UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS EM GESTÃO E TECNOLOGIA

PROGRAMA DE PÓS-GRADUAÇÃO EM ECONOMIA

LEONARDO FERRAZ

The Gravity of COVID-19: An assessment of international trade policies

Sorocaba – SP

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Dissertação apresentada ao Programa de Pós Graduação em Economia, para obtenção do título de mestre em Economia

Orientação: Prof. Dra. Rosane Nunes de Faria

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DEDICATÓRIA

Dedico este trabalho aos meus pais, Juraci e Simoni, que sempre me apoiaram, incentivaram e foram essenciais para eu poder avançar ao encontro dos meus objetivos.

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RESUMO

FERRAZ, LEONARDO. *The Gravity of COVID-19: An assessment of international trade policies***.** Dissertation (Master degree) – Science Center in Management Technology, Universidade Federal de São Carlos, Sorocaba, 2022

Este estudo avalia os efeitos das políticas de isolamento e políticas comerciais internacionais relacionadas à pandemia de Coronavirus nos fluxos de comércio de 33 países no período de janeiro de 2020 a junho de 2021. São considerados na análise produtos essenciais ao combate da COVID-19 como equipamentos médicos, suprimentos médicos, equipamentos de proteção pessoal e farmacêuticos, também são considerados produtos não essenciais como produtos agrícolas entre outros. O modelo gravitacional de comércio é utilizado para captar os efeitos das políticas de isolamento e políticas comerciais internacionais que são representadas por dias do mês em que *Stay-at-home orders* e *Workplace Closures* foram impostas, o número de casos e mortes e as notificações de medidas comerciais relacionadas à COVID-19. Nossos resultados sugerem que uma parte importante da resposta política à pandemia da COVID-19 está nas mudanças de políticas comerciais. Além disso, essas políticas se concentraram nos produtos essenciais para o combate à COVID-19. O modelo gravitacaional agregado mostrou que os efeitos de variáveis como *Stay-at-Home orders*, *Workplace Closures*, número de casos e mortes podem não ser suficientes para explicar as flutuações nos valores dos fluxos comerciais, pois suas estimativas não são significativas. Por outro lado, quando as medidas comerciais são inseridas no modelo agregado, essas variáveis são capazes de explicar as flutuações comerciais. Para avaliar os efeitos das políticas de isolamento e políticas comerciais em diferentes categorias de produtos, as regressões do modelo de gravidade são realizadas desagregadas por categorias de produtos. No geral, os resultados das estimativas das políticas de contenção, casos e variáveis de mortes funcionam como *proxies* para o aumento da demanda por bens, mas seus coeficientes nem sempre são significativos. Os resultados da regressão desagregada refletem o aumento da demanda para determinados produtos, desta forma tem-se que as categorias sofreram diferentes impactos. Produtos farmacêuticos tiveram um aumento de volume de trocas entre os anos de 2020 e 2021 e foram mais impactados pelas políticas comerciais durante a pandemia. Licenças de exportação, barreiras técnicas ao comércio e políticas tarifárias impactaram significativamente os fluxos comerciais de fármacos. Quando essas políticas foram aplicadas por importadores os sinais das estimativas resultaram como positivos, por outro lado, quando aplicadas por exportadores os sinais das estimativas são negativos. Isso é um exemplo da maneira desordenada e autocentrada em que os países buscaram garantir seus estoques de bens essenciais, implementando uma série de políticas que apresentavam obstáculos às exportações e concomitantemente facilitavam as importações. Os resultados para alguns produtos médicos e produtos de proteção pessoal reforçam esta noção, tendo em vista que proibições de exportação e políticas tarifárias afetaram negativamente os fluxos comerciais para essas categorias. Por fim, nota-se que os países buscaram, em conjunto, facilitar os fluxos de produtos agrícolas buscando aliviar práticas aduaneiras e amenizar proibições de exportação.

Palavras-chave: Políticas comerciais; COVID-19; Comércio Internacional; Modelo Gravitacional.

ABSTRACT

FERRAZ, LEONARDO. *The Gravity of COVID-19: An assessment of international trade policies***.** Dissertation (Master degree) – Science Center in Management Technology, Universidade Federal de São Carlos, Sorocaba, 2022

This study assesses the effects of the containment policies and international trade policy notifications related to the novel Coronavirus pandemic on the trade flows of 33 countries from January 2020 to June 2021. COVID-19 essential products such as medical equipment, medical supplies, personal protective equipment, and pharmaceuticals are considered in the analysis. Non-essential products such as agricultural products, among others, are also considered. The gravity model of trade is used to assess the effects of containment policies and international trade policies, which are represented by days of the month when Stay-at-home orders and Workplace Closures were imposed, the number of cases and deaths and COVID-19 trade-related notifications sent to the WTO. Our results suggest that an essential part of the policy response to the pandemic of COVID-19 lies in trade policy changes. Furthermore, these policies focused on the critical products to fight against COVID-19. The aggregated empirical gravity model showed insignificant estimates for stay-at-home requirements, workplace closures, cases, and deaths, indicating they might not be sufficient to explain the fluctuations in trade flows. On the other hand, the estimates presented by trade policies suggest that these variables can better explain trade fluctuations. The gravity model is performed disaggregated across product categories to assess the effects of different policies on different product categories. Overall, the results of the estimates of the containment policies, cases, and deaths variables seem to work as proxies for the rise in demand for goods, but their coefficients are not always statistically significant. The product disaggregated regression results reflect the demand increase for specific products. Thus the categories suffered different impacts. Pharmaceuticals presented a rise in trade volume between 2020 and 2021 and were also the category most impacted by trade policies during the pandemic. Export licenses, technical barriers to trade, and tariff policies significantly impacted the trade flows of pharmaceuticals. When importers applied these policies, the signs of the estimates resulted as positive, on the other hand, when used by exporters, the signs of the estimates are negative. It is an example of the disorderly and self-centered manner in which countries sought to secure their stock of essential goods by implementing policies that presented obstacles to exports and concomitantly sought to facilitate the importation of goods. The results for medical products not elsewhere specified and personal protection products reinforce this notion since export bans and tariff policies negatively affected trade flows for these categories. Finally, it is noted that countries have collectively sought to facilitate the flow of agricultural products by seeking to ease customs practices and export bans.

Keywords: Trade policies; COVID-19; International Trade; Gravity Model.

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SUMMARY

1 INTRODUCTION

In December 2019, several patients with similar pneumonia symptoms were reported in Hubei, China. A new virus caused a new disease, severe acute respiratory syndrome coronavirus 2, or SARS-CoV-2, later named Coronavirus Disease 2019 (COVID-19). This pathogen can be distributed broadly among humans and cause fatal illnesses (ZHU *et al.*, 2020). The ease of infection due to long incubation periods, large number of asymptomatic individuals, quick viral reproduction, capacity to last on surfaces, and massive cross-border movement of people enabled the fast spread of the disease throughout the world. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic (HAYAKAWA; MUKUNOKI, 2021a; QIU; CHEN; SHI, 2020; WORLD HEALTH ORGANIZATION, 2020a; WU; CHEN; CHAN, 2020).

In response, countries have developed public containment policies based on surveillance and detection, clinical management of cases, prevention of the spread, and maintenance of essential services (WTO, 2020). Containment policies related to the prevention of the spread involve restrictions on people and businesses, such as lockdowns and quarantines that vary in strictness (HALE *et al.*, 2021a; HAYAKAWA; MUKUNOKI, 2021b; QIU; CHEN; SHI, 2020). Such policies, paired with death and prolonged illness, have negatively affected international trade and reduced the supply of goods. On the demand side, these circumstances decreased earnings and the need for non-essential goods (HAYAKAWA; MUKUNOKI, 2021a, 2021b). On the other side, the negative impact on the supply is coupled with the increased demand for essential goods. (FUCHS *et al.*, 2020; LEIBOVICI; SANTACREU, 2021).

The supply and demand distortions caused shortages for most goods, especially those needed to fight the pandemic, and COVID-19 has pushed the world into a crisis. Several economic indexes show that the severity of the pandemic is now evident. Gross domestic product (GDP) estimates and forecasts convey the contraction of the economies of most countries. In some regions, new orders, inventory levels, production, supplier deliveries, and employment figures decreased sharply in some months. There was an increase in unemployment insurance claims and a decrease in nitrogen oxide emissions (BLUEDORN; GOPINATH; SANDRI; BARICHELLO, 2020; INTERNATIONAL MONETARY FUND, 2020a, 2020b, 2020c, 2021a). There are also pieces of evidence that the severity of the current crisis is similar to 2008’s financial crisis. Comparing both crises makes it possible to assess that the economic slump of the COVID-19 crisis could be greater when looking into GDP estimates. While in

2020 the world growth rate was -3,5%, in 2009 it was only -0,1% (BARICHELLO, 2020; INTERNATIONAL MONETARY FUND, 2020b; KASSA, 2020; SOCRATES; LASHITEW, 2020; YAGI; MANAGI, 2021).

The harshness of the current crisis is given due to its characteristics. Major economies such as the United States, China, Japan, Germany, the United Kingdom, France, and Italy were affected. Those countries represent 60% of the world GDP, 65% of global manufacturing, and 40% of global imports. On top of that, nations experienced synchronized sharp economic downturns.

The containment of the pandemic is nothing short of complex. Throughout 2021 countries were still struggling to battle the virus due to the evolving character of the SARS-CoV-2. Due to the massive infection rates and the ease of mutation, new virus variants began to manifest throughout 2020 and 2021. These new variants, such as Delta and Omicron, were even more infectious than the original ones. The Omicron variant was also said to be more resistant to vaccines. The result is that by the end of 2021, confirmed COVID-19 cases were rapidly rising. As a result, the number of confirmed COVID-19 deaths continues to increase, and by the end of 2021, the world had lost more than 5.390.000 lives (WORLD HEALTH ORGANIZATION, 2020b, 2021a). As of June 2022 the pandemic is still having an effect on the countries' health. In January and February 2022 the omicron variant was still causing massive infections throughout all the regions in the globe, cases and deaths were increasing sharply in these months, reaching its highest levels in February 2022 (WORLD HEALTH ORGANIZATION, 2022a, 2022b). Towards March and April 2022, these numbers began to fall due to the implementation of containment policies and mass vaccination, but the number of cases and deaths could still be considered very high (WORLD HEALTH ORGANIZATION, 2022c). The overall decline in cases and deaths continued during May and June, but, they were still increasing in the Americas region (WORLD HEALTH ORGANIZATION, 2022d, 2022e).

These circumstances extend and deepen the period of uncertainties in the international system. Public administrators maintained and still have to maintain a balance between containing the disease by implementing lockdowns and reducing economic disruptions by trying to keep economic activities undeterred. The alternation between closing and reopening the economy and many deaths jeopardizes the production capacity, disrupts supply chains, and unsettles the financial markets of all countries, which profoundly affects international trade. These distortions, combined with the fiscal policies applied to dampen the COVID-19, worsened the growth forecast for the world GDP in 2022. The projections for 2022 point to an uncertain outlook of higher food and housing prices, unemployment paired with lower wages, production, and low and slow growth rates (COIBION; GORODNICHENKO; WEBER, 2020; IBN-MOHAMMED *et al.*, 2021; INTERNATIONAL MONETARY FUND, 2021b; JENA *et al.*, 2021; ZU *et al.*, 2021).

It is noticeable that the challenges presented by the COVID-19 crisis are related to international trade, which has been hindered by supply and demand shocks caused by the pandemic. Countries responsible for at least 50% of the volume of global exports have been severely hit by the pandemic, which implies that their capacity to produce and demand goods is impaired. The decrease of at least 15% in overall trade value in the first two quarters of 2020 is representative of that (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, 2021; WORLD TRADE ORGANIZATION, 2020a, 2020b, 2021).

Besides that, countries are dependent on one another to produce goods, forming global value chains (GVC) in which different countries partake in the production process supplying parts that vary in added value. While GVC benefits trade, in this crisis, specifically, it is presenting a hurdle because the GVC contagion effects intensify the impacts caused by COVID-19. Countries have to deal with the lower supply of parts due to the infection rates in other countries, which furthers the overall supply of finished products. The GVC contagion effects impact countries faster and more persistently than their supply and demand changes (FRIEDT; ZHANG, 2020; HAYAKAWA; MUKUNOKI, 2021b; MEIER, M., PINTO, 2020).

Furthermore, an important issue that can help stabilize the world economy or boost the economic crises is how countries decide to deal with each other in the international field. The choice to raise barriers makes countries more dependent on their internal suppliers or hanging on a smaller number of global suppliers, which, in turn, increases the risk of not meeting their demands. In this way, international trade is awkwardly part of the problem and the solution for the COVID-19 crisis (BALDWIN; TOMIURA, 2020; BOWN, 2020; EVENETT, 2020a; FARIA; GRIMALDO HIDALGO; FERRAZ, 2021; MARTIN; GLAUBER, 2020).

The literature has shown that countries began to apply international trade policies to guarantee their share of essential goods. Furthermore, they implemented them with little international coordination. While some countries used import facilitating measures, others carried out export and import bans or restrictions. It has somewhat hindered international commerce since countries depend on each other to ensure their stock of products. These international trade measures transformed simple goods, such as food or uncomplicated medical products, into scarce articles. Moreover, the tone of the global system was set to fierce competition in which retaliatory measures have been standard. Consequently, countries highly dependent on developed nations' imports could not secure their share of goods. (BOWN, 2020; EVENETT, 2020b, 2020c; FUCHS *et al.*, 2020; LEIBOVICI; SANTACREU, 2021; SOCRATES; LASHITEW, 2020; STELLINGER; BERGLUND; ISAKSON, 2020; UDMALE *et al.*, 2020).

Recent international trade literature has focused on the damages caused by the pandemic and its impacts on trade. Hayakawa and Mukunoki (2021) applied the structural gravity framework to analyze the effect of the COVID-19 deaths and cases and lesser mobility on trade flows. They also evaluated the GVC contagion effects by examining how the number of confirmed COVID-19 deaths and confirmed COVID-19 cases in other countries affect trade flows (HAYAKAWA; MUKUNOKI, 2020a). Different frameworks have also been used to gauge the COVID-19 effects. Leibovici and Santacreu (2021) consider a multi-country and multi-sector general equilibrium model to assess the role of international trade of essential and non-essential goods in mitigating or amplifying the loss of economic welfare during the pandemic. In addition, Meier and Pinto (2020) analyze the effects of international supply chain disruptions on economic activity and prices during the Covid-19 pandemic, employing a two-sector two-countries Constant Elasticity of Substitution (CES) model using input-output prices, production, employment, imports, and exports data.

The literature has also addressed the trade impact of containment measures implemented at the national level, such as workplace closures and stay-at-home orders. Hayakawa and Mukunoki (2020, 2021a) also checked how these containment policies affected trade flows. Socrates (2020) estimated the effects of covid-19 containment policies in Kenya, providing a new outlook for these policies. Telias and Urdinez (2020) and Fuchs et al. (2020) tried to understand the role of political drivers in the trade of medical products, especially from China.

Nevertheless, little effort has been made to assess the impact of COVID-19 trade-related policies on international trade flows. Authors have focused on describing the measures, pointing out their short-term results, and inferring possible scenarios based on past events. Others focused on discussing the institutional body that could have been used to ensure free trade and cooperation between countries (BOWN, 2020; EVENETT, 2020a, 2020c; EVENETT; WINTERS, 2020; STELLINGER; BERGLUND; ISAKSON, 2020). However, these studies have not examined the impact trade impact of the measures.

Countries extensively applied international trade policies as instruments to guarantee the supply of essential products, with little regard to free trade or the needs of other countries. However, these policies were implemented in a disorganized manner. While some countries implemented trade-restricting measures, others tried to ease the importation of essential products necessary to combat the pandemic, such as Medical Equipment, Medical Supplies, Personal Protective Equipment (PPE), and Pharmaceuticals. This scenario could be detrimental to trade and to the fight against the pandemic since countries depend on one another to supply their demands for essential products (BOWN, 2020; EVENETT, 2020a, 2020c; FARIA; GRIMALDO HIDALGO; FERRAZ, 2021; FUCHS *et al.*, 2020; LEIBOVICI; SANTACREU, 2021).

To understand how these measures have impacted trade throughout the pandemic, one should note which policies were implemented, how they were implemented, and which products they have impacted. Therefore, we aim to contribute to the recent literature by presenting the first attempt to address the following research question: *How have COVID-19 trade-related policies impacted trade flows?* We rely on the WTO trade policy notifications, which are documents that accurately report the changes in trade policy implemented by members during COVID-19 pandemic.

We contribute to the empirical literature in three ways. First, we assess the implementation of the COVID-19 trade-related policies across 33 countries from January 2020 to June 2021. In this way, we provide information on how containment and trade policies were implemented throughout the pandemic, which trade policies were more extensively used, which products were affected by these policies, and to what extent these measures are related to trade fluctuations. Second, we augment the Gravity of COVID-19 models by considering the COVID-19 trade-related policies. Finally, after estimating several general specifications across the entire panel, we differentiate the data set into product categories. It allows for an even more differentiated view on the trade impact of COVID-19 trade-related policies by focusing on the effects of different products and the strategies countries adopted when facing increasing demand for different products.

In summary, our results show that from January 2020 to June 2021, COVID-19 trade-related policies were more capable of explaining trade fluctuations than containment policies. Countries aimed their trade policy response toward essential products, especially pharmaceuticals, to guarantee their stockpile of these goods. In this sense, countries acted individually and disorganizedly, hindering trade measures for exports and facilitating measures for imports.

2 THEORETICAL FRAMEWORK

2.1 GRAVITY MODEL LITERATURE REVIEW

Simply put, gravity equations represent models of bilateral interactions in which two characteristics, size and distance, are expected to affect a dependent variable. These models have been extensively used in applied social science fields outside economics to assess empirical regularities frequently found in social interactions. Gravity equations started to be used in economics because scholars noted that the relation between economic size, distance, and trade flows between countries fit the gravity structure remarkably. Since then, academics have made efforts to offer these models a theoretical background so that the model could be used in a broader range of scenarios with consistent and plausible results (HEAD; MAYER, 2013).

Isard (1962) states that these models were being used with remarkable empirical success, citing Stewart (1948) and Zipf (1946) as forefathers of a thin theoretical background. Zipf (1946) presents the hypothesis that there are economies to be made between the residents of cities or regions when people are more closely distributed. The first economy happens when raw materials are transported to the factories. The second economy occurs when the transportation of goods to the final consumer is done. This logic presents the argument that interactions between regions decrease as the distance increases.

