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Utilization of a Gravity Model to Determine the Impact of COVID-19 in US Bilateral Trade

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UTILIZATION OF A GRAVITY MODEL TO DETERMINE THE IMPACT OF COVID – 19 IN US BILATERAL TRADE

A Thesis

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Abstract

In April 2022, the United States traded with approximately 233 countries. Exports and imports of goods and services represent 11.73% and 14.58% of U.S. GDP respectively. Because of that, U.S. bilateral trade is important. COVID-19 impacted the economy and trade in different ways as supply and demand changes. The objective of this study is to determine the impact of COVID-19 in U.S. bilateral trade using an augmented gravity model and panel data from 20 U.S. partner countries and the United States over 24 quarters, from 2015 to 2021.

To accomplish these objectives, a gravity model was used and Random effects GLS and PPML methods were applied. Two models were created, one for U.S. exports and another for U.S. imports with both having explanatory variables that include, GDP from the U.S. and partners countries, currency exchange rate, free trade agreements, new COVID-19 cases for the U.S. and trader partners, direct payments to individuals for both the U.S. and trade partners and other stimulus given to trader partners. All these variables were normalized as indices.

The study shows that GDP impacts trade flows, both exports and imports, as the gravity model suggests. COVID-19 had a significant impact on US exports and imports, both in the U.S. and trader partners. The results show that when new U.S. COVID-19 cases increased, U.S. exports increased, and U.S. imports decreased. When new COVID-19 cases of U.S. trading partners increased, U.S. exports are shown to decrease and U.S. imports increase. Theory suggests that the impact on U.S. exports and imports may occur due to a decrease in consumption resulting from lockdowns.

Chapter 1. Introduction

In December 2019, the first case of COVID-19 was reported in China that in a matter of months become a pandemic. By the nature of this highly contagious coronavirus, confinement was necessary and as preventive measure countries and regions closed their borders. With the closure of borders many areas were affected, raising concerns about global supply chain including acquisition of raw materials and intermediate inputs. This directly affected the production of final products production, generating complications for American manufacturers operating in other countries affecting exports and imports of goods and services.

Not only was the health of citizens affected, but the economy also suffered as thousands of temporal employees were without income and companies were shutting down due to a lack of inputs or labor. Especially companies related to services, luxury goods, and tourism were paralyzed causing reductions in domestic trade. However, goods of first necessity had a peak in demand due to concerns about shortage and storage of products to avoid exposure to the virus. On the other hand, new distribution channels were opened or gained popularity, positioning e-commerce and contactless delivery above store-based sales. Also, it is important to consider that this happened during the Trump Administration which created travel restrictions but kept the border open for trading commodities. However, given that many of the goods are shipped on passenger flights, the decreased in passenger flights also limited the options of shipping goods. As part of the adaptation to the new reality, teleworking or the provision of services remotely has been normalized and with the development of vaccines and preventive measures, trade has been returning to what it was before. Due to all these changes, the emergence of these new distribution channels could have compensated for the losses in other sectors. This consumption and production points of view will be reviewed in further chapters, for now current trade situation is introduced.

In April 2022, the United States traded with approximately 233 countries, according with the U.S. Department of State. Out of these 233 countries, only 20 countries have a free trade agreement with the United States. Canada, Mexico, China, Japan, Germany, South Korea, Vietnam, Taiwan, India, UK, Netherlands, Switzerland, Ireland, France, and Italy are the top 15 countries accounting for 74.4% of total trade (United States Census Bureau, 2022).

Since 1934 that US enters world markets and international trade a higher real income benefit has been possible by focusing on the most competitive industries in the US economy, increasing productivity and investing in exports to increase output and lower average production costs. From the consumer´s point of view, imports increase purchasing power through a wide range of products helping to keep prices low. Imports also provides quality inputs for different industries contributing with US competitiveness. Exports has contributed a one-third of the real GDP annual rate growth of US, more than 95% of world consumers are outside US (USTR, 2013).

Trade is one of the most important components of US economy, involving employment, living standards, economic growth and making US the world's largest economy in the world. Exports and imports of goods and services represent 11.73% and 14.58% of US GDP respectively according to the WITS (2019) which explains its importance for the economy, policymakers in the government have recognized the importance of unfettered international commerce (Authenticated U.S Government Information, 2006). Because of the importance of trade for US, many studies had been conducted in different areas, the gravity model has been used to study international trade flows, impact of free trade agreements and bilateral trade, among others. To measure different variables affecting trade, the gravity model allows us to be augmented, that is why is one of the most important models in international trade research.

Trade disruptions most of the times are occasioned for friction between large global trading nations, it has been studied since the beginning of trade, for negotiations and polices created to keep bilateral trade and countries competitive. From an economic point of view studies conclude than main causes of conflicts in trade are exchange rate, trade imbalances and market systems (Friedberg, 2005; Lin & Wang, 2018), economic recessions cause a protectionism than promote trade friction (Irwin, 2017). In a political way, strategies from political parties and US elections lead also to friction, between some large economies as China (Jervis, 2016; Kim, 2019).

