. The magnitude of the effect even doubled with the increase in export value for 2018 (Column 4). It is consistent with what we found in the literature. For instance, Oster (2012) showed that doubling exports led to 10% to 70% increase in new HIV infections.

It is worth noting that our data collection took place while the pandemic was still on-going. In fact, some countries such as Brazil or India only experienced the peak of the pandemic later in May 2020. However, the spread of the virus in these countries could have been the result of the internal policies, such as the lockdown and communication policies, rather than trade policy. Indeed, it is suggested that the biggest threat to Brazil's response to the pandemic is its president, Jair Bolsonaro, with his confusing messages to the public by "openly flouting and discouraging the sensible measures of physical distancing and lockdown brought in by state governors and city mayors" (Lancet, 2020*a*). And in India, the enforcement of the lockdown policy failed terribly because of the "the spread of misinformation driven by fear, stigma, and blame" (Lancet, 2020*b*).

In Table 3, we see that the impact of globalization on the pandemic increased with the country income (Columns 1 and 3). Moreover, there was a clear ranking in term of the magnitude: the impact of globalization in high income countries was the highest, followed by that in the upper middle income countries and in the lower middle income countries (Columns 2 and 4).

In Table 4, we dissected the impacts of trade into its components. In particular we were interested in the Food sectors. What is interesting is the heterogeneous impacts across sectors. In Column 1, we used the annual trade data for 2019. It shows that export of Meat, Dairy products and Fruits seemed to have no impact on the infection rate. The export of Fish, however, seemed to raise the number of people catching the virus. And more interestingly the export of Vegetables reduced the infection rate. When we used the annual trade data in 2018 (Column 2), the results were similar. It shows the robustness of our results.

5 Conclusions

In this paper we examined the impact of trade on the Covid-19 pandemic. We found increased trade led to higher pandemic infection. Accordingly, for every 1 billion USD increase in export value in 2019, the infectious rate increases by 0.85 basis points. This result indicated that globalization influenced the spread of the infectious diseases globally. Indeed, other aspects of globalization such as international travels and cultural exchanges could have played a role in spreading the diseases. We also found that the impacts varied across countries. In particular, globalization made the disease more contagious in high income countries where the economy admittedly was more complex and involved more interactions. Finally we provided evidence that trade in different sectors had heteroge-

Table 2. The role of globalization

	(1)	(2)	(3)	(4)
Dependent variable: Estimated new infections				
IS	8.385***		1.465**	1.669**
	(0.531)		(0.668)	(0.667)
Export		9850.221***	1259.883	1909.468
		(952.694)	(770.430)	(1508.198)
IS#Export			0.008***	0.016***
			(0.001)	(0.002)
Obs	225	225	225	225
R-squared	0.528	0.324	0.749	0.744
Adj. R-squared	0.526	0.321	0.746	0.741

Standard errors in parentheses. The new infections were estimated from the new reported deaths. Trade data for 2019 were used in Columns 1, 2 and 3, while trade data for 2018 were used in Column 4. Export value unit is $1 billion USD
* p<0.1, ** p<0.05, *** p<0.01

Table 3. The role of income

	(1)	(2)	(3)	(4)
Dependent variable: Estimated new infections				
IS#Export#GDPpc	0.0003***		0.0005***	
	(0.00007)		(0.0001)	
IS#Export#HIC		0.011***		0.022***
		(0.0004)		(0.001)
IS#Export#UMC		0.006***		0.011***
		(0.001)		(0.002)
Obs.	222	225	222	225
R-squared	0.812	0.79	0.81	.79
Adj. R-squared	0.806	0.786	0.804	0.786

Standard errors in parentheses. The new infections were estimated from the new reported deaths. Trade data for 2019 were used in Columns 1, 2 and 3, while trade data for 2018 were used in Column 4. Export value unit is $1 billion USD

* p<0.1, ** p<0.05, *** p<0.01

Table 4. The sectoral effect

	(1)	(2)
Dependent variable: Estimated new infections		
Meat and edible meat offal	0.00017	0.00027
	(0.00033)	(0.00061)
Fish and crustaceans, molluscs and other aquatic invertebrates	0.0019***	0.0042***
	(0.00033)	(0.00071)
Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ...	0.00057	0.0011*
	(0.00035)	(0.00066)
Edible vegetables and certain roots and tubers	-0.0013***	-0.0030***
	(0.00029)	(0.00072)
Edible fruit and nuts; peel of citrus fruit or melons	0.00041	0.00048
	(0.00039)	(0.00067)
Obs	222	222
R-squared	0.807	0.811
Adj. R-squared	0.797	0.801

Standard errors in parentheses. The new infections were estimated from the new reported deaths

* p<0.1, ** p<0.05, *** p<0.01

neous effects. It will be interesting to (i) embed the economic structure to explain the role of income and (ii) characterize the sectoral trades to explain the heterogeneous impacts found in the paper. These ideas will be left to future research.

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