Similarly, Stewart (1948) reasoned that, much like physics, studying a single actor in social sciences can be laborious and unfruitful. Besides, some characteristics and behaviors can only be implied to larger groups of social units, such as people. Therefore the study of aggregates of such units could present unseen results. The author presents the concept of “Gravitational Force” in which the interaction between two aggregates of social units is given by a constant, similar to the gravitational constant in physics, the population of both regions (i and j) and is negatively related to the squared distance between them.

Compelled by consistent empirical results, Isard (1962) condenses the theory mentioned above into a general approach to the “Gravity Model”. The model is outlined as a simple relationship that can describe actual data, depicting the interaction of people within an area as a function of the population of subareas and the distance between them.

The model continues to be widely tested across a range of topics, including international trade in which the trade flow between countries is related to their economic size and the distance between them. Papers by Tinbergen (HASSON; TINBERGEN, 1964; VANEK; TINBERGEN, 1964), Pöyhönen (1963) and Linneman (1966) are regarded as examples of this (MENDOZA CUELLO, 2017; NASCIMENTO; PREGARDIER JÚNIOR, 2013; PIANI; KUME, 2000). The suggestion was that the economic size measured by the GDP could be used as a proxy for the ability to supply other countries and also to demand products from other countries. But, on the other hand, the distance would act as a detriment to trade by increasing the cost of transportation.

Tinbergen (HASSON; TINBERGEN, 1964; VANEK; TINBERGEN, 1964) and Linneman (1966) suggested other models that were being used at that time, such as Ricardian models, could hardly contribute to understanding the value of trade flows. Their papers introduced key concepts and practices into the literature. Tinbergen (HASSON; TINBERGEN, 1964; VANEK; TINBERGEN, 1964) studied a larger set of countries, whereas Linneman (1966) pointed to the idea that variables other than distance also could adversely affect trade flows, such as the element of time, unknown economic horizon, different institutions, laws, market structure, and habits, although in his paper the author states that a proxy, such as distance, could represent all those variables. Their results are as expected and in line with the literature, distance works against trade, and GDPs are positively proportional to trade.

Pöyhönen, Tinbergen and Linneman’s (HASSON; TINBERGEN, 1964; POYHONEN, 1963; VANEK; TINBERGEN, 1964) fundamentally showed that trade data mirrors the gravity equation in a way that exports rise proportionately with the economic size of the destination and imports rise in proportion to the size of the origin economy. Concomitantly these flows decrease with the distance between countries. Additionally, gravity equation models could infer less exaggerated trade patterns than previous models since they accounted for variables that were not accounted for previously. Nevertheless, as of 1960, the theoretical background of these models could still be considered dubious. In subsequent developments, scholars would make an effort to develop micro-foundations for the gravity equation so that these models could be applied to a broader range of trade interactions without baring biased results (HEAD; MAYER, 2013)

The gravity model has maintained its explanatory power even with increased scope and the addition of new variables, but the model still did not have a sound theoretical foundation. Anderson (1979) reasoned that the lack of theory may have rendered inference about the results invalid. Therefore, he provided a theoretical explanation of the gravity equation by using the properties of Cobb-Douglas and Constant Elasticity of Substitution (CES) expenditure systems. His essential hypotheses were identical and homothetic preferences across regions and differentiated products by region of origin. The usage of expenditure systems enabled the model to encompass non-unitary income elasticity and traded and non-traded goods, which represents steps towards a better representation of actual trade. The separable traded expenditure characteristic, in turn, allowed the model to include more complex ways to depict the factors that hinder trade with the addition of tariffs. With this theoretical construction, Anderson (1979) introduced the idea of relative distance and tariffs.

Bergstrand (1985, 1989) uses expenditure systems to provide a theoretical foundation to the model by justifying the addition of new variables such as the population used to complement the measure of economic magnitude, contiguity dummies, and trade blocs dummies. Furthermore, the author also shows the possibility of depicting complex economic characteristics with simple proxies such as exchange rates or value indexes due to the use of expenditure systems. Further improvement comes from using less aggregated trade data, which proved new results.

Deardorff (1998) managed to insert the Heckscher-Ohlin (HO) trade theory into the Gravity Structure. In this theoretical experiment, Deardoff (1998) stated that frictionless trade within an HO-model equilibrium can result in trade patterns similar to gravity models. In this case, trade is positively related to the economic magnitude of the trading countries. Likewise, obstructed trade between countries within a HO approach also yields equilibria that can bear results akin to gravity model patterns. Trade flows between two countries depend on economic magnitude and the distance between the exporter and importer country relative to the rest of all countries.

In a remarkable paper, McCallum (1995) analyzed the trade between 30 U.S. states and ten Canadian provinces and within the Canadian provinces to gauge the effect of distance, economic magnitude, and the border between both countries. The results shed light on the model's estimation biases and exaggerated interpretations. For example, the coefficients of the border variables were exceedingly high, implying that interprovincial trade was more than 20 times larger than trade between a province and a state. An implication is that when performing comparative statics, removing barriers and distance, it doesn’t result in a proportional change of trade values regarding economic magnitude. The results from using states and provinces reinforced the idea that gravity models, as they were being used, were not encompassing some factors that have effects on trade (HEAD; MAYER, 2013). This question has been puzzling international trade economists since McCallum's (1995) publication. What were the missing factors that the gravity equation theory framework could not yet encompass?

Aiming to solve this puzzle, Anderson and Van Wincoop (2003) proposed the structural theory-based gravity underpinned by Constant Elasticity of Substitution (CES) and preferences in goods that are differentiated by region of origin. Anderson and Van Wincoop (2003) show that trade flows are positively related to the economic magnitude and inversely proportional to trade resistances. In the theory-based gravity, trade resistance is composed of bilateral trade barriers between exporting and importing countries, exporter's resistance to trade with all regions (outward multilateral resistance term), and importer's resistance to trade with all regions (inward multilateral resistance term).

So far, the gravity model has been widely used to estimate the impact of several policies such as regional blocs, currency, direct investment, political blocs, regulatory dissimilarities, patent issues, and various other similar concepts. The advancements achieved by the literature addressed the criticism that the gravity methodology would bear biased results. As a result, the gravity equation has become the workhorse trade model. It has been adopted as a reliable tool to assess the trade impact of human-made or natural crises, national or international policies such as trade barriers or regional trade agreements, foreign direct investment, etc. (HEAD; MAYER, 2013).

2.2 THEORY CONSISTENT GRAVITY MODEL

Anderson and Van Wincoop (2003, 2004) proposed a structurally sound gravity equation in which Multilateral Resistance Terms (MRT) represent the average trade costs that exporting and importing countries face relative to their other trading partners. The authors state that all goods are supposed to be differentiated by place of origin, which is specialized in producing only one good. The supply of each good is fixed, and preferences are identical, homothetic, represented by a CES utility function as in equation (1):

$$\left(\sum_i \beta_i^{(1-\sigma)/\sigma} c_{ij}^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)} \tag{1}$$

Where c_{ij} is the consumption by region *j* of goods from region *i*. Consumers maximize (1) subject to the budget constraint:

$$\sum_{i} p_{ij}c_{ij} = y_j \tag{2}$$

The elasticity of substitution between all goods is σ, β_i is a positive distribution parameter, y_j is the nominal income of region *j* residents, and p_{ij} is the price for region *j* consumers of goods exported from region *i*. It is assumed that the prices are affected by trade or transportation costs incurred by the exporter but passed on to the importer. Then, $p_{ij} = p_i t_{ij}$, t_{ij} is the trade cost factor. The nominal value of exports from *i* to *j* (j's payments to i) is $x_{ij} = p_{ij}c_{ij}$ and the total income of region *i* is a sum of all the sales from *i* to all *j*, $y_i = \sum_j x_{ij}$. The maximization of (1) subject to (2), yields:

$$x_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{(1-\sigma)} y_j \tag{3}$$

P_j is a consumer price index, given by:

$$P_j = \left[\sum_{i} \left(\beta_i p_i t_{ij}\right)^{1-\sigma}\right]^{1/(1-\sigma)} \tag{4}$$

Equations (3) and (4) introduce the idea that relative values should be considered when estimating gravity. It is specified that the income of a region may be dampened or enhanced depending on the prices of goods from other regions. Market clearance implies:

$$\begin{aligned} y_i &= \sum_j x_{ij} \\ &= \sum_j \left(\beta_i t_{ij} p_i / P_j\right)^{1-\sigma_j} y_j \\ &= (\beta_i p_i)^{1-\sigma} \sum_j \left(t_{ij}/P_j\right)^{1-\sigma} y_j, \ \forall i. \end{aligned} \tag{5}$$

Anderson and Van Wincoop (2003) suggest that (5) should be solved for $(\beta_i p_i)$ and then the result should be substituted in (3). Defining world nominal income as $y_W = \sum_j y_j$ and income shares $\theta_j = y_j / y_W$, this, in turn, yields:

$$x_{ij} = \frac{y_i y_j}{y^W} \left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \tag{6}$$

Where:

$$\Pi_i \equiv \left(\sum_j \left(t_{ij}/P_j\right)^{1-\sigma} \theta_j\right)^{1/(1-\sigma)} \tag{7}$$

Substituting the equilibrium scaled prices into (6) we obtain:

$$P_j = \left(\sum_i \left(t_{ij}/\Pi_i\right)^{1-\sigma} \theta_i\right)^{1/(1-\sigma)} \tag{8}$$

Equations (6) to (8) are the structural gravity model, which includes the Multilateral Resistance Terms P_j and Π_i. By observing (6) we see that the nominal value of exports from *i* to *j*, x_{ij}, is positively proportional to the economic magnitude of *i* and *j* relative to the world and inversely proportional to the trade cost factor from *i* to *j*, t_{ij}. However, the importance of the bilateral trade cost factor to the trade flows may be attenuated or raised by the Multilateral Resistance Terms that represent average trade barriers from all trading partners. Moreover, equations (6) to (8) show that the relative prices of products are connected to trade barriers between all countries. The trade barriers between countries *i* and *j* are conditioned on the barriers of all other countries. When an importing country *j* raises trade barriers with all other countries but not with country *i*, the relative price of the goods exported by country *i* decreases, thus increasing trade between countries *i* and *j*.

Anderson and Van Wincoop (2004) were aware that the framework proposed by them, in the way that it was presented in their former paper in 2003, was capable of accurately encompassing trade costs such as tariff ad valorem barriers. They also knew that various trade restricting variables were being tested in the gravity framework when they published their work. The authors state that trade costs, in their multiple forms, had intense effects on trade flows and could be fitted into the consistent gravity framework.

Anderson and Van Wincoop (2004) define trade costs as all costs incurred in getting good to a final user other than the marginal costs of producing the good itself. It includes transportation, tariff, and non-tariff policy barriers, information costs, contract enforcement costs, costs associated with using different currencies, legal and regulatory costs, and local distribution costs. Furthermore, they state that the consistent gravity framework provides the primary relationship between trade costs and trade flows. Additionally, the authors affirm that biased, unreliable results are expected when trade costs are implemented in non-theory consistent gravity equations on an ad-hoc basis.

Anderson and Van Wincoop (2004) stated that the theoretical gravity model allows inference about unobservable trade costs by connecting trade costs to observable cost proxies. The trade cost factor could represent a plethora of trade restricting variables such as distance between the importing and exporting country, common language, import tariffs, technical regulations, preferential trade agreements, etc. These variables could be inserted in the model as dummies or tariff-equivalent values within the z_{ij}^{m} (m=1,..., M), with each m representing a variable that may present a hurdle to trade, as shown in (9):

$$t_{ij} = \prod_{m=1}^{M} \left(z_{ij}^{m}\right)^{\gamma_m} \tag{9}$$

Transforming (6) lognormally, we have:

$$\ln(X_{ij}) = \mathrm{k} + \ln(Y_i) + \ln(Y_j) + \sum_{m=1}^{M} \lambda_m \ln\left(z_{ij}^{m}\right) - (1-\sigma_k)\ln\left(P_j\right) - (1-\sigma_k)\ln(\Pi_i) + \varepsilon_{ij} \tag{10}$$

2.3 THE GRAVITY OF COVID-19

International economics scholars have been developing COVID-19 gravity literature since the pandemic started. Hayakawa and Mukunoki (2020) aimed to quantify how containment policies implemented in response to the COVID-19 pandemic affected international trade. The authors state that containment policies such as stay-at-home orders and workplace closure orders[1] are expected to decrease imports and exports. Workplace closure policies negatively impact production, consequently population income and demand. Stay-at-home orders negatively impact consumer income, impacting a country's ability to demand goods (HAYAKAWA; MUKUNOKI, 2020).

To assess the effects of these policies, the authors (HAYAKAWA; MUKUNOKI, 2020) examined monthly world trade data from 26 exporting countries and 170 importing countries from January to June 2019 and 2020. They regressed trade value in dollars to the extent of stay-at-home orders enforced in importing countries and workplace closure orders implemented in exporting countries at the country-pair-month level. Therefore, three different levels of strictness effects of each policy are captured in the regression. Stricter measures were expected to have more impacts on trade (HAYAKAWA; MUKUNOKI, 2020).

Hayakawa and Mukunoki (2020) test the effects of stay-at-home and workplace closure requirements on international trade in two ways. First, they estimate the coefficients overall, and then they test the same effects, but they interact stay-at-home and workplace closure requirements with a dummy indicating that the country is located in Asia. Their results point out that the estimates of stay-at-home and workplace closure requirements are negative for importers and exporters, but the stay-at-home estimates are not always statistically significant. When the authors interact the variables with the Asia dummy, these results become positive or statistically insignificant. The authors conclude that stay-at-home requirements do not have robust impacts on trade and that in some cases, as in the case of trade between Asian countries, workplace closure requirements also do not reduce trade. They state that these results may

[1] Stay-at-home orders forced people to remain in their houses with exceptions for grocery shopping, and "essential" trips. While Workplace Closures imposed the closure of all-but-essential workplaces.

indicate that governments imposed such policies but did not ensure that they were strictly followed or that even such measures were imposed in a way that did not wholly impede the functioning of the economy.

Their results show that both stay-at-home orders and workplace closure orders reduce trade, and the higher the strictness, the higher the adverse effect. Furthermore, the results differ for different types of industries. Most of them suffer adverse effects, but the most significant impacts of the workplace closures and stay-at-home orders are found in agricultural goods, mineral products, leather goods, and transport equipment. On the other hand, textiles and chemical products were not as much impacted. According to the authors, some goods considered essential against the pandemic are categorized within these categories. So, this result could point that countries tried to shift their production focus to COVID-19 essential products (HAYAKAWA; MUKUNOKI, 2020).

Their findings point out that the negative effects on international trade due to workplace closure orders in exporting countries are significant and found in most industries. On the other hand, the negative impact of stay-at-home orders in importing countries is less present and found only in some sectors, including firms that manufacture durable and essential products. These results imply that the supply-side effects from lockdown policies have a stronger incidence in trade, while the demand-side effects are important in only some industries.

Hayakawa and Mukunoki (2021a) assess the effects of COVID-19 lockdown policies paired with cases, deaths and mobility reports indicating the percent change in visits to retail and recreational locations and workplaces. These variables were regressed to industry trade flow data monthly from 34 exporting countries to 173 importing countries from January to August in 2019 and 2020.

Their results point out that all variables representing COVID-19 have significantly negative effects on the international trade of exporting and importing countries. Furthermore, the effects of COVID-19 in importing countries tended to become insignificant faster than in the exporting countries. Finally, they found heterogeneous effects across industries. For example, labor-intensive industries are more likely to suffer from the adverse effects of COVID-19 in exporting countries. Lastly, the effects of COVID-19 on essential products, such as medical and textile goods, were insignificant due to the higher demand and production for these goods. (HAYAKAWA; MUKUNOKI, 2021a). By advancing the timeframe by a few months, the authors show that the containment policies start to lose intensity and significance by moving the time frame further ahead from 2020 and adding new variables.

The results by Hayakawa and Mukunoki (HAYAKAWA; MUKUNOKI, 2020, 2021a) reinforced the argument that the COVID-19 pandemic impacted the ability of countries to supply and demand goods. Furthermore, the results presented in the industry regression shed light on a new issue. Although all the industries suffered similar shocks because lockdown policies were being implemented country-wide, the pandemic affected them in different intensities. Hayakawa and Mukunoki (2020a) argued that it happens because the production of some goods is more diffuse than others. While the goods entirely produced in one location are hit once by the pandemic, products with diffuse manufacturing processes are hit multiple times. Many authors called this the Global Value Chain contagion effect (BALDWIN; TOMIURA, 2020; HAYAKAWA; MUKUNOKI, 2021b).

The authors regressed bilateral trade in finished machinery products to assess the GVC effect, considering 26 exporting countries and 185 importing countries from January to June 2019 and 2020. Besides the number of confirmed COVID-19 cases and deaths, they also captured the GVC contagion effects by using the weighted average of the number of confirmed COVID-19 cases and deaths in countries supplying machinery parts to the exporting country (HAYAKAWA; MUKUNOKI, 2021b). The variable created to capture the GVC contagion effects works similarly to the other COVID-19 variables but is related to countries that supply parts to finished machinery exporting countries.

The results indicate that exports of final goods decrease if an exporting country is directly affected by COVID and if it imports inputs from countries affected more seriously by COVID-19. This supply-chain effect was more significant than the output effect, indicating that both the direct COVID-19 and supply-chain effects are relevant to identifying the impacts of COVID-19 on trade in a world interconnected through GVCs. Hayakawa and Mukunoki (2021b) confirm the importance of internal supply and demand shocks driven by COVID-19 disturbances. Moreover, it validates the effects that COVID-19 shocks suffered in other countries have on trade.

Friedt and Zhang (2020) have also considered the supply, demand, and GVC effects and tested if they had impacted trade. To capture the GVC effects, the authors create a variable that measures the exposure of Chinese export industries to the infection of the underlying GVC networks these industries depend upon. The authors found that the GVC contagion is the primary driver of the losses in Chinese exports. The difference between the shocks is that the domestic supply and international demand shocks carry a significant negative influence on Chinese exports during the first two months of the outbreak, while the impact of GVC contagion persists and strengthens over three months after the initial rise in Coronavirus infections (FRIEDT; ZHANG, 2020). These features shape a distinct characteristic of the pandemic, it has demand, supply and GVC effects that persist over time, and in the case of the GVC impacts, it strengthens over time.