Here it is investigated what is the impact of COVID-19 in US bilateral trade. Since the beginning of the pandemic, together with the uncertainty of what the impacts on the global economy would be and how long it would last, multiple studies were initiated on what could be expected including friction complicating bilateral trade. Different scenarios were raised early in the pandemic, however at present, with the pandemic almost coming to an end and despite having data available, there is an absence of information, the impact of this pandemic on trade is not clear, we do not know the impact of COVID-19 in US bilateral trade.

The objective of this study is to determine the impact of COVID-19 in US bilateral trade. This analysis was done using an augmented gravity model and panel data from 21 countries including United States (US) over 24 time periods.

The process of this study can be described through different chapters: a literature review to know previous studies using gravity model, different statistics regressions used and related to possible effects of a pandemic in trade; a theoretical framework to evaluate possible models and theories and to have ideas about expectations and assumptions, using the logic and existing knowledge, possible impacts that were had in the US trade due to COVID-19 can be raised. COVID-19 impact on US exports, COVID-19 impact on US imports, COVID-19 impact on

production, COVID-19 impact on global supply chain, COVID-19 impact on the demand side; an empirical model that through observation lead us to variables affecting our dependent variables, collecting data from reliable sources and creating a matrix detailing the data obtained, generating results through an statistical software Stata, analyzing the results using the hypothesis raised before and what theories or expectations of the study, and concluding the main points found in the study.

The study found that when the US had more new cases of COVID-19, US exports had a positive impact and a negative impact on US imports, when trade partners had more new cases of COVID-19, US exports had a negative impact and a positive impact on US imports.

The contribution of this research is to the literature about bilateral trade and the gravity model. This study shows how a gravity model can be augmented with different kind of explanatory variables and continuing effective to determine effects in trade. In addition, this work can be the base line to conduct further research about the impact of COVID-19 in trade when more data will be available. The results from this study can be further extended to study the impact of Covid-19 pandemic on commodity specific trade. Also, this study can contribute to create policies to prevent this kind of impacts in case of future events that can affect the economy like Covid-19 pandemic.

Chapter 2. Literature Review

2.1. Gravity model and different empirical methods

According with Baltagi *et al.* (2014) the gravity model considers bilateral trade as a multiplicative function of economic masses of two countries and the inverse of distance, and some constants added. The origin of the gravitational model dates to 1962 when Jan Tinbergen had the idea of creating an economic model considering that there were no impediments in trade and determining the pattern that would follow, based on Newton's law of universal gravitation. Concluding that trade flows are directly related to the economic size of the countries trading measured by the Gross Domestic Product and inversely related to distance between them (Benedictis & Taglioni, 2011). This concept perfectly fit the Newton's Law, gravity force between two objects is directly proportional to the product sizes and inversely proportional to the square of the distance between each other (Golovko & Sahin, 2021).

Maciejewski and Wach (2019) used an augmented gravity model through panel data, they consider six different hypothesis: (1a) The higher GDP, both of the exporting country and of the importing country (as its partner), should, therefore, be conducive to an increase in the value of the trade, (1a) The higher levels of GDP per capita of both exporting and importing partners foster an increase in the value of the trade, (2a) The lower the relative difference in the value of GDP of entities belonging to the analyzed pair of countries (especially in bigger economies), the larger the volume in trade between these countries, (2b) Leveling the GDP per capita of trading partners cause the increase of the value of their trade. (3) The closer the geographic distance of the exporting and the importing partners, the intensity of trade is higher, (4) Having a common border between the exporting and importing partners stimulate the value of the trade, (5) The membership in the EU as the integration grouping stimulates trade between exporting and importing partners, (6) The

membership in the single currency area (EMU) stimulates trade between exporting and importing partners. They used “the Classical Least Square (CLS) method for evaluating the significance of the interaction of individual independent variables can be used when there are no individual effects specific to individual pairs of countries that cannot be explained solely by the magnitude of the effects observed for observing independent variables and when there is no change in the analyzed phenomenon over time” (Maciejewski & Wach, 2019). They confirmed hypothesis (1a), (2a), (2b), (3), (4) and (5), concluding that “the free movement of goods, services, capital and labor, such factors (being crucial in the design of gravity-based foreign trade models) remain essential for the attractiveness of commercial co-operation as the size and level of economic partners, the geographical distance or the common border” (Maciejewski & Wach, 2019).

Vemuri and Siddiqui (2009) studied the impact of Internet on International Trade, according with them the world merchandise trade increase coincides with the commercialization of internet, they wanted to know the relationship between these two, concluding there was a positive between both. The endogeneity can be a problem in this kind of study, they used lagged variables to solve it. I was struck by the fact that they mention that due to ethnic, religious, politics, or the access to similar natural resources, proximity between countries could be negative for trade and give as example North Korea and South Korea, Israel and its neighboring Middle Eastern countries, and India and Pakistan that even they are close is each other have low trade between them. But for other factors as transportation costs and time, distance is still of strong influence on trade, however, in panel data the distance between countries do not change over time and cannot be estimated. The Ordinary Least Square (OLS) can generated inconsistent estimates because it does not take advantage of the repeated measurement of cross-sectional data. When omitted variables appear can be remove because of the difference between measurements of a cross-sectional unit at two

points in time. In addition, due to the use of a common intercept, heterogeneity in trade between two sets of countries is ignored (Vemuri & Siddiqui, 2009).