Regarding political drivers affecting the donations of essential goods to combat COVID-19, Telias and Urdinez (2021) designed a dataset comprising Chinese essential goods donations to 33 Latin American countries from February 2019 to June 2020. They regressed the monthly donation value to a variable denoting strategic partnership with China, a dummy representing agreement with the “One China Policy,” a dummy representing strategic alignment with the United States of America, a democracy dummy, monthly COVID-19 death number, and the GDP per capita of the importer, controlling for monthly bilateral trade flows.

The results indicate that strategic alignment with China positively relates to higher donations. Additionally, the support for Taiwan's independence strongly negatively affected masks donations. Besides that, democracies seem to be a less preferred target of donations. Finally, higher values of offerings are not positively related to COVID-19 deaths. These results could be considered an example that countries are not making decisions on international policies based on the optimal results. If so, donations would go to countries more harshly impacted by COVID-19. These could point out that these policies attract political support at high-level diplomatic events, influence voting in international forums, and secure diplomatic recognition at the expense of better solutions.

Corroborating this point, Fuchs et al. (2020) analyzed the monthly donation value and then the export value of 80 products considered essential to the pandemic for pairs of exporting Chinese provinces and importing countries through March and April 2020. To assess the strength of political ties between Chinese provinces and importing countries, the authors used a variable that measures differences in voting behavior between China and its trade partners within the United Nations General Assembly. They assessed whether a country recognizes the government in Taipei on Taiwan rather than the Chinese. Lastly, they identified if each importing country maintained at least one sister relationship with a Chinese province. To assess the effects of economic ties, the authors used the total value of 2019 essential goods exports from Chinese provinces to importing countries as a proxy of past economic integration. Besides that, the value of foreign direct investment made by importing countries to exporting Chinese Provinces, the number of confirmed COVID-19 cases in importing countries, and lastly total value donations made to China towards importing countries from January to February 2020.

The authors gather that these variables affect donations and trade differently. They pointed out that past economic ties matter to the trade value of essential goods in the face of the pandemic. Conversely, COVID-19 infection rates and political ties do not matter to trade. Regarding donation flows, the authors state that the recognition of Taiwan is strongly negatively related to the value of donations, whereas sister linkages are positively related. Similar to Telias and Urdinez (2021) results, the donations do not seem to be affected by the infection rates.

Leibovici and Santacreu (2021) argued that countries were not committing to optimal choices concerning international policies during the pandemic. They argued that while some countries struggle to get the essential goods needed to damper the COVID-19 impacts, others raise trade barriers while having abundant supplies. While some countries are lowering their import trade barriers to ease access to these goods, others are making it harder for domestic firms to sell them internationally. This situation validates the argument that international trade has a fundamental role in the global impact of a pandemic. To investigate the impacts of such policies in mitigating or amplifying the supply shortages, the authors analyze the demand and supply shocks considering a dynamic general equilibrium model with two countries, home and foreign, and two sectors: a sector that produces essential goods and one that produces non-essential goods. Each country has a domestic variety in each sector resulting in four goods in the world economy: home and foreign essential goods, and home and foreign non-essential goods, all traded internationally. Each country is populated by: a household, a producer of domestic essential goods, a producer of domestic non-essential goods, a producer of an essential good composite, and a producer of a non-essential good composite (EVENETT; WINTERS, 2020; LEIBOVICI; SANTACREU, 2021).

The authors assume that essential goods are hard to substitute intertemporally within this model. Capital and labor can be reallocated across sectors in response to shocks, but this adjustment is subject to costs. Furthermore, it is assumed that firms are myopic and do not internalize the impact of their production decisions on the welfare of households. Regarding preference, households enjoy higher levels of utility from essential goods while on a pandemic. With this framework, Leibovici and Santacreu (2021) assess the extent of the welfare losses that are derivative of the pandemic and the trade policy between countries. Their results point out that in both countries, the demand for essential goods rises even if the cost of these products also rises, and both countries earn more from their sales of essential goods but also have to spend more. The country with relative advantages in producing essential goods sells relatively more than it purchases, having fewer costs in this situation. The increase of international barriers to trade helps marginally with the internal shortage of goods, but it dramatically aggravates the scarcity of these goods internationally, increasing their relative prices. Thus, policies that raise international barriers to trade have negative effects on welfare in the exporting and importing countries.

These results are consistent with preliminary evidence on changes in trade barriers across countries during the COVID-19 pandemic presented by recent literature. Stellinger et al. (2020) noted that in early 2020 some nations were enrolling in plurilateral efforts to ensure the supply of medicines to the world population. Nevertheless, they stated that more actions were needed to guarantee medication to most of the world's population. They noted a pattern between the two waves of international policy, the first one slightly restrictive to trade and the second one primarily supportive of trade. Their results corroborate the analysis of Bown (2020), Evenett (2020c) and Fiorini et. al. (2020), in which export restrictions are inefficient and ineffective because they affect not only importing countries but exporting countries' markets by price volatility, reallocation of supplies, and price spikes. Lastly, it corroborates that some countries are already facing essential goods shortages, as argued by Arouna et al. (2020) and Martin (2020) and Arouna et al. (2020).

Table 1 summarizes the results of the leading studies in recent international economics literature related to COVID-19. These works aimed to assess the effects of containment policies on international trade flows. It is suggested to refer to it to quickly grasp the units of measurement, timeframe, variables, techniques, and results of these papers.

TABLE 1 - Structured Literature Summary

Authors	Units of Exporters and Importers	Timeframe	Independent Variable	Products	Regression Technique	Summary of Results
Hayakawa and Mukunoki (2020)	26 Countries Exp. and 170 Countries Imp.	January to June 2019/2020	Percentage of days per month: Workplace Closure and Stay-at-home.	All	PPML-FE	WPC (-) ; SAH (-)
Hayakawa and Mukunoki (2021)	34 Countries Exp. and 173 Countries Imp.	January to August 2019/2020	Percent of days per month: Workplace Closure and Stay-at-home; Confirmed Number of Cases and Deaths; Google Community Mobility Reports.	All	PPML-FE	WPC and SAH (-); Cases (-); Deaths (-); Mobility (-);
Hayakawa and Mukunoki (2020a)	26 Countries Exp. and 185 Countries Imp.	January to June 2019/2020	GDP; Trade Agreements; Confirmed Number of Cases and Deaths.	Machinery Products - Finished and Intermediate; Electrical Machinery; Transportation Equipment; Precision Machinery.	PPML-FE	GDP (+); Agreements (+); Cases (-); Deaths (-);
Friedt and Zhang (2020)	31 Chinese Provinces Exp. and 199 Countries Imp.	January/2019 to June/2020	Confirmed Number of Cases and Deaths.	All	Not Informed - FE	Cases (-); Deaths (-);
Telias and Urdinez (2020)	China Exp. and 33 Countries Imp.	February/2019 to June/2020	GDP/Capita; Dummy Alignment with China; Dummy US alignment; Dummy Democracy and Confirmed Number of Deaths; Chinese Exports.	Personal Protection Masks	OLS	GDP/Capita (NULL); China Align (+); Taiwan (-); US Align (NULL); Democracy (-); Deaths (+); China Exports (NULL)
Fuchs et al. (2020)	31 Chinese Provinces Exp. and 195 Countries Imp.	March and April of 2020	Exports 2019; FDI to China; UN Voting Distance; Taiwan; Donations to China; Sister Linkages; COVID-19 infection rates; Government Effectiveness.	80 Essential Medical Products	Not Informed-FE	Exports 2019 (+); FDI (NULL); UN (NULL); Sister (NULL); Taiwan (NULL); Effectiveness (NULL); COVID-19 (+);

Source: authors' own work

Trade-related policies are linked to the COVID-19 crisis in a unique way because only a few countries can be self-sufficient in the production of essential goods to combat the pandemic, such as medical and textile goods. In this way, international trade plays an important role in the supply of these products, which is vital to the struggle against the pandemic (FIORINI; HOEKMAN; YILDIRIM, 2020; STELLINGER; BERGLUND; ISAKSON, 2020). Plurilateral international organizations took notice of that and advised against using trade policies that could hinder trade even further than COVID-19 damages or national-level containment policies already have. The implementation of export curbs, prohibitions, or the increase in tariffs or technical barriers potentialize shortage effects on all countries and create uncertainty among them. This, in turn, results in retaliatory increases of trade barriers, putting the world supply of essential and food products at risk (AROUNA et al., 2020; FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, 2020; UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT, 2020; WORLD TRADE ORGANIZATION, 2020c; FARIA et al., 2021).

Consequently, the importance of transparency increases in international crises because a higher volume of veritable information helps the effectiveness of trade-related policies and lowers the uncertainty between countries. Countries ensure transparency through the notification systems in which new trade-related measures must be notified to the WTO. For example, in crises such as the one presented by the pandemic, countries have been notifying ad-hoc notifications that provide information about specific measures implemented in the face of the pandemic. These documents provide a summary containing information about the product and countries being affected, objectives, and the date of coming into force. Notifications that aim to inform about the imposition of export prohibitions or export restrictions are considered to be trade-restricting notifications, while notifications that aim at improving trade flows and notify withdrawal of import charges and simplification of customs procedures are considered trade-facilitating. (FARIA; GRIMALDO HIDALGO; FERRAZ, 2021; WORLD TRADE ORGANIZATION, 2007, 2020c, 2020d)

Faria, Hidalgo and Ferraz (2021) analyzed these notifications throughout 2020 and showed two peaks of higher frequency of notifications, one happening in April and another at the beginning of July. The first wave comprised mostly of trade-restricting measures, and trade-facilitating measures mainly formed the second. Besides that, the authors stated that multilateral tools were used in the wrong ways. Countries have not shown proper regard for transparency when notifying. For instance, the same objectives have been used to justify trade-restricting and facilitating measures. Not only have goods sensitive to COVID-19 been affected by trade-related policies, but also agricultural and food products.

3 METHODOLOGY

The present work assesses the impact of the COVID-19 pandemic and COVID-19 trade-related policies on the trade flow across countries. The number of confirmed COVID-19 cases, confirmed related deaths, and the share of days in which the countries imposed stay-at-home orders and workplace closures represent the COVID-19 variables. In addition, information on COVID-19 trade-related notifications gathered from the WTO constitutes the variables that indicate changes in trade policies. The impact of these variables is evaluated within a theory-consistent gravity model framework such as that developed by Anderson and Van Wincoop (2003, 2004).

This section first shows how the COVID-19 trade-related policy database was built. Next, the empirical approach is described, the empirical equation is presented, and the regression techniques are discussed. Finally, the data sources and the timeframe are discussed.

3.1 COVID-19 TRADE-RELATED DATABASE

WTO notifications work as a transparency tool so that the implementation of the commitments under the WTO agreements is periodically evaluated and the countries' implementation of new policies or policy changes remain scrutinized by the international community. Generally, governments should notify any policy change that may impact free trade (WORLD TRADE ORGANIZATION, 1994, 1996a, 1996b, 2018a).

Notifications should contain the date of notification, implementation, and expiration if applicable. In addition, the notifications should address the countries and products that are likely to be affected and provide a general description of the policy, the underlying agreement, and the objective and rationale to justify the policy. Besides that, further detailed information such as the type of policy (WORLD TRADE ORGANIZATION, 1995a, 1995b, 2012, 2018b).

We gathered information from the “WTO members' notifications on COVID-19” database[2] to build our database and assess how the implemented policies affected the trade flows of 33

[2] https://www.wto.org/english/tratop_e/covid19_e/notifications_e.htm

countries[3] from January 2020 to June 2021[4]. The countries accounted for roughly 58% of the global trade value in 2019. They filed 64 notifications, accounting for approximately 53% of the total notifications from January 2020 to June 2021.

Notifications with spelling mistakes, those canceled by the notifying members, those policies unrelated to COVID-19, those sent to the Government Procurement Agreement (GPA), and those not written in the official WTO languages were not included in the database[5]. Some notifications were addendums or corrigendum, including date extensions, correction of some product codes, changes in the application period, and lifted restrictions. In this case, we have not added these notifications as new ones. Instead, we have included these changes in the original notification in our database. In addition, notifications that did not contain information about the date, reporting country, affected product and enforced policy were discarded. For instance, "Declaration Notifications" in which countries collectively pledged to remove trade barriers in general but did not present information about products or the policies to be implemented, were not included in the database. The list of all notifications that compose our database can be found in table 8 in the ANNEX.

We classified all the affected products in our database into seven categories considering the HS 2-digit code, as shown in Table 2. To create the categories, we followed WTO (2020b), which lists all the products considered essential to the fight against the pandemic and classifies them as Medical Equipment, Medical Supplies, Personal Protective Equipment (PPE), and Pharmaceuticals[6]. The other products not specified in the WTO (2020b) were classified as non-essential to COVID-19 prevention. It includes agricultural products, Medical Products NES, and others. Lastly, the category Medical Products NES was created to convey information about products that closely resemble the products listed in the WTO (2020b) but have not been specified there.

TABLE 2 - Product Category

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[3] Australia; Belgium; Brazil; Bulgaria; Canada; China; Colombia; Croatia; Czechia; Denmark; Egypt; Estonia; Finland; Germany; Greece; Hungary; Ireland; Israel; Japan; Kyrgyzstan; Lithuania; Luxembourg; Mexico; Netherlands; Poland; Portugal; Romania; Slovakia; Slovenia; Spain; Sweden; Ukraine and United States.

[4] Countries that didn't have available monthly trade data from 2020 to 2021 were dropped from the research, and those countries were Argentina, Peru, Russia, Singapore, South Korea, Thailand and United Arab Emirates.

[5] The "WTO members' notifications on COVID-19" database also compiles information about trade measures that were not officially notified by the partner countries. Data within this database was not used due to lack of verifiability and quality.

[6] Medical Equipment is made up of products such as electro-diagnostic apparatus and equipment; Medical Supplies is formed by products with less added value such as Undenatured ethyl alcohol or sterile suture materials; Personal Protective Equipment is composed by hand soap or sanitizer and face masks and shields; lastly Pharmaceuticals are composed by medicaments and vaccines.

Product category	HS 2-digits
Agricultural Products	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 23; 24
Medical Equipment	90
Medical Supplies	22; 28; 34; 35; 37; 38; 40; 70
Personal Protective Equipment (PPE)	39; 63
Pharmaceuticals	30
Medical Products not specified elsewhere (NES)	25; 26; 27; 29; 31; 32; 33; 36; 50; 51; 52; 53; 54; 55; 56; 57; 58; 59; 60; 61; 62; 68; 69; 91; 92
Other	41; 42; 43; 44; 45; 46; 47; 48; 49; 64; 65; 66; 67; 71; 72; 73; 74; 75; 76; 77; 78; 79; 80; 81; 82; 83; 84; 85; 86; 87; 88; 89; 93; 94; 95; 96; 97

Source: authors' own work based on WTO (2020) and Faria et al. (2021).

Based on the information "Type of Restriction" and "General description of the restriction" provided in each notification, we classified the measures into Export Prohibition, Licensing requirements to Exports, Licensing requirements to Imports, Tariff Policies, Technical Requirements to Trade and Trade Facilitating Measures. Export Prohibitions denote prohibitions applied to exports. Licensing requirements to exports or imports mean the application of non-automatic licensing for certain products, these import or export licenses are to be provided by regulatory government agencies. Tariff Policies are measures that change customs duties, such as temporary tariff concession measures to facilitate the importation of certain goods required to manage the crisis created by the COVID-19 pandemic. Trade Facilitating Measures aim to promote trade by allowing the use of electronic documents such as alternative arrangements to the use of original paper phytosanitary certificates due to the impacts of COVID-19 on airfreight and courier mail. Lastly, notifications classified as Technical Requirements to Trade include changes in design requirements for imports, such as the relaxation of import requirements for some products.

3.2 EMPIRICAL APPROACH

Supported by Anderson and Van Wincoop (2003, 2004) and based on the recent COVID-19 literature and empirical fitting techniques, we estimate a gravity model with a trade costs matrix augmented by proxies for COVID–19 damages and COVID-19 trade-related policies. We consider the following log-linear gravity specification:

$$\begin{aligned}
&\left(Y_{ijt}^{k}\right) = \\
&\beta_2(SAH_{it}) + \beta_3\left(SAH_{jt}\right) + \beta_4(WPC_{it}) + \beta_5\left(WPC_{jt}\right) + \\
&\beta_6\ln\,(DEATH_{it}) + \beta_7\ln\,\left(DEATH_{jt}\right) + \beta_8\ln\,(CASES_{it}) + \beta_9\ln\,\left(CASES_{jt}\right) + \\
&\beta_{10}\left(LM_{it}^{k}\right) + \beta_{11}\left(LM_{jt}^{k}\right) + \beta_{12}\left(LX_{it}^{k}\right) + \beta_{13}\left(LX_{jt}^{k}\right) \\
&\beta_{10}\left(XP_{it}^{k}\right) + \beta_{11}\left(XP_{jt}^{k}\right) + \beta_{12}\left(TBT_{it}^{k}\right) + \beta_{13}\left(TBT_{jt}^{k}\right) \\
&\beta_{10}\quad\left(TFM_{it}^{k}\right) + \beta_{11}\quad\left(TFM_{jt}^{k}\right) + \beta_{12}\quad\left(TPO_{it}^{k}\right) + \beta_{13}\quad\left(TPO_{jt}^{k}\right) + \\
&\alpha_{ij} + \alpha_t + \alpha_k + \epsilon_{ijkt}
\end{aligned} \tag{11}$$

Where β_s and α_s are the parameters to be estimated. The definition of each variable is given in Table 3.

TABLE 3 - Definition of the variables used in the model

Variable name	Definition
Y_{ijt}^{k}	Country *j's* import value (US$ million) of product *k* originating from country *i* at the month t.
SAH_{it} and SAH_{jt}	The share of days within a month when stay-at-home orders are in effect in countries *i* and *j* at the month *t.*
WPC_{it} and WPC_{jt}	The share of days within a month when workplace closure orders are in effect in countries i and j at the month t.
$DEATH_{it}$ and $DEATH_{jt}$	The log of confirmed COVID-19 deaths + 1 in countries i and j at the month t.
$CASES_{it}$ and $CASES_{jt}$	The log of confirmed COVID-19 cases + 1 in countries i and j at the month t.
LM_{it}^{k} and LM_{jt}^{k}	The cumulative sum of Import Licensing notifications on product k on month t implemented in countries i and j.
LX_{it}^{k} and LX_{jt}^{k}	The cumulative sum of Export Licensing notifications on product k on month t implemented in countries i and j.
XP_{it}^{k} and XP_{jt}^{k}	The cumulative sum of Export Prohibitions notifications on product k on month t implemented in countries i and j.
TFM_{it}^{k} and TFM_{jt}^{k}	The cumulative sum of Trade Facilitating Measures notifications on product k on month t implemented in countries i and j.