Fixed and random effects models are included in panel data, Vemuri and Siddiqui (2009) mentioned both, including some of the problems in each: “In the fixed effects model, the intercept is allowed to vary for each set of trading partners and each period. Fixed effects panel data models are more general in that they allow for arbitrary correlation between individual effects and the independent variables”, also “An alternative to fixed effect panel data model is the random effects mode, in which individual effects are absorbed into the error term. In the random effects model the effects of time-invariant variables, such as distance and commonality of languages, can be estimated”. The Hausman and Taylor solves the inconsistency on the fixed and random effects model because consistent estimation of time-invariant regressors is possible, correlation between individual effects and regressors is permitted (Vemuri & Siddiqui, 2009).

Frede and Tetkiner (2017), studied the regional trade dynamics of Turkey using a panel data gravity model, they found the gravity model very effective in the analyze of export and import flows of Turkey, adding explanatory variables as trade agreements and cultural dummies. They conclude that the EU Customs Union has a negative effect on Turkish exports and a positive effect on imports.

An empirical application to Mercosur-European union trade flows through an augmented gravity model was conducted by Martinez-Zarzoso and Nowak-Lehmann in 2003 where they used panel data. They emphasize two advantages with the use of data panel, make possible to capture the relevant relationships among variables over time. the ability to monitor the possible unobservable trading-partner pairs individual effects. OLS method when individual effects are correlated with the regressors estimates are biased because individual effects are omitted. They

decided to use a fixed effect model because it is used when one is interested in estimating typical trade flows between an ex ante predetermined selection of nations (Egger, 2000, as cited in Martinez-Zarzoso & Nowak-Lehmann, 2003). OLS were used for comparison with Cross-Section Means that in this case showed similar results however, OLS results are biased, and it was a better option to choose a model with individual effects. They estimate fixed and random effects models, to choose between the two models they used the Hausman test for the null hypothesis that the explanatory variables and the individual effects are uncorrelated. Further discussion led them to select fixed effects estimates since random effects estimates are inconsistent. Their results show that exporter and importer incomes have a positive influence on bilateral trade flows, as expected. Also, "Exporter population has a large and negative effect in exports showing a positive absorption effect, whereas importer population has a large and positive effect on exports, indicating that bigger countries import more than small countries" (Martinez-Zarzoso & Nowak-Lehmann, 2003). In addition, they conclude that infrastructure variables, income differences and exchange rates are important because all of them are statistically significant and present the expected sign, apart from the importer infrastructure variable that is not significant (Martinez-Zarzoso & Nowak-Lehmann, 2003).

Iqbal and Islam (2014) studied the bilateral trade between Bangladesh and the European Union using a panel data and an augmented gravity model approach, they consider two methods for their research Generalized Least Squares (GLS) and Seemingly Unrelated Regression (SUR) to have results without heteroscedasticity and autocorrelation. They found appropriate to use random after running a Hausman Test because fixed effect omit variables creating biased results. In conclusion, they determined the correlation of GDP and real exchange rate between Bangladesh and European Union and that both countries are benefit from trading.

GLS method is a tool to solve inverse problems, the solution is generated by minimizing the generalized error, to eliminate non-uniqueness presented in the case of using only observations, the prior information is added to the model. The covariance in GLS comes from the sum of a term that is identical in form to the one in simple least squares, and an analogous term created from the prior information. (Menke, 2015).

Rahman *et al.* (2006) used an augmented gravity model to found potential trade in South Asian Free Trade Area (SAFTA), they added a real exchange rate variable to consider the impact of depreciation (or appreciation) of domestic currency, following Soloaga and Winters (2001) as cited in Rahman *et al.* (2006) and a dummy variable to consider bilateral trade agreement. Also, because of the presence of zeros in the dependent variable they used a Tobit model but also OLS. In this research paper they confirm that the flows between trading partners are significantly explained by the size of the economy and distance.

As international trade study flows of goods and services there is also international tourism that is the flow of people between countries, the gravity model was also used to approach this area, considering panel data and a random effect model decided after the Hausman test (Keum, 2010).

Frankel et al. (1996) as cited in Keum (2010) gives three reasons why the gravity model is successful, prediction of bilateral trade, support for theories of trade and the idea of considering countries or regions as existent physically in a specific space.

Peru's foreign trade was analyzed through a panel data gravity model where expectations of the gravity model were confirmed, positive coefficients for economic size and negative coefficients for distance. (Wang & Badman, 2016). Acharya (2019) analyzed the determinants of Nepal foreign trade using panel data with a gravity model approach, where they affirm that an

increasing in GDP of trade partner countries increases both export and import; however, at least in this case export increases at higher rate than import, also than distance to trade partner countries is highly significant implying higher the distance, lower the trade.