TBT_{it}^{k} and TBT_{jt}^{k}	The cumulative sum of Technical Barriers to Trade notifications on product k on month t implemented in countries i and j.
TPO_{it}^{k} and TPO_{jt}^{k}	The cumulative sum of Tariff Policies notifications on product k on month t implemented in countries i and j.
α_{ij}, α_t and α_k	Country pair fixed effects account for the multilateral resistance terms, and time-invariant bilateral trade costs, such as distance. Time-fixed effects control for variations in world income. And product category fixed effects account for unmeasurable variables that differ between products.

Source: Elaborated by the author

The structure for estimating equation (11) is panel data formed by a spatial dimension represented by 33 countries and a time dimension represented by 18 months. Panel data has some benefits compared to cross-sectional or time-series data. Firstly, it increases the sample size, allowing for more information, greater data variability, less collinearity among the variables, and guarantees higher degrees of freedom, resulting in a more efficient estimation. Other than that, panel data efficiently assesses the results of policy changes because its structure allows this type of change to be registered in the database, and the bias resulting from subject aggregation is eliminated or reduced since data on multiple subjects is gathered. Perhaps most importantly, panel data allows the treatment of heterogeneity among the subjects of the analysis (GUJARATI; PORTER, 2011; WOOLDRIDGE, 2012).

Heterogeneity can be defined as the effect of variables that are constant across time, are not observed or gathered, and are therefore omitted from the analysis. The main advantage of modeling panel data is that it becomes possible to do away with the heterogeneity among the subjects. Effects of variables like distance, contiguity among countries, and historical and political variables such as colonization and language characteristics are captured in a time-demeaning transformation of the model; therefore, the estimates of the parameters of interest can be analyzed in an efficient and non-biased way (GUJARATI; PORTER, 2011; WOOLDRIDGE, 2012).

In the fixed-effect model, it is assumed that the unobservable effect, the heterogeneity, is constant over time. Additionally, it is assumed that the error term is not correlated with the explanatory variables. Finally, it is allowed the heterogeneity effect to be correlated with the explanatory variables (WOOLDRIDGE, 2012). To eliminate the effect of the non-observables a_i, in order to correctly estimate the β coefficients the fixed effects transformation must be done. Consider a model with a single explanatory variable:

$$y_{it} = \beta_1 x_{it} + a_i + u_{it},\ t = 1,2, \dots, T \tag{12}$$

Where y_{it} represents the dependent variable for the subject i at the time t, x_{it} represents the explanatory variable for the subject i at time t, a_i is the unobservable heterogeneity effect and u_{it} is the stochastic error term. This equation is to be averaged over time for each subject i:

$$\bar{y}_i = \beta_1 \bar{x}_i + a_i + \bar{u}_i \tag{13}$$

Where $\bar{y}_i = T^{-1} \sum_{i=1}^{T} y_{it}$, $\bar{x}_i = T^{-1} \sum_{i=1}^{T} x_{it}$ and $\bar{u}_i = T^{-1} \sum_{i=1}^{T} u_{it}$. Because a_i is constant over time; when (14) is subtracted from (13), the heterogeneity is eliminated, resulting in:

$$y_{it} - \bar{y}_i = \beta_1 (x_{it} - \bar{x}_i) + u_{it} - \bar{u}_i,\ t = 1,2, \dots, T \tag{14}$$

Or

$$\ddot{y}_{it} = \beta_1 \ddot{x}_{it} + \ddot{u}_{it},\ t = 1,2, \dots, T \tag{15}$$

In (15) $\ddot{y}_{it} = y_{it} - \bar{y}_i$ is the time-demeaned data on y. The same can be said about $\ddot{x}_{it}$ and $\ddot{u}_{it}$. After the fixed effects transformation, the unobserved effect a_i disappears and the estimations based on (15) are not biased due to missing variables. The process is done similarly when multiple explanatory variables are of interest; the only necessary change is to time-demean all variables.

According to Wooldridge (2012) the method called dummy variable regression is a traditional way to implement the fixed effects transformation. It is assumed that the unobserved effect, a_i, is a parameter that is to be estimated for each cross-sectional subject i and time t along with the β coefficients. To estimate an intercept for each i, it is necessary to include a dummy variable representing each i along with the time dummies and the explanatory variables.

We include country pairs fixed effects to capture the multilateral resistance terms correctly. Additionally, year-month fixed effects were also employed to capture the impact of variables that cannot be measured but vary over time, as suggested by Wooldridge(2012). It is important to note that since the time structure of the data is monthly, it was not possible to measure the change in the GDP of countries. Therefore, year-month fixed effects also capture the GDP variations, as shown in Hayakawa and Mukunoki (2020, 2021a) and Friedt and Zhang (2020).

Finally, product category fixed effects were used to capture the impact of industry characteristics that may have influenced trade (HEAD; MAYER, 2013).

The multiplicative form of the gravity equation, specifically the models like the one proposed by Anderson and Van Wincoop (2003, 2004), is another critical issue when dealing with trade data. To assess the coefficients of the gravity equation, one must log-linearize it. However, this transformation causes problems applying the Ordinary Least Squares (OLS) method due to zero trade flows and heteroskedasticity (Santos Silva and Tenreyro, 2006).

The data collected for this paper extend from January 2020 to June 2021 and comprise trade data for seven aggregate categories of goods for 33 countries. The total number of trade flows is 127.162, and this database shows 9933 zero trade flows, representing about 7.8% of the full trade flow lines. Accordingly, Santos Silva and Tenreyro (2006) state that to get unbiased and consistent estimates in the face of data that presents zeros and heteroskedasticity, the estimates should be assessed via Poisson Pseudo Maximum Likelihood (PPML).

Woodridge (2012) corroborates it, stating that when linear models for $\mathrm{E}(y \mid x_1, x_2, \ldots, x_k)$ might not provide the best estimates, researchers should pay attention to exponential functions:

$$\mathrm{E}(y \mid x_1, x_2, \ldots, x_k) = \exp\left(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k\right) \tag{16}$$

Because (16) is an exponential function, it ensures that *y* will always be at least zero, so it is compatible with the data. Since (16) is not linear, one should not use linear regression methods to assess its β coefficients. Furthermore, trade data presents heteroskedasticity, so the usage of nonlinear least-squares regression techniques is considered less than ideal. To correctly estimate the β coefficients, one should log-linearize (16) and use Poisson Pseudo Maximum Likelihood regression (WOOLDRIDGE, 2012). It is precisely the process that is done in this work to evaluate the empirical equation (11).

The $\boldsymbol{\beta}$ estimates obtained by a Poisson Maximum likelihood should be interpreted as the percentage change of $\mathrm{E}(y \mid x)$ given one unit increase of $\mathbf{x}_i$. Furthermore, when estimating dummy variables, the change of 0 to 1, would result in a proportionate change in the expected value of (exp $\left((\hat{\beta}_k\right) - 1)100$. Either way, the $\boldsymbol{\beta}$ estimates could be interpreted as the elasticity of the expected value of y concerning x (WOOLDRIDGE, 2012). Finally, Wooldridge (2012) also states that it is possible to use the Poisson Maximum Likelihood regression model without assuming that the Poisson distribution is entirely correct, and one would still get consistent, asymptotically normal $\boldsymbol{\beta}$ estimates.

3.2 Data

Import value (US$ million) at HS 2-digit level was gathered from the UN COMTRADE database (UNITED NATIONS, 2022) from 33 countries. In addition, the containment policy variables were collected from the Oxford COVID-19 Government Response Tracker (HALE *et al.*, 2021b). Furthermore, information about trade policies was gathered from the “WTO members' notifications on COVID-19”.Finally, the number of confirmed COVID-19 monthly death and cases was gathered from the European Centre for Disease Prevention and Control (2022).

All the data ranges from January 2020 to June 2021. Although some authors, Hayakawa and Mukunoki (2020b, 2020a, 2021) and Fuchs et. al. (2020), work with data from 2019, the use of information from 2019 brings some peculiarities to the model because all variables related to COVID-19 have the value 0 throughout 2019. Concomitantly the trade flows start to fall intensely from January 2020; therefore, the trade flows in 2020 are much lower than the average values for the same months in 2019. However, when using data from 2020 and 2021, these same variables display more uniform fluctuations (WORLD HEALTH ORGANIZATION, 2022b, HALE et al., 2021b), which suggests that data for these years can better capture the impacts of fluctuations in these variables.

The COVID-19 trade-related policies are measured by a sum of the times a country notified a policy change in a month. The trade policy changes represented by the notifications have an emergency and temporary nature, and previous analysis of the contents of these measures pointed out that policies of the same type could influence trade by affecting requirements and procedures related to imports and exports (FARIA et al., 2021). Thus, when these variables are considered in the regressions, they appear once regarded as being related to the importing country and again considered related to the exporting country. By including these variables related to both importers and exporters, we aim to capture the ways they affect trade flows.

4 RESULTS

4.1 PANDEMIC OVERVIEW

In this section, we explore the duration, intensity, scope, and drivers of the trade crisis caused by the COVID-19 pandemic. Furthermore, we analyze how it developed over time, its effects on countries and products and what bolstered it. Finally, we illustrate how data indicates that trade policies can be considered pertinent to the trade crisis.

The effort against the COVID-19 spread began as soon as countries took notice of the significant adverse impacts that massive contamination could bring to their economies. In most countries, policy responses against the virus occurred such as school closures, workplace closures, cancelation of public events, restrictions on gathering size, closure of public transport, stay-at-home requirements, restrictions on internal movement, restrictions on international travel, and general information campaigns. These policies prevented death, ensured that the countries' health systems would not be saturated, and helped contain the virus. Nevertheless, those measures had negative economic impacts on the supply side, with restrictions on production and the movement of people, as well as on the demand side, with lower incomes and shifts in consumption.

These containment policies, paired with the confirmed number of cases and COVID-19-related deaths are proxies for the extent of the COVID-19 damages and comprise the set of variables that we refer to as direct disruptions to production and demand. On the supply side, direct disruptions hindered the scale of the production of goods, which reduced the supply of exports, whereas, on the demand side, the direct disruptions caused an overall decrease in aggregate demand (BALDWIN; TOMIURA, 2020; HAYAKAWA; MUKUNOKI, 2021a). Besides the effects caused by prolonged death and illness, the intensity of these disruptions is closely related to the implementation of containment policies (HAYAKAWA; MUKUNOKI, 2020). To understand how countries implemented these policies, Table 4 presents information about the stringency index of the Oxford COVID-19 Government Response Tracker (HALE *et al.*, 2021b). The index considers policies such as school closures, workplace closures, cancelation of public events, gathering size restrictions, public transport closures, stay-at-home requirements, internal movement restrictions, international travel, and public information campaigns. The index ranges from 0 to 100; the higher the index, the stricter the policies are.

TABLE 4 - Oxford COVID-19 monthly stringency index, selected countries, January 2020 - June 2021

Countries	**20/jan**	**20/feb**	**20/mar**	**20/apr**	**20/may**	**20/jun**	**20/jul**	**20/aug**	**20/sep**	**20/oct**	**20/nov**	**20/dec**	**21/jan**	**21/feb**	**21/mar**	**21/apr**	**21/may**	**21/jun**
Australia	1	19	39	71	67	55	70	75	75	67	64	66	61	62	51	49	46	63

Belgium	1	11	49	81	77	57	51	58	53	51	65	60	61	63	64	69	52	51
Brazil	1	6	44	75	81	77	80	72	69	63	56	64	68	72	69	67	60	62
Bulgaria	0	7	49	72	61	39	38	39	37	37	49	54	54	54	56	52	50	58
Canada	1	3	39	73	71	70	68	67	64	63	68	71	75	75	73	75	75	73
China	22	77	80	60	75	78	78	78	60	63	69	79	78	74	53	74	68	72
Colombia	3	9	44	87	88	87	87	87	71	69	65	60	77	81	81	80	65	60
Croatia	1	14	51	95	73	53	45	35	30	29	35	58	59	53	44	51	48	40
Czechia	3	17	58	67	52	38	36	36	38	54	72	67	75	78	80	66	54	45
Denmark	0	1	53	70	66	58	57	51	50	43	46	50	68	66	63	64	58	53
Egypt	0	0	29	84	85	74	60	63	64	63	60	62	61	55	53	51	63	41
Estonia	0	0	34	77	59	38	35	32	34	35	39	51	49	42	56	61	43	37
Finland	1	13	47	70	64	40	37	34	32	36	41	51	52	52	52	52	52	48
Germany	1	10	49	77	64	61	57	58	50	55	62	75	84	83	77	75	75	68
Greece	0	2	55	84	71	52	57	56	61	56	76	84	82	81	88	83	66	49
Hungary	0	0	48	77	68	59	55	51	44	41	66	72	72	72	78	71	59	48
Ireland	0	5	40	90	87	68	39	60	62	64	81	75	86	88	84	82	63	51
Israel	0	18	59	89	77	75	64	42	58	80	63	71	85	70	61	59	53	27
Japan	2	22	41	46	42	28	28	33	33	33	37	47	49	50	44	45	49	53
Kyrgyzstan	2	14	51	92	83	76	76	78	69	60	53	49	42	37	48	53	53	55
Lithuania	0	1	51	82	74	43	26	29	29	45	57	67	72	68	66	53	45	44
Luxembourg	0	0	50	76	58	41	30	42	47	50	57	61	55	55	55	48	47	43
Mexico	0	0	20	82	82	72	71	72	72	72	72	72	72	67	48	45	44	44
Netherlands	0	1	47	79	74	61	40	45	51	62	63	68	80	80	75	74	68	61
Poland	2	6	41	84	82	53	43	40	30	41	74	75	74	71	72	74	64	53
Portugal	1	6	51	83	70	60	63	61	60	62	67	67	72	82	78	70	65	64
Romania	0	7	53	87	79	48	42	43	44	48	69	77	77	73	68	63	53	39
Slovakia	0	3	52	77	72	45	39	36	31	56	71	63	70	72	72	71	50	38
Slovenia	0	0	46	88	58	40	44	50	50	58	81	84	80	68	69	72	50	35
Spain	0	11	52	85	79	54	59	63	61	65	71	73	73	70	69	69	65	52
Sweden	0	6	35	65	65	61	59	57	56	56	59	68	69	69	69	66	65	55
Ukraine	0	0	54	89	87	64	42	58	64	59	60	59	60	55	60	68	58	57
United States	0	5	46	73	73	71	68	67	64	64	70	72	72	68	64	57	52	55

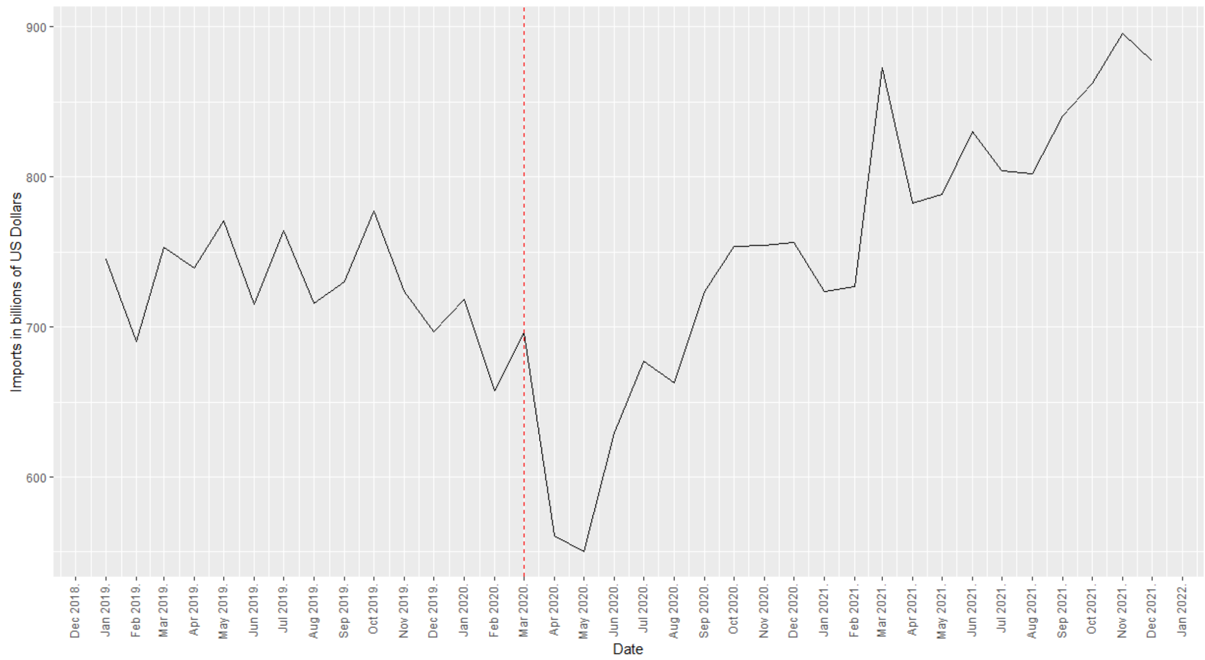
Source: authors' own work based on Hale et al. (2021).

Table 4 shows that from March 2020 onwards, most countries implemented strict measures to contain the proliferation of the virus, causing intense disruptions to production, demand and trade (HAYAKAWA; MUKUNOKI, 2020). Furthermore, countries considered hubs for the supply chain of all goods, such as China, the United States and Germany (BALDWIN; TOMIURA, 2020), were all affected by the COVID-19 pandemic and were forced to impose strict policies. The strictness of the policies, and thus the intensity of the disruption caused by them, were more substantial at the beginning of the pandemic (April and May 2020), and then, in December 2020 and January 2021 when the stringency of these policies was increased again.