Kea et al. (2019), published a paper where using Generalized Least Square (GLS), the Poisson Pseudo-Maximum-Likelihood (PPML) models identified the factors influencing Cambodia rice exports. To deal with zero problems in the data, according to Santos Silva and Tenreyro (2006) as cited in Kea et al. (2019), the PPML model enables the estimation of gravity model including zeros.

Hussain (2017), worked in gravity model of Trade about Pakistan using PPML as estimator, indicating that PPML is consistent with gravity model, provides robust results, addresses common issues associated with panel data and it is as simple as OLS. In PPML the dependent variable is taken on level and explanatory variables are in logarithm.

Oberhofer and Pfaffermayr (2021) estimated the trade effects of Brexit (a referendum presented in United Kingdom) with panel data and structural gravity model, according with them, PPML has restrictions of multilateral resistances for estimation purposes, avoiding the estimation of a large set of dummy variable parameters, downward-biased estimates of the standard errors are showed with many dummies. In addition, PPNL takes care of unobserved heterogeneity across country, because it treats all dummies as functions of the structural parameters of the bilateral, time-varying trade friction indicators and the observed data.

Bilateral trade within the Central African Economic and Monetary Community (CEMAC) bloc determinants were evidenced through PPML and an augment gravity model, where agrees with Oberhofer and Pfaffermayr (2021) mentioning that PPML takes care of heteroskedasticity and zero

values (Eric et al., 2020). In this study findings are the significant impact of GDP, existence of borders, population, and capital in trade flows.

Larson, et al. (2018), applicated PPML to a gravity model to model international trade of forest products, they used the basic explanatories variables in the gravity model, GDP, and distance. They highlight two issues explaining why OLS represents problems in this kind of studies, unable of include zeros in the model because there is not natural log for zero and heteroscedasticity because of the multiplicative error term of the stochastic gravity model. These two issues are avoided when using PPML as model.

2.2. COVID-19

From the beginning of the pandemic as expected, human beings began to want to understand the reason of the problem, cause, and effect. Due to the magnitude of the situation, it lent itself to studies in multiple fields of study including economy.

According with McKibbin and Fernando (2020) from the Australian National University and Brookings Institution and the Centre of Excellence in Population Ageing Research (CEPAR); because the beginning of the pandemic was in China and China is one of the main suppliers of many companies globally, with the decrease in the production of China, the functioning of global supply chains was disrupted. They used G-cubed model is a hybrid of dynamic stochastic general equilibrium (DSGE) models and computable general equilibrium (CGE) models to analyze seven different scenarios for the spread of COVID-19 where only in two scenarios were considered the epidemiological shocks occur in all countries. They calculated the GDP loss in 2020 from a percentage deviation from baseline where for US the higher was -8.4 and the lowest was -0.1. They recommended policy responses in monetary, fiscal and health for this multi-faceted crisis.

Baldwin and Tomiura (2020) from Graduate Institute, Geneva and CEPR in conjunction with Hitotsubashi University made an anticipated study about the trade impact of COVID-19, they mentioned an important fact, usually pandemics affect the most, less economically economics countries, however, in this one is the opposite, the biggest world economies are the most affected including: (in order) China, Korea, Italy, Japan, US, and Germany. In past recessions, global trade has slowed faster than global growth, this outcome was especially marked during the Great Trade Collapse in 2008. In addition, to being global giants, the manufacturing sectors of the six hard hit economies are at the heart of a myriad of international supply chains; each is an important supplier of industrial inputs to each other and to third nations. Due to the above manufacturing sector gets the most impact, in the demand side macroeconomics decrease in aggregate demand and shortage for consumers. The gravity model that considers destination's aggregate demand and the origin's aggregate supply in GDP form suggests that exports and imports will decrease. Baldwin and Tomiura (2020) demonstrated that the goods and parts produced the US, Germany (DEU), China (CHN), and Japan (JPN) are massively important in the expenditure on all major nations. In terms of services, tourism related services were affected the most and in less proportions for financial and medical services due to due to the ease of being provided remotely. Since these services are directly involved in the pandemic, this could lead to increasing trade in services. Because of the US previous history this pandemic could lead to repatriate supply chains, considering that US wanted to decrease the excess dependence on China, same as other countries, however, more for US due to the ongoing trade war with China (Baldwin & Tomiura, 2020). If we look at financial levels, banks can be a support for firms, however in a long run it will put pressure on bank's loans and solvency.

According to Wren-Lewis (2020) from Oxford University, there may be an increase in costs for companies because of disruption in labor, taking in to account those workers get sick or schools close and they will need to take time off to look after children, impacting GDP. The biggest impacts on GDP occur when we have people reducing their social consumption in an effort not to get the disease. However, falls in social consumption do not scale up all scenarios by the same amount, for the simple reason that supply, and demand are complimentary. If we consider companies that are already with financial issues and instability can lead to shutting down because of inability to get short term loans.