The continuous strain caused by the joint implementation of strict policies throughout the years 2020 and 2021, which caused supply and demand disruptions in all countries, enables one to understand another driver of the trade crisis. The downturn in trade is also related to Global Value Chains. Authors call the inability to supply external demands faced by each country a contagion effect. Illness and death, paired with containment policies, cause countries to have difficulties producing finished and intermediary goods to supply their internal demand and other countries. It deepens the impacts caused by direct disruptions (BALDWIN; TOMIURA, 2020; FRIEDT; ZHANG, 2020; HAYAKAWA; MUKUNOKI, 2021b, 2021a).

Observing monthly import data is helpful to understand further how these disruptions affect international trade. Figure 1 shows the sum of monthly imports between the 33 chosen countries, ranging from 2019 to 2021. The red dashed line shows when the WHO classified the COVID-19 crisis as a pandemic. Before the classification of COVID-19 as a pandemic, only a few countries had imposed measures to contain the virus, China being the strictest. The failure to set containment policies at the beginning of the pandemic resulted in the COVID-19 death and case count soaring in March, April, and May 2020 (WORLD HEALTH ORGANIZATION, 2020c, 2020d). However, after the WHO declared COVID-19 a global pandemic, governments began to set stricter policies to contain the virus. As a result, the disruptions the policies caused began to affect production and demand in the countries. These disturbances are noted in Figure 1, which indicates the lowest trade flows in April and May 2020.

FIGURE 1 - Monthly Imports Fluctuations between 33 select countries since the event of the COVID-19 pandemic.



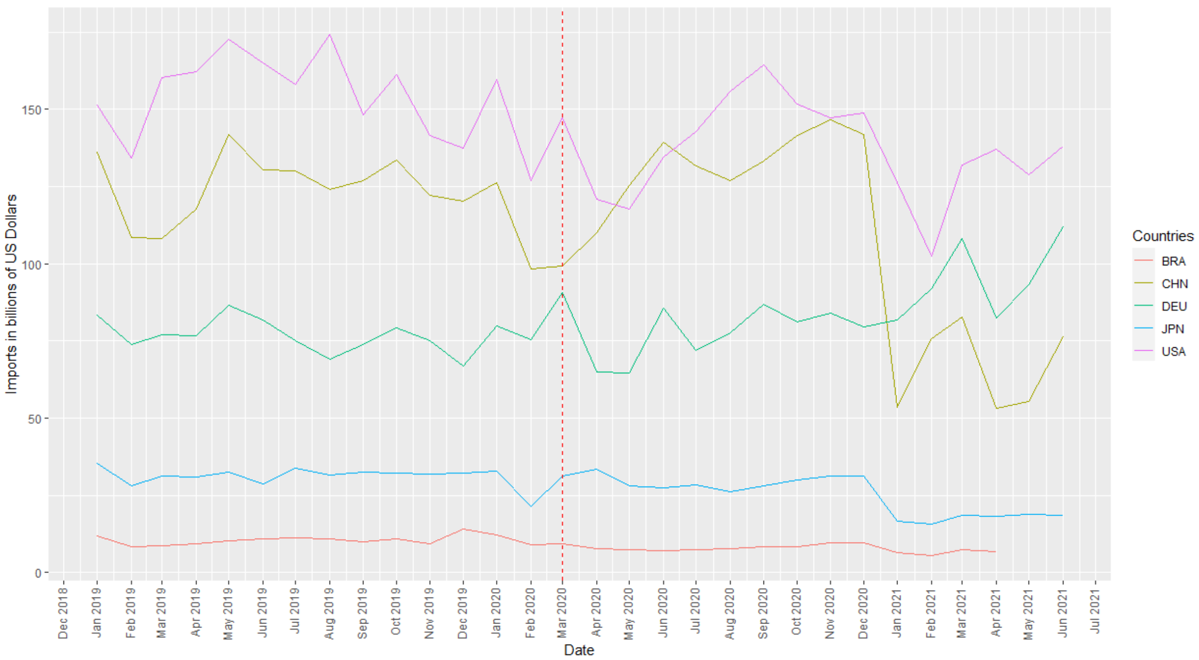
Source: authors' own work based on UN's COMTRADE database

Figure 1 offers insights into the intensity of the COVID-19 trade crisis throughout time. It is possible to gather that the trade effects were more intense in March and April 2020, when countries showed high cases and deaths caused by COVID-19 and imposed strict containment measures. In the subsequent months, the effect became milder, but as countries relaxed their policies, the number of cases and deaths began to increase again. This setup resulted in the prolongation of the crisis and another set of months with intense trade downturns, from December 2020 to January of 2021 and March 2021 to April 2021 (WORLD HEALTH ORGANIZATION, 2021b, 2021c).

Former studies about the COVID-19 trade crisis inferred that the intensity of direct disruptions caused by illness, death and containment policies diminishes over time and that the intensity of the adverse effects of Global Value Chain contagion tends to persist over time (FRIEDT; ZHANG, 2020; HAYAKAWA; MUKUNOKI, 2021a). Thus, successive increases in the strictness of containment policies followed by relaxation seem to have prolonged the timeframe of the pandemic (WORLD HEALTH ORGANIZATION, 2022d)..

Figure 2 shows the imports of Brazil, China, Germany, Japan and United States, ranging from 2019 to 2021. Again, we notice an overall decrease in trade for the group of countries. Furthermore, the United States, Japan, Germany, and Brazil displayed a joint downturn in the values of imports during March and May 2020. Additionally, China and the US significantly declined imports in January and February 2021. The decrease of import values from countries that are significant for international trade corroborates previous works in which the downturns in trade flows seems to be related to the fact that most countries had their production concomitantly impaired by illness and death and were forced to implement strict containment policies, that further hindered their ability to supply and demand goods (BALDWIN; TOMIURA, 2020; FRIEDT; ZHANG, 2020; HAYAKAWA; MUKUNOKI, 2021a).

FIGURE 2 - Monthly import Fluctuations for selected countries



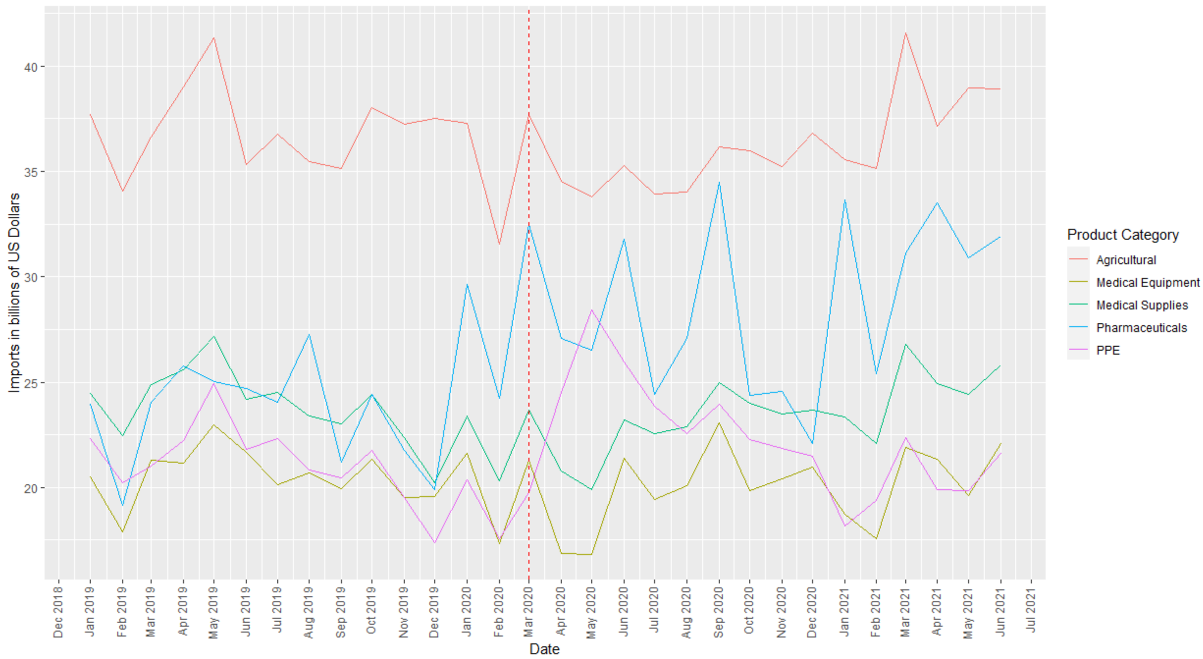
Source: authors' own work based on UN's COMTRADE database

Recent literature (FUCHS *et al.*, 2020; HAYAKAWA; MUKUNOKI, 2020, 2021a) argues that the impacts of the direct disruptions and the GVC contagion are heterogeneous across industries. Most sectors not essential to the fight of the pandemic were intensely affected, whereas industries that produce critical goods were not as significantly hit or displayed positive outcomes throughout the pandemic.

One can understand the heterogeneous effects of the COVID-19 disruptions between industries by looking at the total import values of different product categories. Figure 3 and Figure 4 show how the import values oscillated throughout the pandemic for different products. We observe sudden contractions in imports for most of them, but there is difference in the intensity between essential and non-essential products. For instance, imports of Medical Equipment, Medical Supplies, Pharmaceuticals, and Personal Protective Equipment (PPE) that are essential to the fight against the pandemic have increased after the first negative disruption in March and April 2020. On the other hand, imports of products such as Agricultural goods, Medical Products NES, and Other have displayed sharp contractions in March and April 2020 and have decreased over time.

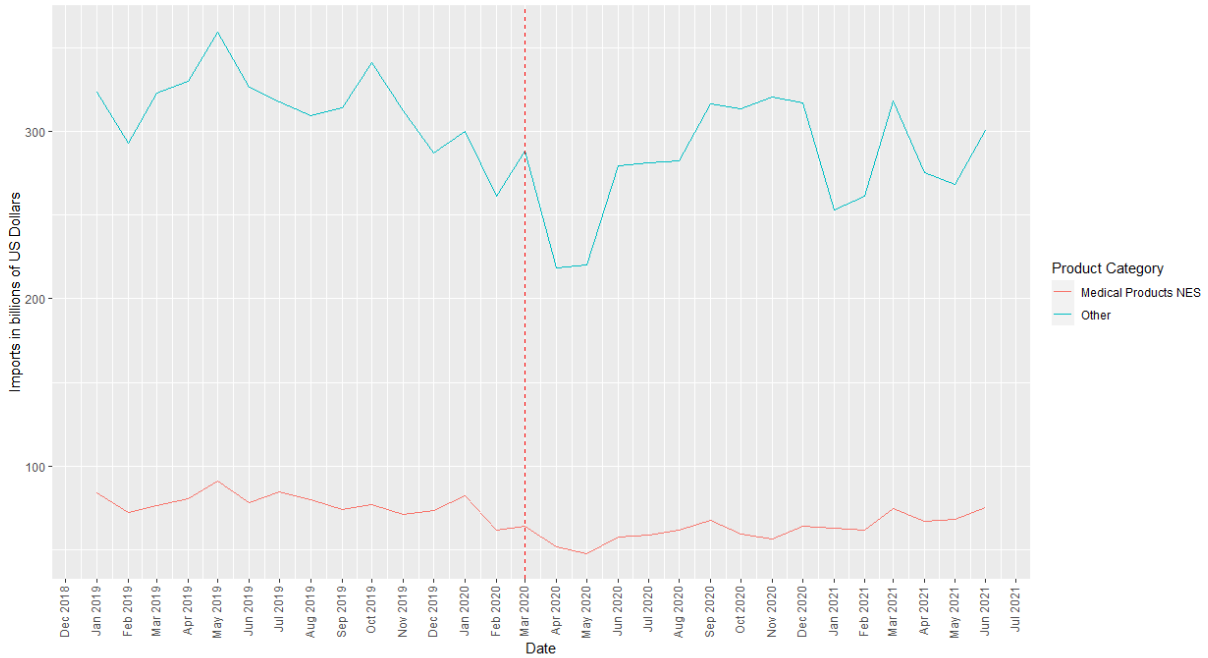
These results may corroborate the point that demand shifted towards essential goods to contain the virus during the pandemic. At the beginning of the pandemic, the demand for crucial products soared, and countries could not meet it; therefore, abrupt downturns in import values were formed. There is also a difference between Agricultural products and the products category called Other. By comparing them, one notices that even though agricultural imports dropped at the beginning of the pandemic, the import values rose and achieved pre-pandemic levels as of February 2021. On the other hand, the category Other has not recovered its pre-pandemic levels, which corroborates the idea that products with more diffuse production lines are more intensely affected by the disruptions of the pandemic.

FIGURE 3 - World Monthly Imports Fluctuations by Product Category



Source: authors' own work based on UN's COMTRADE database

FIGURE 4 - World Monthly Import Fluctuations for Medical Products NES and Other Product Categories



Source: authors' own work based on UN's COMTRADE database

Since the beginning of the pandemic, countries started to demand more products that are essential to fighting COVID-19 and increased their production. However, in some months, even with the changes in production, countries could not meet the massive increase in demand, so they began competing for these products in the international economic system.

Table 5 shows the number of notifications[7] by product category. It is possible to observe that Medical Equipment, Medical Supplies, Personal Protective Equipment, and pharmaceutical are the most affected by the trade policies related to COVID-19. These products considered essential to fighting against the pandemic account for 62% of all notifications. The figures in Table 4 seem to corroborate the points made by previous studies (BOWN, 2020; EVENETT, 2020c; FUCHS *et al.*, 2020; STELLINGER; BERGLUND; ISAKSON, 2020) in which countries employed trade measures trying to secure their share of the stockpile of essential goods. But interestingly enough, countries also notified policy changes regarding non-essential goods, which shows that the disruptions caused by the pandemic have a broad scope. Countries have felt the need to implement trade policies related to products that are not essential for fighting COVID-19 because they have also been unable to meet their demand.

TABLE 5 - Notifications by product category

Product category	Number of Notifications	Percentage

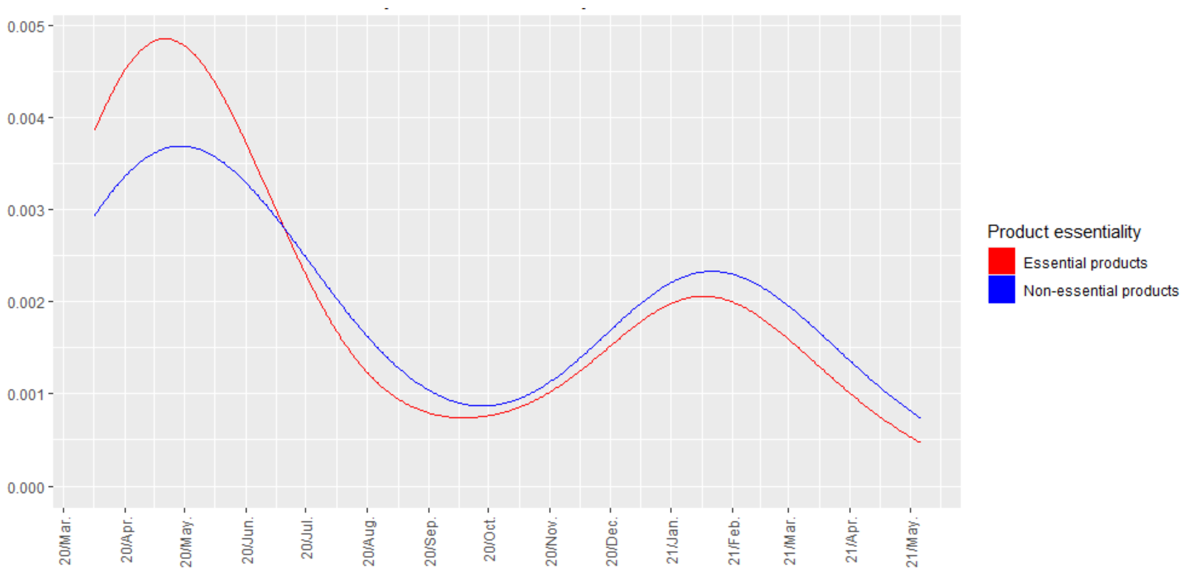
[7] The sum of the number of notifications in table 4 is greater than the total number of notifications (64) because a single notification can convey informations about different measures

Agricultural	14	8%
Medical Equipment	19	12%
Medical Supplies	27	16%
Medical Products NES	32	20%
Personal Protective Equipment (PPE)	24	15%
Pharmaceuticals	31	19%
Other	16	10%

Source: authors' own work.

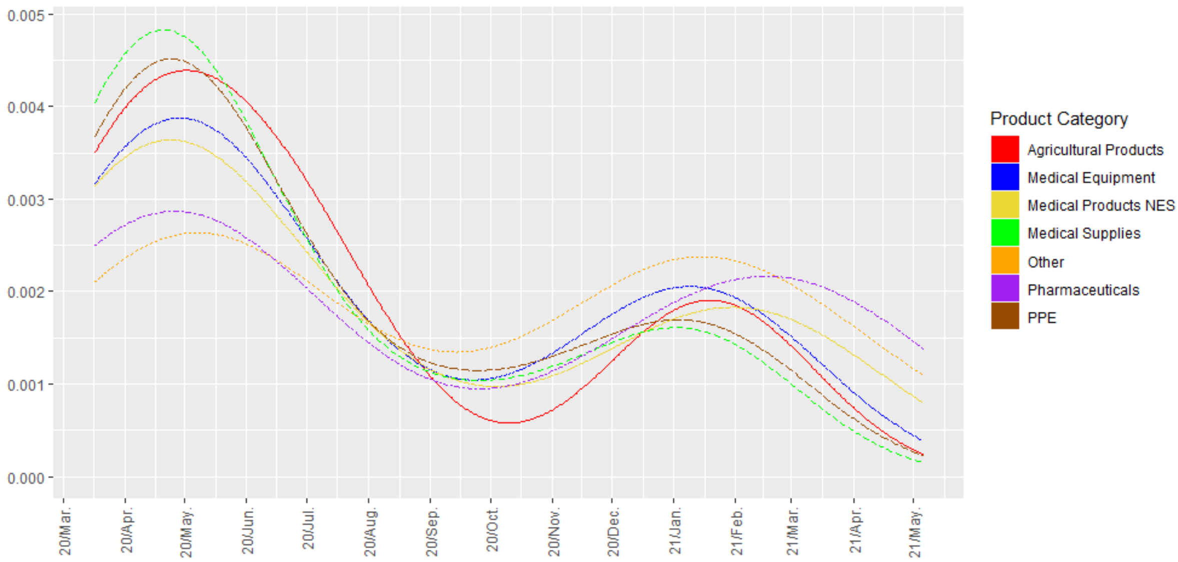
Figures 5 and 6 illustrate the relative frequency of the notifications from January 2020 to June 2021 regarding the product category and the product characteristics as essential or non-essential. First, we noticed that measures were frequently notified from April to May 2020. After that, they were only intensely reported again from December 2020 to March 2021. Besides that, the content of the notifications changed as the pandemic advanced. For example, countries often declared measures related to essential and agricultural products at the beginning of the pandemic, but as time passed, they mostly notified measures unrelated to crucial products. Second, April, May and December 2020, and January 2021 are the months that presented the highest frequency of notifications and also the lowest trade flows.