The World Bank Group (East Asia and the Pacific Region Office) published a preliminary report on the potential impact of COVID-19 on GDP and Trade in April 2020 where they used a standard global computable general equilibrium model. It concludes that GDP fall by 2 percent below the benchmark for the world, 2.5 percent for developing countries, and 1.8 percent for industrial countries and that the biggest negative shock is recorded in the output of domestic services affected by the pandemic, as well as in traded tourist services. They consider that it is still too early in 2020 and is an illustration (Maliszewska, *et al.,* 2020).

Depending on how long the constraints in the major economies persist and measures taken, the severity of the economic impact will be. Because of companies lack liquidity many people lose their jobs and the economies of many countries had been put under heavy pressure. Import and export rates have declined, and government support for producers during the quarantine regime becomes crucial (Akbulaev, *et al.,* 2020).

In a summary presented by Maital and Barzani in March 2020, they emphasized China's crucial role during the pandemic. China suffered a similar situation during 2003, however at that time it represented only 4% of world GDP unlike the present one in which China is the second largest

economy, 16% of world GDP. COVID-19 mostly affects the manufacturing and services sectors that currently account for 93% of China's GDP (Han *et al*, 2020). Due to the above the impact on the world's global GDP due to China's GDP will be greater and considering that the other countries that are in the highest positions of the world economies are also being more affected, it is common sense to expect a stronger hit than we think (Mirzayev & Kelly, 2021).

Rodeck (2022) thinking positive indicates that COVID-19 recession will be V-shaped, it means a sharp downturn followed by a sharp recovery, considering previous epidemics. In March 2020, an estimation of GDP loss considering 24 industrial countries was made by McKibbin and Fernando where the range was from $283 billion to $9.2 trillion. In this same study, in the worst scenario there is a decrease in consumption and investment directly affecting equity markets and generating a major shift into bonds and decline in profits.

Maital and Barzani (2020) provide a clear example where this kind of crisis saw as opportunity, they take us back to the year 2003, when Alibaba created an online platform with new media, thanks to this Alibaba now capitalizes $ 547 billion.

Because of all the uncertainty around the actual impact of COVID-19 in US trade and after to review different empirical methods that help to explain trade flows, in Chapter III the theorical framework that could be used to generate the empirical methods is defined followed by Chapter IV where the empirical methods used are described, that will give results than answer the research question.

Chapter 3. Theorical Framework

According to the literature review, different scenarios were raised, thought pandemics affect the most, less economically economics countries, however, in this one is the opposite, the biggest world economies are the most affected. In addition, the goods and parts produced in the US, Germany (DEU), China (CHN), and Japan (JPN) are massively important in the expenditure on all major nations. In terms of services, tourism related services were affected the most and in less proportions for financial and medical services due to due to the ease of being provided remotely. Since these services are directly involved in the pandemic, this could lead to increasing trade in services (Baldwin and Tomiura, 2020). About GDP, losses were expected for the increase in costs for companies and decrease in consumption (Wren-Lewis, 2020). Imports and exports are expected to decline because of companies lack liquidity many people lose their jobs and the economies of many countries had been put under heavy pressure (Akbulaev, *et al.*, 2020). Thinking positive indicates that COVID-19 recession will be V-shaped, it means a sharp downturn followed by a sharp recovery, considering previous epidemics (Rodeck, 2022).

COVID-19 represents a shock in the market, it could develop shifts in supply and demand for both, exporting and importing countries, these changes can be described through the theory of trade, explained below.

Theory of trade explains a two-nation trading regime, Houck (1986) illustrated a diagram that could be used to experiment with some hypothetical shifts, what would happen in trade when different changes occur on the supply and demand curve in exporting and importing countries. Suppose that COVID-19 create a disruption in the supply chain of the exporter country, this could be for border closures, restrictions or polices as some protectionism to keep domestic markets supplies or businesses closures in countries where raw materials and intermedium inputs are

produced, shortage in labor to process. This shock in supply chain will move the supply curve of the exporting country to the left, meaning less quantity at a higher price leading to a move to the left also in the world market, reducing trade, this concept can be explained in the figure 3.2. When there is a shift to the left in supply for the exporting country, represented in the red line S' in the graph (a) in figure 3.2, the world market has a shift to the left as shown in graph (b) in figure 3.2, from ES to ES' that represent the excess supply before and after the shift of supply, respectively, decreasing trade from T1 to T2.

In the other hand, about the demand, if COVID-19 made a shock in the demand of the exporting country, this could be related to change in consumer behavior it means consumption because of lockdowns, either in a household level or business purchases, this impact can be expected to be negative moving the demand curve to the left, meaning less quantity at a lower price, generating an increase in trade in the world market, this shock is illustrated in figure 3.3. When exporting countries have a shift to the left as shown in the graph (a) in figure 3.3, in the world market there is a shift to the left in the supply as well from ES to ES' increasing trade from T1 to T2 indicated in the graph (b) in the figure 3.3.

From the importing country approach, supposed COVID-19 generated a shock in the supply, like the exporting country this could be caused for border closures, restrictions or polices as some protectionism to keep domestic markets supplies or businesses closures in countries where raw materials and intermedium inputs are produced, shortage in labor to process. This negative impact decrease quantity at a higher price and it affects the world market by increasing the price and the trade quantity, showed in figure 3.4. When there is a shift to the left in supply as represented in the graph (c) in the figure 3.4, from S to S', the world market had shift to the right from ED to ED'

that indicates the excess in demand before and after the shift, respectively, trade increases from T1 to T2 , showed in the graph (b) in the figure 3.4.

In the case of COVID-19 creating a shock in demand for importing countries, is expected to have a negative impact, change in consumer behavior it means consumption because of lockdowns, either in a household level or business purchases, moving the demand curve to the left at lower prices and lower quantity, this modifies the world market, decreasing trade and lowering price, as visualize in figure 3.5. When there is a shift to the left in demand for the importing country as showed in the graph (c) in the figure 3.5, trade decrease from T1 to T2 as an effect from the shift from ED to ED', the excess in demand, all this represented in graph (b) in the figure 3.5. Similarly, to exporting country this change can be attributed to the decrease in demand from businesses closed and households' behavior during the lockdown, resulting in the decrease of the market price increasing trade.

According to Sullivan (2020), American exports had declined and almost one hundred thousand businesses had been permanently shut, without forgetting the decline in global trade estimated about 13-22 % less. Supply chain had been affected, until March 2020, 10.6% of global containers were idling as shown in figure 3.1. Considering this information, we can expect a negative impact from COVID-19 in American exports because of supply chain disruptions