FIGURE 5 - Distribution of notifications by essential and non-essential products



Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

FIGURE 6 - Distribution of notification by product category



Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

Table 6 presents the measures that countries have applied over the pandemic. Countries have notified the implementation of export prohibitions, validating the points made by Bown and Evenett that countries tried to secure their stock of products that were in short supply (2020; 2020a, 2020c). But these policies were not the only ones being implemented; countries have extensively notified changes in technical trade barriers, accounting for 47% of all notifications. Exports' licensing requirements were moderately used, accounting for 16% of all notifications. Licensing requirements for Imports, tariff policies and trade facilitating measures were not extensively used, none surpassing 10%.

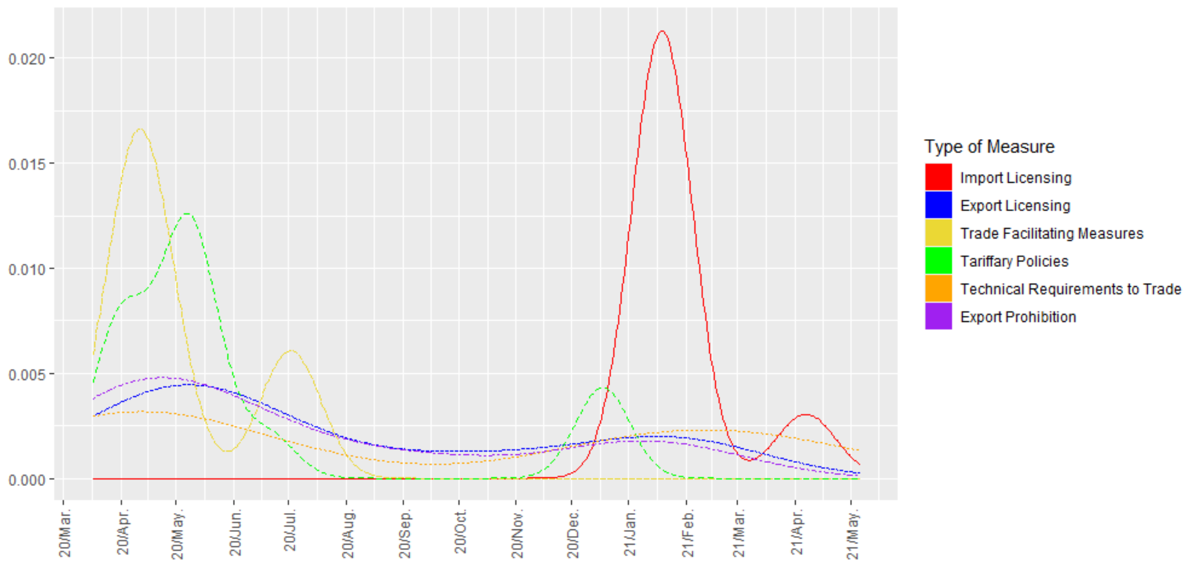
TABLE 6 - Notifications by Type of measure

Type of measures	Number of notifications	Percentage
Export Prohibition	13	19%
Export Licensing	11	16%
Import Licensing	2	3%
Tariff Policies	6	9%
Technical Barriers to Trade	33	47%
Trade Facilitating Measures	4	6%

Source: authors' own work based on (WORLD TRADE ORGANIZATION, 2020e).

Figure 7 denotes the distribution of different types of notifications during the pandemic. We observe that countries notified measures in higher numbers from March 2020 to May 2020, then from December 2020 to March 2021. Countries mostly notified tariff policies and trade facilitation measures in the first period. However, after that, they focused on implementing licensing requirements for imports and tariff policies. Import licensing peaked in January and February 2021, caused mainly by Colombia that notified the document G/MA/QR/N/COL/1/Add.2, which has a massive sprawl of affected goods. Another remarkable insight is that countries reported their policy changes in a downward trend, and by the end of our timeframe, they were barely notified. Nevertheless, policies such as Export Prohibitions, Export Licensing, and Technical Barriers to trade were more evenly implemented throughout the pandemic.

FIGURE 7 - Distribution of notification by type of measures



Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

Previous studies (BOWN, 2020a; EVENETT, 2020b, 2020a; FUCHS et al., 2020; LEIBOVICI; SANTACREU, 2020) argued that as countries were not able to shift their production efficiently, or other countries were having difficulties in supplying them, they implemented different trade policies at a different intensity to secure their stockpile of essential goods. This transformed international trade into a fierce competition to access essential goods that helped ease the disruptions caused by infection, illness, and death.

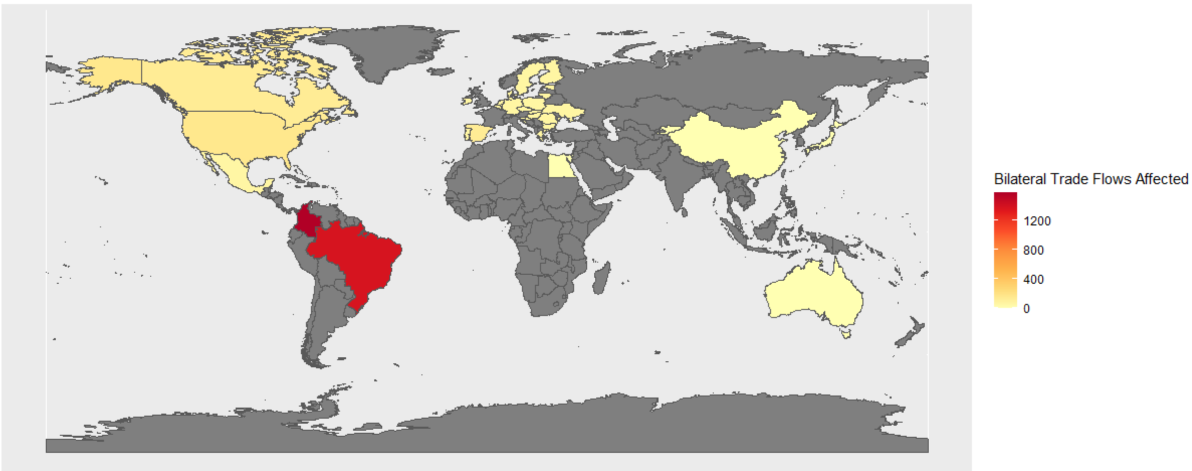
To understand how countries implemented policies at different intensities, Figures 8 and 9 present the number of the affected bilateral trade flows by changes in Technical Barriers to trade and Export Licensing measures for each country[8]. These policies were frequently and

[8] Furthermore, the information presented in Figures 8 and 9 can be verified in Table 9 in the annex

evenly notified during the pandemic. The affected bilateral trade flows by the other measures can be seen in Figures 10 to 15 in the annex. The colors in Figures 8 and 9 represent the sum of all times that these international trade measures affected a bilateral trade flow during the pandemic[9]. Therefore, by implementing those two policies, one can interpret Figures 8 and 9 as to how each country affected international trade from January 2020 to June 2021.

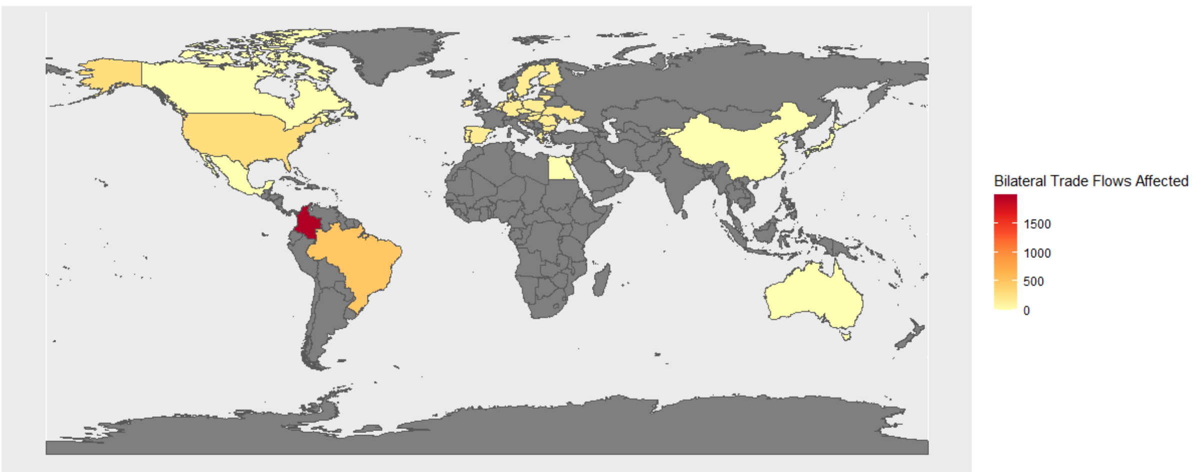
We notice that Brazil, Colombia, and the US notified a higher sum of these trade measures, so those countries affected an increased number of bilateral trade flows. On the other hand, China and Australia notified fewer policy changes affecting a lower number of bilateral trade flows.

FIGURE 8 - Technical Barriers to Trade Heatmap



Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

FIGURE 9 - Export Licensing Heatmap



[9] The way the information was entered into the database is: Month – Importing Country – Exporting Country – Product Category – Trade value in dollars – Number of notifications regarding Policy K

Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

Trade data show that the disruptions caused by illness, death and containment policies affected countries differently but negatively. When the international trade is categorized into different product categories, it can be seen that the demand for products essential to fighting COVID-19 skyrockets as soon as countries notice that the impacts of the pandemic could be mitigated by using these products, yet countries have not been able to shift the focus of their production to these products efficiently, so the trade of these products also decreases in some months.

Moreover, with production hampered, there is also a decrease in trade of non-essential goods, such as agricultural products and others. Therefore, countries began to implement trade policies to try to mitigate shortages. These policies are closely related to the disruptions caused by the pandemic and trade downturns displayed by trade data. Thus, these policies represent a set of variables that yet need to be appropriately analyzed.

4.2 GRAVITY MODEL RESULTS

So far, it is indicated that the effects of COVID-19 cases, deaths and containment policies should be studied because they are linked with decreases in trade flows. The impacts of the cases and deaths caused by the pandemic of COVID-19 coupled with containment policies directly affect a country's ability to produce and demand goods. Moreover, these same variables can affect a country more than once. The prolonged illness, death, and containment policies affect the production of all nations. As the production of goods is diffuse, the inability to produce in a foreign country can reach other countries if it cannot supply finished products or parts. Furthermore, it is pointed out that these impacts do not affect industries uniformly. For instance, industries that have diffuse production and are not considered essential to combat COVID-19 suffer more decreases in trade flows.

However, it is also shown that these variables are not the only ones related to international trade during the pandemic of COVID-19. Furthermore, as countries became aware of the decreases in trade flows, they chose to implement trade policies to secure their stockpiles of goods, so these policies should also be analyzed.

This section evaluates the impacts caused by the number of cases, deaths, containment policies, and COVID-19 trade-related policies using a theory consistent gravity trade model.

The framework consists of data from 33 countries representing 58% of global trade in 2020 and 53% of the notifications pointing to trade policy changes related to COVID-19.

4.2.1 Trade policies

The results shown in the literature (FRIEDT; ZHANG, 2020; FUCHS *et al.*, 2020; HAYAKAWA; MUKUNOKI, 2020, 2021b, 2021a) indicate that the COVID-19 direct disruption variables may not be the only ones affecting trade flows during the pandemic. It is understood that part of the policy response developed by countries to the trade crisis triggered by the pandemic is represented by notifications sent to the WTO specifying changes in their trade policies. Thus, it becomes necessary to estimate the effects on trade flows of these trade policy changes

Table 7 shows the Poisson pseudo-maximum likelihood regression estimates for the effects of cases, deaths related to COVID-19, containment policies, and trade policies. Column I presents the estimates for all variables. Next, we perform sensitivity tests shown in columns II to VII. In column II, cases and deaths are left out of the regression. In column III containment policies variables are left out. In column IV only the trade policies are considered. Column V presents the regression estimates using direct disruption variables, cases, deaths, stay-at-home and workplace closure requirements. Column VI only offers the estimates for stay-at-home orders and workplace closures requirements. Finally, VII presents only the estimates for cases and deaths.

Some remarks must be made about the trade policy variables in Table 7. The estimates of LM_{it}^{k} and LM_{jt}^{k} are related to policy changes concerning import licensing requirements, the estimates of LX_{it}^{k} and LX_{jt}^{k} are linked to export licensing measures, XP_{it}^{k} and XP_{jt}^{k} are associated with measures concerning export prohibitions, the coefficients of TFM_{it}^{k} and TFM_{jt}^{k} should reflect the impacts of Trade Facilitating measures, the results of TBT_{it}^{k} and TBT_{ij}^{k} demonstrate the effects of Technical Barriers to Trade measures, and lastly TPO_{it}^{k} and TPO_{jt}^{k} are linked to Tariff Policies. The subscript *i* indicates that the variable is associated with the importing country and the subscript *j* indicates that the variable is associated with the exporting country

TABLE 7 - Overall results of the aggregate gravity model estimates for all variables

Dependent variable:

	Import Value in USD						
	I	II	III	IV	V	VI	VII
SAH_{it}	-0.108	**-0.108***			**-0.111***	**-0.113***	
	(0.066)	**(0.065)**			**(0.065)**	**(0.065)**	
SAH_{jt}	0.117	**0.123***			**0.123***	**0.129***	
	(0.075)	**(0.075)**			(0.074)	(0.074)	
WPC_{it}	0.060	0.066			0.065	0.072	
	(0.074)	(0.075)			(0.073)	(0.075)	
WPC_{jt}	-0.042	-0.014			-0.047	-0.020	
	(0.097)	(0.096)			(0.097)	(0.095)	
$CASES_{it}$	0.009		0.008		0.010		0.009
	(0.013)		(0.013)		(0.013)		(0.013)
$CASES_{jt}$	0.0004		0.001		0.0003		0.001
	(0.013)		(0.013)		(0.013)		(0.013)
$DEATH_{it}$	-0.008		-0.009		-0.009		-0.011
	(0.011)		(0.011)		(0.011)		(0.011)
$DEATH_{jt}$	0.012		0.011		0.012		0.011
	(0.014)		(0.014)		(0.013)		(0.014)
LM_{it}^{k}	-0.036	-0.037	-0.035	-0.036			
	(0.029)	(0.029)	(0.029)	(0.029)			
LM_{jt}^{k}	0.012	0.011	0.011	0.009			
	(0.023)	(0.023)	(0.023)	(0.023)			
LX_{it}^{k}	-0.027	-0.028	-0.029	-0.030			
	(0.055)	(0.055)	(0.055)	(0.055)			
LX_{jt}^{k}	0.022	0.025	0.024	0.027			
	(0.039)	(0.039)	(0.039)	(0.039)			
XP_{it}^{k}	0.044	0.045	0.038	0.039			
	(0.032)	(0.032)	(0.032)	(0.032)			
XP_{jt}^{k}	-0.057	-0.060	-0.047	-0.047			

	(0.134)	(0.133)	(0.134)	(0.133)			
TFM_{it}^{k}	**0.226***	**0.228***	**0.222***	**0.224***			
	(0.123)	**(0.123)**	**(0.123)**	**(0.123)**			
TFM_{jt}^{k}	0.024	0.019	0.032	0.030			
	(0.168)	(0.170)	(0.170)	(0.173)			
TBT_{it}^{k}	-0.037	-0.035	-0.037	-0.035			
	(0.041)	(0.040)	(0.040)	(0.039)			
TBT_{jt}^{k}	0.074	0.075	0.077	0.078			
	(0.054)	(0.055)	(0.054)	(0.055)			
TPO_{it}^{k}	**0.128***	**0.125***	**0.136****	**0.134****			
	(0.069)	**(0.068)**	**(0.069)**	**(0.067)**			
TPO_{jt}^{k}	-0.156	-0.139	-0.183	-0.165			
	(0.156)	(0.152)	(0.159)	(0.154)			
Constant	14.711***	14.713***	14.724***	14.758***	14.703***	14.707***	14.714***
	(0.345)	(0.344)	(0.336)	(0.336)	(0.345)	(0.344)	(0.336)
Observations	127,162	127,162	127,162	127,162	127,162	127,162	127,162
PseudoR^2	0.9105	0.9107	0.9104	0.9106	0.9104	0.9106	0.9103
Country-pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Heteroscedastic robust standard errors are in parentheses
* Denote 10 percent significance level
** Denote 5 percent significance level,
*** Denote 1 percent significance level.

Source: Research results

From Table 7 we verify that the only direct disruption variable statistically significant is stay-at-home requirements. However, the estimates are not robust, becoming insignificant when COVID-19 trade-related policies are considered. These results align with Hayakawa and

Mukunoki (2020), who also obtained non-robust results for this variable when they performed tests in which they interacted stay-at-home requirements with other variables. It further corroborates the idea that throughout the pandemic, the containment policies might not have been correctly followed or enforced (HAYAKAWA; MUKUNOKI, 2020). Therefore, they might not explain the fluctuations in trade flows alone.

The addition of changes in COVID-19 trade-related policies yields significant results. Table 7 shows that facilitating trade and tariff policy measures are positive and statistically significant, explaining fluctuations in trade flows. The effect of trade facilitating measures is positive in the aggregate model, which may be explained by the fact that throughout the pandemic, countries aimed to positively impact international trade flows by allowing for alternative digital customs arrangements. Tariff policies are also positively related to trade, meaning that the notification of one of these measures is linked to improved trade flows. Another interesting result is that these policies were only statistically significant for importing countries. This outcome is associated with the fact that these measures primarily aimed to facilitate the entry of goods. When reported by exporting countries, the effects of these measures are adverse but not statistically significant. It indicates that governments may have tried to hinder the export of goods by raising tariffs, but these measures did not have a substantial impact on trade either because they were not used in abundance or were not intense enough to impede trade.