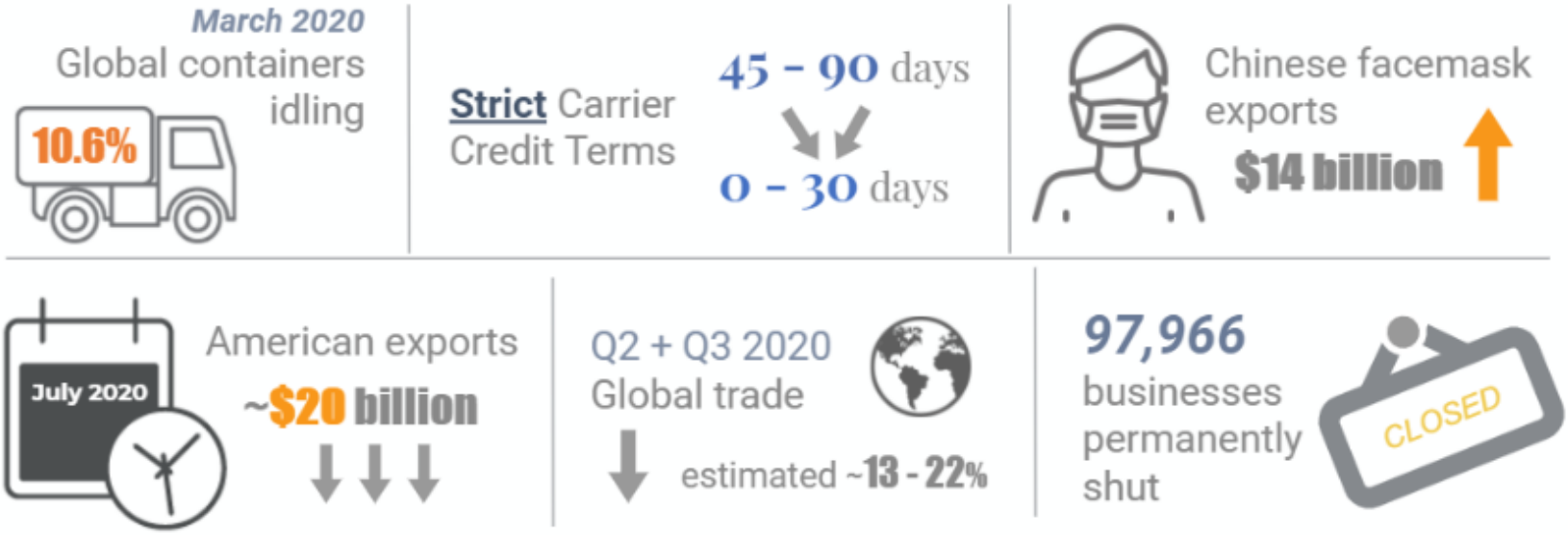
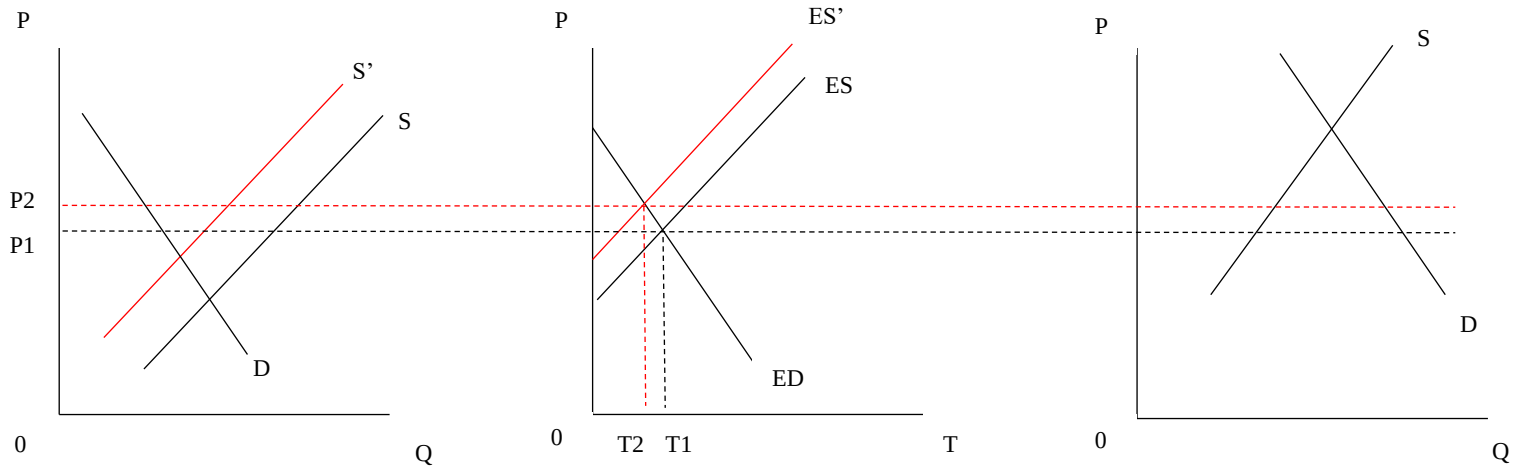
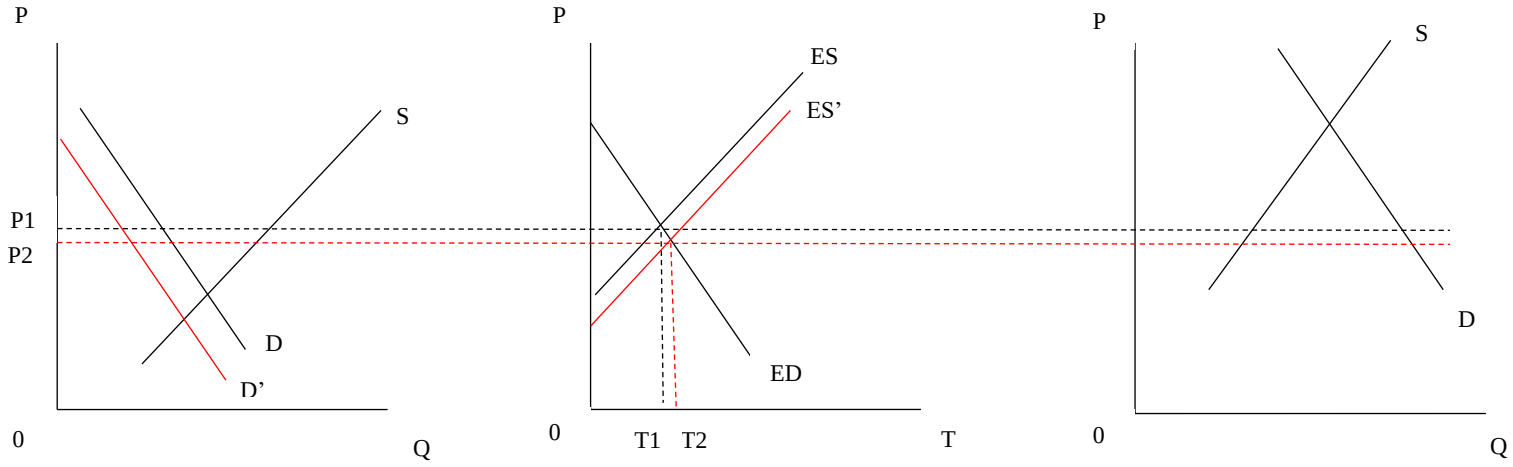


Figure 3.1. COVID-19 and Supply Chain
Source: Sullivan, 2020.