Recent covid literature (BOWN, 2020; EVENETT, 2020a, 2020c; FRIEDT; ZHANG, 2020; FUCHS *et al.*, 2020; HAYAKAWA; MUKUNOKI, 2021a) state that the disruptions caused by the pandemic and its related variables have different effects in different industries. Furthermore, the trade policies sent to the WTO may vary in intensity, content, and across different product categories. Therefore, disaggregated models into product categories may help understand how each policy affected trade and assist in evaluating countries' actions in the face of the COVID-19 pandemic. Table 8 presents the Poisson pseudo-maximum likelihood regression estimates with all variables, confirmed cases and deaths related to COVID-19, containment policies and trade policies, divided into product categories.

TABLE 8 - Overall results of the gravity model estimates by product categories

	Dependent variable:						
	Import Value in USD						
	Agric	Med.Equip	Med.Supply	PPE	Pharma	Med.NES	Other
	(1)	(2)	(3)	(4)	(5)	(6)	(7)

SAH_{it}	-0.040	0.054	0.029	-0.008	**0.054***	-0.061	**0.083**
	(0.025)	(0.042)	(0.031)	(0.052)	**(0.012)**	(0.044)	**(0.048)**
SAH_{jt}	0.003	**0.072**	0.046	0.074	**0.170***	0.063	0.063
	(0.024)	**(0.040)**	(0.032)	(0.054)	**(0.012)**	(0.040)	(0.049)
WPC_{it}	-0.010	-0.013	0.029	**0.131**	**0.183***	-0.006	0.049
	(0.026)	(0.050)	(0.038)	**(0.056)**	**(0.014)**	(0.047)	(0.066)
WPC_{jt}	-0.033	-0.047	-0.016	-0.035	**-0.090***	**-0.086**	-0.005
	(0.027)	(0.042)	(0.031)	(0.054)	**(0.017)**	**(0.037)**	(0.040)
$CASES_{it}$	0.008	-0.008	0.007	-0.030	**-0.010**	0.010	0.006
	(0.010)	(0.016)	(0.012)	(0.030)	**(0.006)**	(0.014)	(0.015)
$CASES_{jt}$	**0.015**	-0.005	0.0001	-0.018	**-0.009**	0.013	-0.005
	(0.009)	(0.014)	(0.012)	(0.023)	**(0.004)**	(0.014)	(0.016)
$DEATH_{it}$	**-0.017**	-0.006	-0.007	0.002	**0.014***	**-0.024**	-0.018
	(0.008)	(0.014)	(0.010)	(0.025)	**(0.005)**	**(0.013)**	(0.014)
$DEATH_{jt}$	0.002	0.006	0.010	0.020	**0.019***	0.002	0.018
	(0.009)	(0.013)	(0.012)	(0.022)	**(0.004)**	(0.014)	(0.017)
LM_{it}^{k}	0.085	-0.163	-0.032	-0.076	**-0.178**	-0.016	0.008
	(0.083)	(0.115)	(0.021)	(0.056)	**(0.082)**	(0.022)	(0.055)
LM_{jt}^{k}	-0.036	-0.032	0.005	-0.180	**0.332***	**0.036**	0.041
	(0.080)	(0.050)	(0.013)	(0.117)	**(0.061)**	**(0.017)**	(0.031)
LX_{it}^{k}	-0.267	0.029	-0.010	0.150	**0.083***	-0.023	-0.101
	(0.177)	(0.146)	(0.030)	(0.110)	**(0.012)**	(0.037)	(0.068)
LX_{jt}^{k}	0.073	-0.090	-0.033	-0.038	**-0.459***	**-0.095***	**-0.172***
	(0.173)	(0.130)	(0.034)	(0.150)	**(0.019)**	**(0.036)**	**(0.054)**
XP_{it}^{k}	0.070	-0.042	0.046	**-0.230***	**0.036**	0.091	0.026
	(0.049)	(0.084)	(0.038)	**(0.074)**	**(0.021)**	(0.066)	(0.048)
XP_{jt}^{k}	**0.101***	-0.004	0.032	0.005	-0.081	-0.043	0.089
	(0.028)	(0.069)	(0.033)	(0.100)	(0.069)	(0.051)	(0.076)
TFM_{it}^{k}	**0.116***						

	(0.036)						
TFM_{jt}^{k}	0.005						
	(0.039)						
TBT_{it}^{k}	0.117	0.082	**0.052***	-0.021	**0.103*****	0.013	0.018
	(0.073)	(0.100)	**(0.027)**	(0.021)	**(0.029)**	(0.017)	(0.142)
TBT_{jt}^{k}	0.019	0.097	-0.013	0.033	**-0.432*****	0.018	0.037
	(0.046)	(0.108)	(0.030)	(0.042)	**(0.038)**	(0.021)	(0.081)
TPO_{it}^{k}	-0.004	0.067	0.098	0.089	**0.169*****	**0.209***	0.313
	(0.056)	(0.087)	(0.068)	(0.071)	**(0.026)**	**(0.098)**	(0.203)
TPO_{jt}^{k}	-0.058	0.001	0.008	0.091	**-0.676*****	-0.230	**-0.303*****
	(0.056)	(0.093)	(0.037)	(0.083)	**(0.070)**	(0.118)	**(0.097)**
Constant	14.095***	12.089***	11.196***	11.681***	11.507***	16.496***	15.145***
	(0.104)	(0.295)	(0.355)	(0.352)	(1.611)	(0.430)	(0.108)
Observations	18,208	18,208	18,208	18,208	18,208	18,208	18,208
PseudoR^2	0.9755	0.9736	0.9662	0.9534	0.9655	0.9628	0.9647
Country-pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	No	No	No	No	No	No	No

Note:
Heteroscedastic robust standard errors are in parentheses
* Denote 10 per cent significance level
** Denote 5 per cent significance level,
*** Denote 1 per cent significance level.

Source: Research results

The results of the containment policies in Table 8 partially reinforce the aggregate model presented in Table 7 because these measures do not robustly explain fluctuations in trade flows. Moreover, when the estimates for these measures are shown to be statistically significant, they function as proxies that capture the increased need for imports because these policies were implemented as countries tried to contain rising numbers of COVID-19 confirmed cases and related deaths. In turn, it directly and negatively affects countries' capacity to produce goods for themselves. Other than that, the estimates for these policies might also suggest that the impacts of workplace closures are more intense in exporting countries.

Estimates for stay-at-home requirements in the importing countries are statistically significant only for the categories Other and Pharmaceuticals, whereas in the exporting countries, these estimates are statistically significant only for the categories medical equipment and pharmaceuticals. As all of the above estimates display positive coefficients, it is suggested that an increase in enforcement of stay-at-home requirements is favorable to trade flows. Therefore, the notion that these policies act as proxies for higher import requirements is reinforced.

The estimates for workplace closures resulted as positive and significant only for personal protection equipment and pharmaceuticals for importing countries, whereas for exporting countries, these measures presented significant and negative impacts for medical products not elsewhere specified and pharmaceuticals. Like stay-at-home requirements, these measures appear to signal the increased need for imports in the importing countries. Furthermore, due to its negative coefficients for exporting countries, it is also suggested that these policies hit exporting countries harder than importing countries.

Confirmed cases and COVID-19-related deaths estimates are also in line with the results presented by the aggregate model in Table 7. They are not strongly significant and have inconstant signs. The number of cases in the importing countries resulted in a negative effect on the pharmaceutical goods trade. In the exporting countries, they came out to be positive for agricultural goods and negative for pharmaceutical goods. The death estimates in the importing countries resulted as negative for medical products not elsewhere specified and agricultural goods and positive for pharmaceuticals. The number of deaths in the exporting countries positively affects the trade flows of pharmaceutical products. A plausible conclusion to this result is that the number of deaths increases the demand for pharmaceutical products.

Import licensing procedures in the importing countries significantly reduce pharmaceutical product trade flows. Regarding the other products, the coefficients are negative but not statistically significant. However, import licensing coefficients are positive for medical products NES and pharmaceuticals when considered in the regression as being associated with exporting countries. In our database, two import licensing notifications direct apply to pharmaceutical products. By looking at the content of those notifications, we observe that one of them displays trade facilitating changes to import licenses indicating flexibilization in the authorization process for importing and distributing COVID-19 drugs.

On the other hand, there is also a broad-reaching notification that announced import controls over pharmaceuticals. Therefore, a plausible interpretation for the negative result of the coefficient on this variable for the importing country is that import facilitation measures were not significant enough to positively affect trade, while import control measures were more intense, negatively affecting trade. Furthermore, a possible explanation for the positive result of the coefficient for exporting countries is that one of these two measures was notified by Canada, a significant pharmaceutical product exporter.

Export licensing measures applied by the exporters hindered the trade of medical products, pharmaceuticals, and Other products. These results suggest that the export licensing notifications sent by countries aimed to make the obligations and procedures related to these policies stricter. These findings directly corroborate the results of Bown (2020a), Evenett (2020a, 2020c) and Fuchs et al. (2020), who state that in response to trade downturns, countries began to implement export curbs, some of these being implemented as export licenses, to prevent shortages.

Contrary to what we expected, export prohibitions applied by the exporting countries have a positive and significant effect on the trade of agricultural products. A possible interpretation of the positive results for this variable is that countries tried to lift export prohibitions to ensure that the flow of goods continued to other countries, whereas the insignificance shown in most products points that these policies were not strict enough to affect trade negatively. When implemented by importing countries, export prohibitions had intense and highly significant coefficient in regards to personal protection equipment, it also had a positive coefficient related to pharmaceuticals but it was less intense. This suggest that the implementation of these measures was focused on PPE and were intense enough to have a negative relation to the trade value of these goods. An explanation to this result is pointed by Bown (2020), Evenett (2020a, 2020c) and Fuchs et. al. (2020) that state that most of measures aimed at hampering exports tried to affect PPE exports.

Trade facilitating measures were significant and positive for trade in agricultural goods. It is an expected result since this type of policy had contents that suggested that implementing these measures was aimed to facilitate the importation and would benefit trade flows.

The Technical Barriers to Trade estimates are statistically significant for medical supply and pharmaceuticals products. When observing the signs of the measures, it is noticed an interesting characteristic of the countries' policy response. When these variables are regarded in the regression as related to exporting countries, their estimates were negatively related to trade flows. On the other hand, when these variables are considered in the regression as related to importing countries, their estimates are positive and statistically significant. It suggests that governments have sought to prevent shortages by imposing technical measures on exports and have concomitantly tried to facilitate the entry of goods by relaxing these barriers for imports. The same pattern can be seen for tariff policies, but for these measures, the estimates are statistically significant for the medical NES, pharmaceutical, and other products.

It is worth noting from Table 8 that trade flows of pharmaceutical products were most affected by the pandemic. It is pointed out that all of the direct disruptions variables and most of the trade policies are statistically significant for this product category. Interestingly, export Licensing requirements, technical barriers to trade, and tariff policies imposed by the importing countries have positively affected trade flows of pharmaceutical products. Conversely, the coefficients of those measures are negative and statistically significant when the exporters employ those policies. A plausible explanation for these results is that countries used trade policies individually and disorganizedly, aiming to facilitate the importation of pharmaceutical products. When applied by exporting countries, the negative effect of those policies on trade suggests that countries also tried to guarantee the stockpile of these goods by imposing measures that embedded impediments to trade. These findings are in line with Bown (2020), Evenett (2020c), Fuchs et al. (2020), and Stellinger et al. (2020). These authors argue that countries dealt with the increase in demand for these products by facilitating imports while preventing exports.

Table 8 presents unexpected results for Agricultural Products, a focus of concern within recent literature that discussed the COVID-19 trade crisis (BOWN, 2020; FIORINI; HOEKMAN; YILDIRIM, 2020; SOCRATES; LASHITEW, 2020). Those authors feared that export curbs could be being imposed on these commodities, which could trigger cross-retaliatory policies that could result in a shortage of these products for some countries. Faria et al. (2021) point out that some countries have imposed export prohibitions or export licensing requirements for this product category. Nevertheless, our findings show that the coefficients for most of the policies set on these products were not statistically significant. However, the coefficients for trade facilitating measures came out as positive for this policy whether it was implemented by importing or exporting countries. Additionally, the export prohibition implemented by the exporting countries significantly and positively affects trade flows. This is a result of the countries' efforts to develop regulations and protocols that facilitate the entry of goods through Trade Facilitating Measures. It is also a result of the fact that export prohibition policies were not intense enough to generate significant barriers and were not extensively used as was feared by the authors. In this way, the countries managed to maintain trade flows for these products. (BOWN, 2020; FIORINI; HOEKMAN; YILDIRIM, 2020; SOCRATES; LASHITEW, 2020).

The estimates for the categories Medical Products NES and PPE reinforce the notion that countries tried to guarantee their share of essential goods by implementing policies that hindered trade. This pattern is evident when one notices that export prohibitions are the only policy significant for the PPE trade. Furthermore, the intense negative relationship between these prohibitions and trade flows of PPE results from countries' drive to secure their stockpile of these goods through measures that hinder exports, as pointed by Bown (2020) and Evenett (2020a, 2020c). It becomes clearer when tariff policies are considered. When the exporting countries impose these measures, they negatively impact trade, whereas when importing countries apply these policies their coefficients are positive and statistically significant. These findings show that countries aimed to hamper Medical Products NES and PPE exports while concomitantly trying to facilitate these commodities' imports through these policies.

None of the trade policies have affected the trade flows of medical equipment, while only technical trade barriers applied by the importing countries in medical supplies were positive and statistically significant. Most of the content of the notifications announcing technical barriers to trade regarding medical supplies denotes flexibilization in technical requirements on an emergency basis which may be a plausible reason for the positive coefficient of this variable.

Lastly, it is sensible that the Other category was not as intensely affected as the essential categories, but it should be noted that the policies applied to Other were detrimental to trade. Considering that these products are not regarded as crucial against COVID-19, in theory, countries would not get any benefit from higher barriers to trade for these goods. Accordingly, a possible explanation for this result is that this category ended up being too broad, so some products that help fight the pandemic of COVID-19 may have been classified within it, such as some textile products.

Our results represent a step toward the correct interpretation of the fluctuations of trade flows during the pandemic, indicating that variables directly linked to trade, such as trade policies, more robustly explain these movements. Furthermore, the results by product category presented in Table 7 show that countries focused their policy changes on COVID-19 essential products, especially pharmaceuticals. Finally, different coefficient signs for the same policies when applied by importers or exporters reinforce the notion that countries that implemented these policies individually and disorderly have sought to increase the supply of essential products within their territories through trade policies. In this way, these policies have generally focused on facilitating imports and restricting exports. Therefore, according to recent literature (BOWN, 2020; EVENETT, 2020c; FRIEDT; ZHANG, 2020), implementing these policies does not prevent shortages and is detrimental to trade.

5 CONCLUSION

At the end of 2019, many people started suffering from pneumonia-like symptoms in China. The disease was caused by the severe acute respiratory syndrome coronavirus 2, or SARS-CoV-2, later named COVID-19. One of the main characteristics of this virus, which has made it so dangerous and devastating, is that it is easily transmitted between humans and could lead to death. Due to the features of SARS-CoV-2 and the significant movement of people across countries, COVID-19 spread to many countries, and the number of cases and deaths have risen sharply.

Countries quickly felt the negative consequences of this disease on their health systems and production processes and have responded with public containment policies based on surveillance and detection, clinical management of cases, prevention of the spread, and maintenance of essential services. Nevertheless, as production was hampered and the demand for goods vital in fighting the disease rose sharply, these goods became in short supply for all countries. As a response, countries extensively applied international trade policies as instruments to guarantee the supply of essential products, with little regard to free trade or the needs of other countries.

This study aimed to assess how the implementation of containment and COVID-19 trade-related policies has impacted trade flows throughout the pandemic. In addition, we aimed to answer which products were affected by these policies, which trade policies were more extensively used, and to what extent these measures are closely related to trade fluctuations.

We considered data extending from January 2020 to June 2021 to 33 countries that accounted for more than 58% of the trade volume in 2019. The direct impact of COVID-19 was measured through the number of cases and deaths. Lockdown effects were captured through containment policies, such as stay-at-home requirements and workplace closures. Finally, to represent the changes in COVID-19 trade-related policies, a new database was created from 64 notifications sent to the WTO.

From the analysis of the COVID-19 trade-related policies, we observed that they were intensively implemented during the beginning of the pandemic. Export prohibitions, export licensing requirements, and technical trade barriers were evenly implemented during the pandemic, while other policies were applied irregularly. Additionally, we noticed that these policies focused on the essential products to fight the pandemic. Finally, it was clarified that in addition to containment policies, an essential part of the policy response to the pandemic of COVID-19 lies in trade policy changes. The analysis performed by the gravity model clarified that for 2020 and 2021, the effects of stay-at-home requirements, workplace closures, cases, and deaths might not be sufficient to explain the fluctuations in trade flows. However, the estimates presented by trade policies in the aggregate model indicate that this variable can better explain trade fluctuations.

Overall, our results suggest that, contrary to what has been discussed concerning containment policies and the pandemic, these are not relevant for evaluating fluctuations in trade flows, at least not directly. Instead, what seems to happen is that cases and deaths caused by COVID-19 increase and decrease sporadically. Consequently, countries seek to mitigate the increase in cases and deaths by implementing containment measures, and at these times, there is an even more significant increase in the demand for essential goods, which has already been increasing since the beginning of the COVID-19 pandemic crisis. The dramatic increase in demand for these goods causes countries to compete with each other in the international market by adopting trade policies. Therefore, it carries the notion that COVID-19 trade-related policies are directly associated with trade value fluctuations and more accurately represent how countries have dealt with each other in the international system to secure stocks of these products.

Evaluating the effects of all variables through a product disaggregated gravity model allowed understanding that countries sought to guarantee their stockpile of essential goods, especially pharmaceuticals. The estimates show that countries acted individually and disorganizedly, using trade policies that created barriers to trade to meet their own needs without considering the needs of other countries. These policies have generally focused on facilitating imports and restricting export. The main tool for export hindrance was export licensing requirements, and the only policy that positively affected trade flows was Trade Facilitating Measures applied to agricultural products. Thus, countries did not use the diffuse structure of production of goods and wasted the beneficial potential of trade. In this sense, the estimates in the disaggregated regressions show that the approach countries adopted did not work in a way that benefited trade in these essential goods. Estimates indicate that most of the gains from import facilitation policies are negatively offset, often to a greater degree, by policies directed at hindering exports.

Furthermore, the varying results in different product categories show that trade policies affect products differently, reinforcing that it is essential to look at trade policies during COVID-19 by focusing on various products. Results found by the PPE products that were only negatively affected or even Pharmaceuticals, which show many positive coefficients but not enough to offset the pessimistic estimates, demonstrate the worst possible approach taken by the countries. Although several trade restricting measures have targeted agricultural products, positive coefficients indicate an improvement in trade flows.

The pandemic of COVID-19 is not over yet, so for this crisis and for the next ones governments and policymakers should criticize the use of trade-impeding measures in multilateral forums and commit to not implementing them. These policies result in cross-retaliation preventing trade from acting as a tool to mitigate adverse impacts during a global health crisis. Instead, they should use multilateral organizational frameworks and the opportunities presented by these mechanisms to organize joint responses to improve trade and access to essential products, especially for countries that cannot produce these goods. Two examples in the current crisis demonstrate the positive results of the joint action of countries concerning trade facilitation. One example is in the estimates of the agricultural goods in which all trade policies have had positive effects. Another example is in pharmaceuticals products in which it is known that countries have made efforts to guarantee access to these products, both for themselves and for other countries. It can be seen partially from the positive estimates for this category and actions such as the Covax Facility.

The main limitation of the study lies in the quality of the data. Important countries have no trade data after 2020, and as it approaches the middle of 2021, a more significant number of countries have no data, which considerably increases the number of zero trade flows. In addition, the emergency notifications sent to the WTO due to the pandemic of COVID-19 are instruments that accurately denote trade policy changes. However, these documents do not present much information about these changes' content, making constructing the database and interpreting the results difficult. In that sense, data such as the number and type of trade measures imposed by each country in each product do not allow one to appreciate the relative importance of these measures for restricting trade or adding to trade costs. Finally, another problem arises by the possibility of the endogeneity of trade policies. One way to treat or gauge this endogeneity is to use instrumental variables, but the database structure impedes this technique due to the difficulties of finding good instruments for the variables.

Although the time limit for this study was set for June 2021, the covid-19 continues to impact the economy and trade. Future studies should attempt to understand the impacts of covid-related variables, especially trade policy variables, with the help of additional documents and new data over a broader timeframe relative to annual trade flows, which may be of higher quality. It would be interesting for future research to focus on pharmaceutical products, which were most affected by these policies, or on Agricultural products, which showed positive estimates even though they suffered from implementing policies that presented barriers to trade.

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ANNEX

TABLE 9 - Notification by Type of Measures

	WTO Documentation Reference
Export Prohibition	G/MA/QR/N/EU/4/Add.3; G/AG/N/KGZ/8; G/MA/QR/N/EGY/1; G/MA/QR/N/KGZ/1/Add.1; G/MA/QR/N/COL/1; G/MA/QR/N/AUS/3/Add.1; G/MA/QR/N/EGY/1/Rev.1; G/MA/QR/N/AUS/4/Add.1; G/MA/QR/N/AUS/4/Add.2; G/MA/QR/N/AUS/4/Add.3; G/MA/QR/N/BRA/2/Add.2; G/MA/QR/N/COL/1/Add.2; G/MA/QR/N/BRA/2/Add.1;
License Measures for Exports	G/MA/N/EU/4/Add.1; G/MA/QR/N/BRA/2/Add.1; G/MA/QR/N/BRA/2/Add.2; G/MA/QR/N/COL/1/Add.1; G/MA/QR/N/EU/5/Add.1; G/MA/QR/N/ISR/1; G/MA/QR/N/ISR/1/Add.2; G/MA/QR/N/UKR/4/Add.2; G/MA/QR/N/USA/4/Add.1; G/MA/QR/N/USA/4/Add.2; G/MA/QR/N/COL/1/Add.2
License Measures for Imports	G/TBT/N/CAN/637; G/MA/QR/N/COL/1/Add.2
Tariff Policy	G/AG/GEN/160; G/MA/W/152; G/MA/W/146/Add.1; G/MA/W/146; G/MA/W/153; G/MA/W/165
Technical Requirements to Trade	G/TBT/N/BRA/984; G/TBT/N/BRA/988; G/TBT/N/BRA/989; G/TBT/N/BRA/990; G/TBT/N/BRA/1018; G/TBT/N/BRA/1021; G/TBT/N/BRA/994; G/TBT/N/BRA/1110; G/TBT/N/BRA/1150; G/TBT/N/BRA/1155; G/TBT/N/UKR/162; G/TBT/N/ESP/44/Add.1; G/TBT/N/USA/1602; G/TBT/N/ESP/44; G/TBT/N/CAN/641; G/TBT/N/EU/769; G/TBT/N/EU/786; G/TBT/N/MEX/495; G/TBT/N/USA/1673; G/TBT/N/MEX/494; G/TBT/N/USA/1716 ; G/SPS/N/BRA/1686; G/TBT/N/BRA/1112; G/TBT/N/BRA/992; G/TBT/N/BRA/993; G/TBT/N/BRA/996; G/TBT/N/CAN/609; G/TBT/N/BRA/1000; G/TBT/N/BRA/1017; G/TBT/N/BRA/1032; G/TBT/N/BRA/1149; G/TBT/N/BRA/1154; G/MA/QR/N/COL/1/Add.2
Trade Facilitating Measures	G/SPS/N/AUS/497; G/SPS/N/JPN/755; G/SPS/N/AUS/501; G/SPS/N/BRA/1642

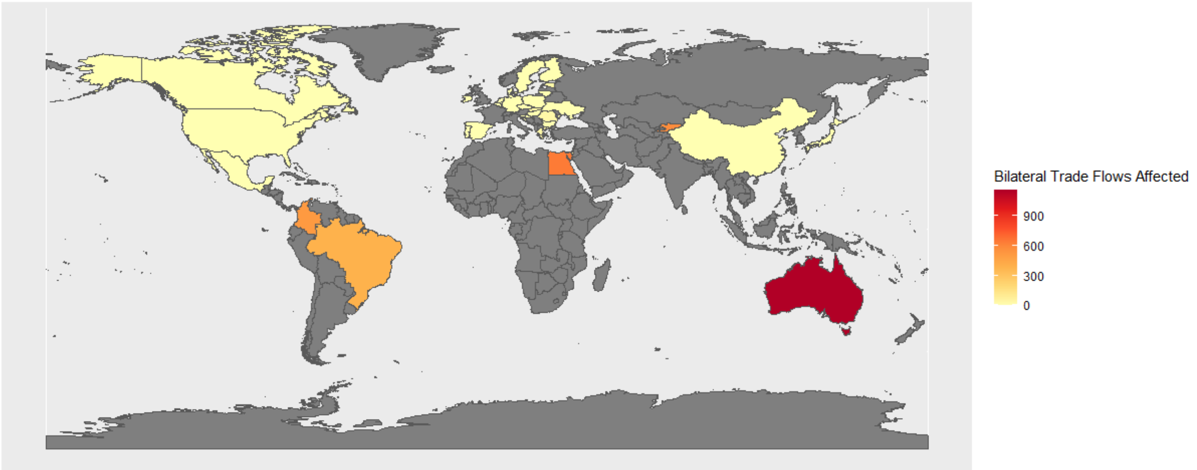
Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

TABLE 10 - Measures by Country

Country	Export Prohibition	Licensing Requirements for Imports	Licensing Requirements for Exports	Tariffary Policy	Technical Requirements to Trade	Trade Facilitating Measures	Total
CHN	0	0	0	0	0	0	0
JPN	0	0	0	0	0	1	1
EGY	2	0	0	0	0	0	2
KGZ	2	0	0	0	0	0	2
MEX	0	0	0	0	2	0	2
UKR	0	0	1	0	1	0	2
ISR	0	0	2	1	0	0	3
BEL	0	0	2	0	2	0	4
BGR	0	0	2	0	2	0	4
CAN	0	1	0	1	2	0	4
HRV	0	0	2	0	2	0	4
CZE	0	0	2	0	2	0	4
DNK	0	0	2	0	2	0	4
FIN	0	0	2	0	2	0	4
DEU	0	0	2	0	2	0	4
HUN	0	0	2	0	2	0	4
IRL	0	0	2	0	2	0	4
LTU	0	0	2	0	2	0	4
LUX	0	0	2	0	2	0	4
NLD	0	0	2	0	2	0	4
POL	0	0	2	0	2	0	4
PRT	0	0	2	0	2	0	4
SVN	0	0	2	0	2	0	4
SWE	0	0	2	0	2	0	4
COL	2	1	2	2	1	0	4
EST	1	0	2	0	2	0	5
GRC	1	0	2	0	2	0	5
ROU	1	0	2	0	2	0	5
SVK	1	0	2	0	2	0	5
USA	0	0	2	0	3	0	5
ESP	0	0	2	0	4	0	6
AUS	4	0	0	2	0	2	8
BRA	2	0	2	0	20	1	23

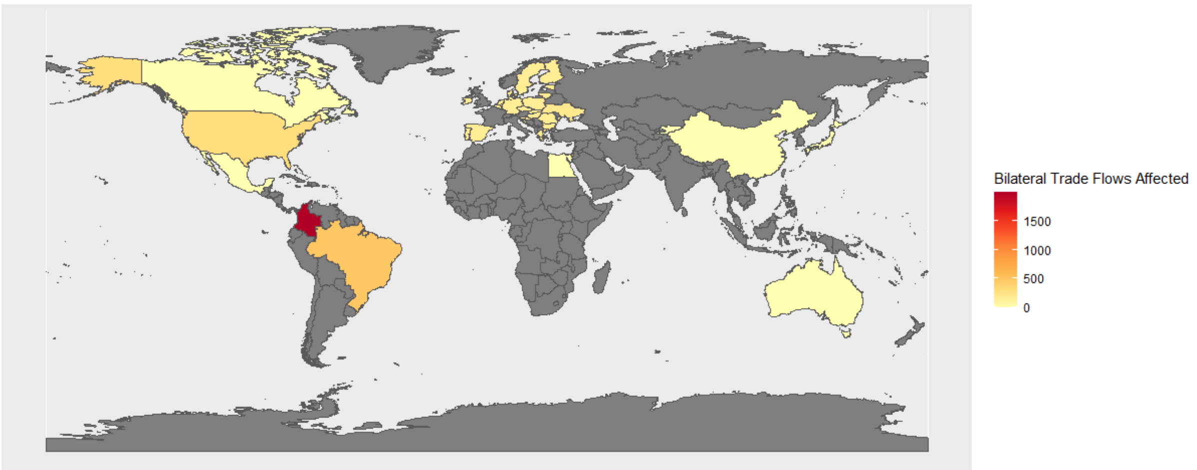
Source: authors’ own work based on WTO members’ notifications on COVID-19 (WTO, 2020d).

FIGURE 10 - Export Prohibition Heatmap



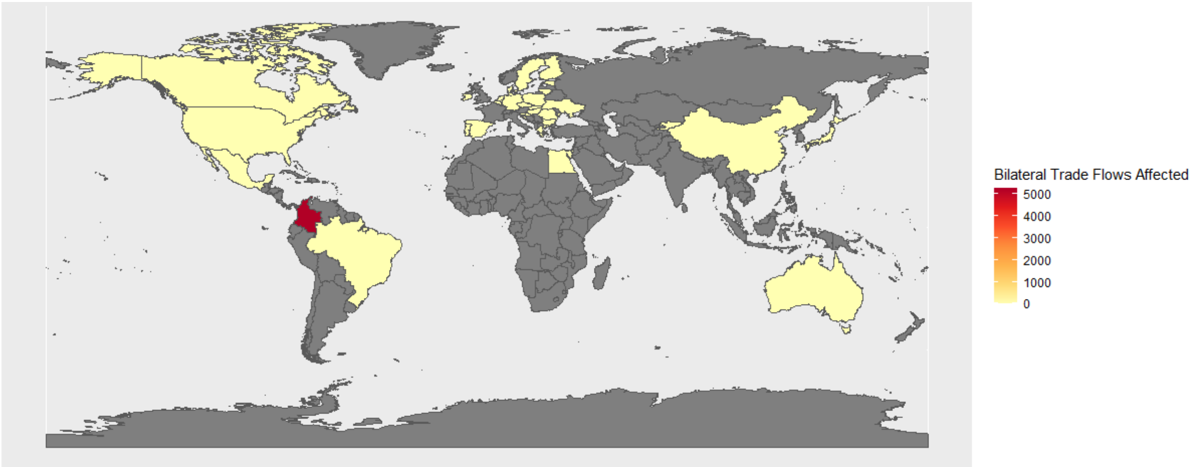
Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

FIGURE 11 - Licensing requirements to Exports Heatmap



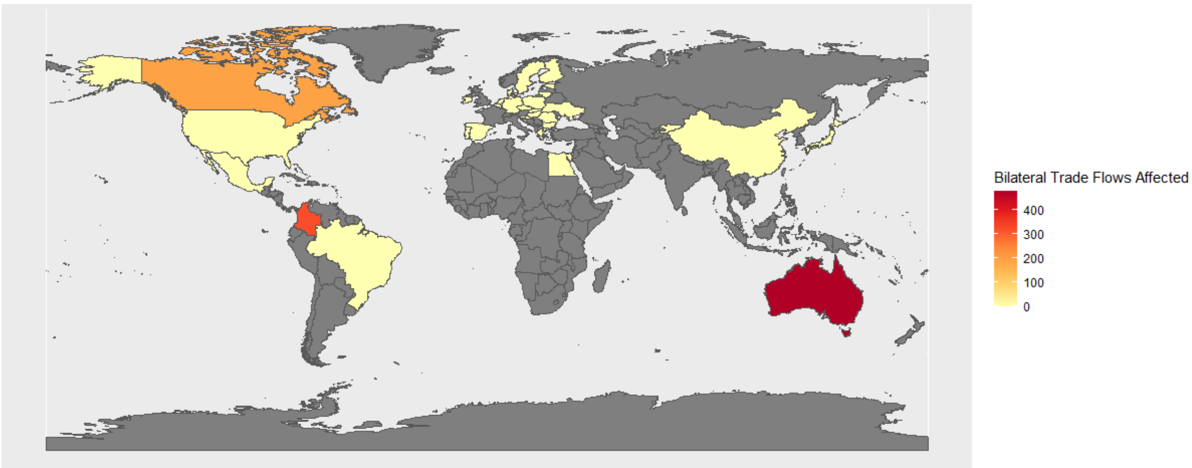
Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

FIGURE 12 - Licensing requirements to Imports Heatmap



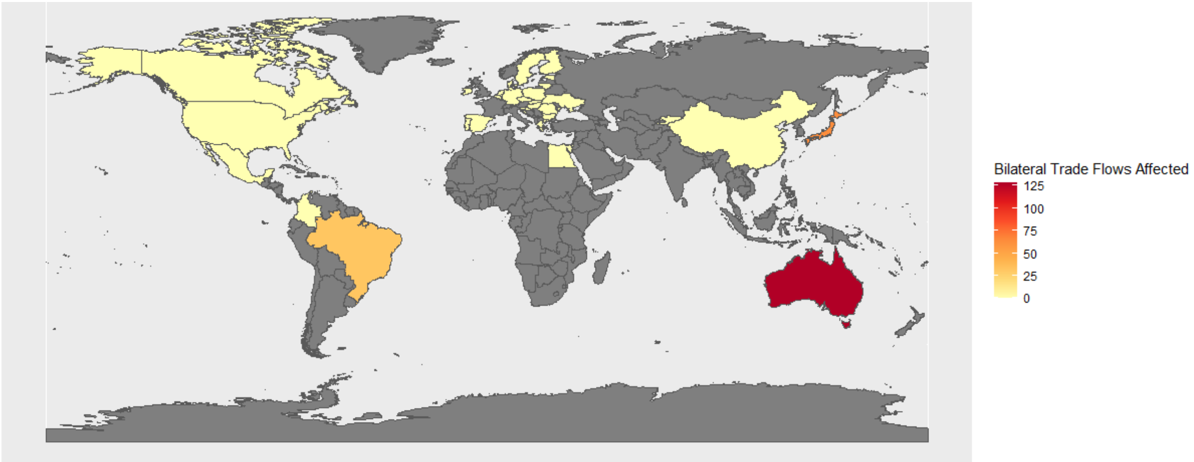
Source: authors’ own work based on WTO members’ notifications on COVID-19 (WTO, 2020d).

FIGURE 13 - Tariff Policy Heatmap



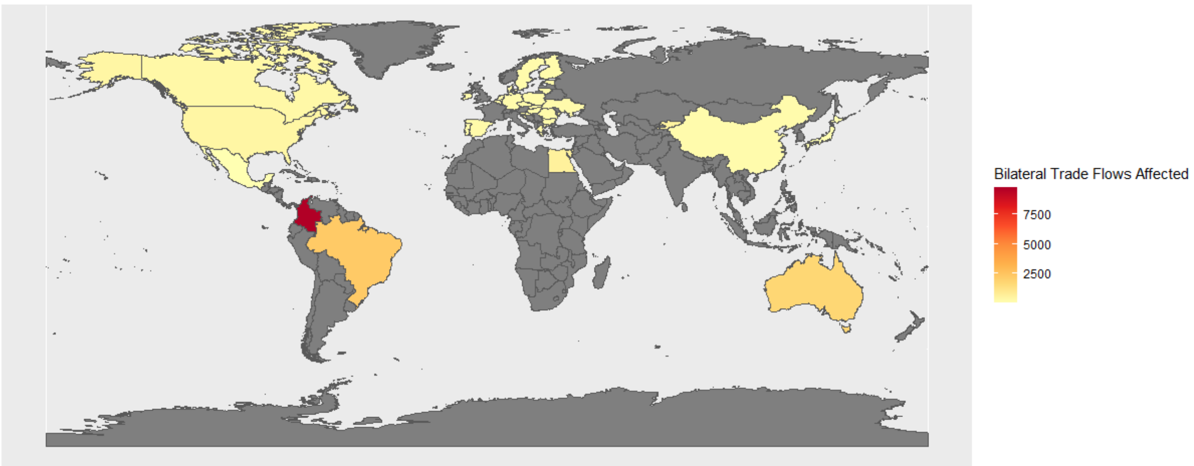
Source: authors’ own work based on WTO members’ notifications on COVID-19 (WTO, 2020d)

FIGURE 14 - Trade Facilitating Measures Heatmap



Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).

FIGURE 15 - All notifications Heatmap



Source: authors' own work based on WTO members' notifications on COVID-19 (WTO, 2020d).