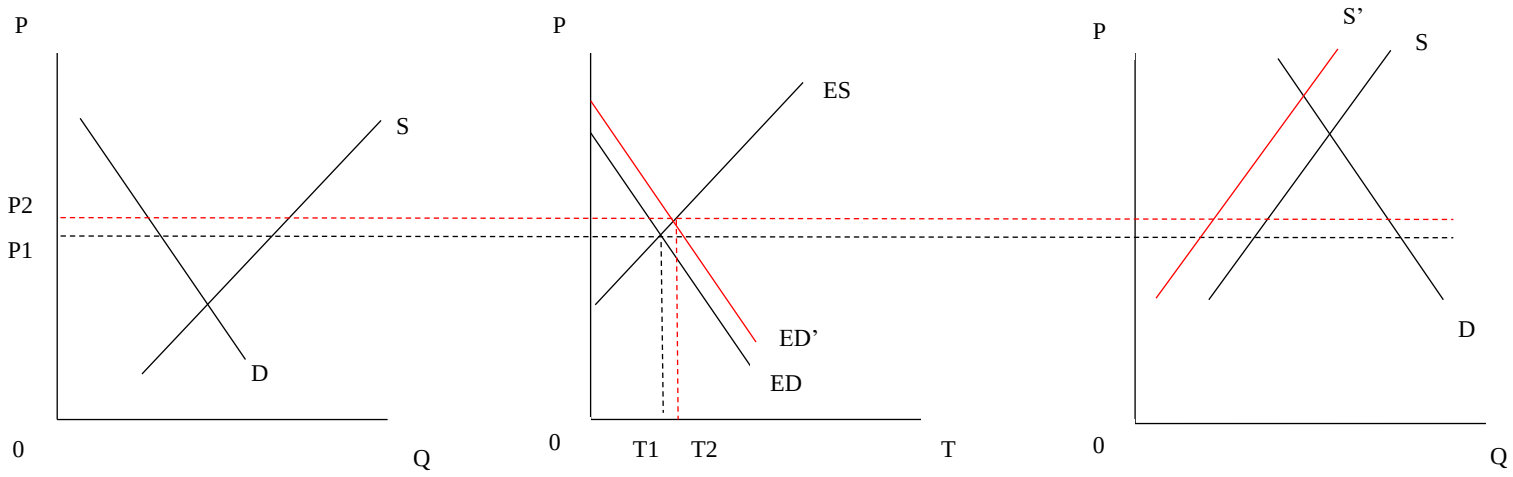
(a) Exporter (b) World Market (c) Importer

Figure 3.2. Impact of COVID-19 on Supply in Exporting Country



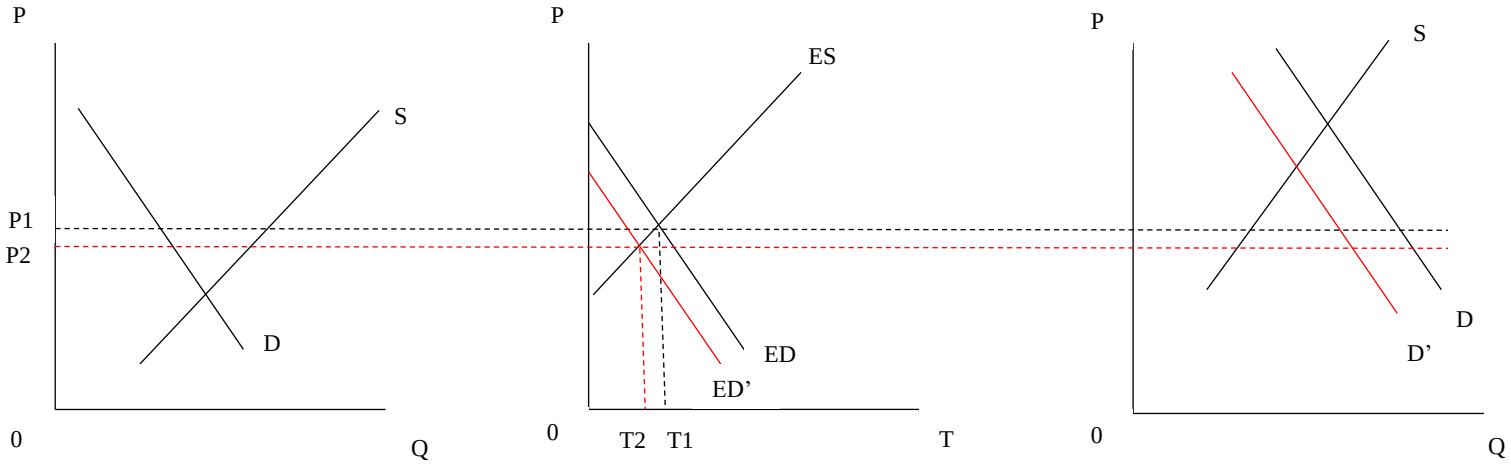
(a) Exporter (b) World Market (c) Importer

Figure 3.3. Impact of COVID-19 on Demand in Exporting Country.



(a) Exporter (b) World Market (c) Importer

Figure 3.4. Impact of COVID-19 on Supply in Importing Country



(a) Exporter (b) World Market (c) Importer

Figure 3.5. Impact of COVID-19 on Demand in Importing Country

Also, Balleer, *et al.* (2020) explained price adjustment during COVID-19 from a demand and supply approach. They showed evidence that most firms are negatively affected through a survey where they used a scale between -3 and 3, negative numbers are negative impact and positive number, positive impacts on their businesses. In these surveys were notorious than services are most affected, then wholesales and manufacturing. However, supermarkets, and manufactures of food, plastics and pharmaceuticals are positive affected.

Further surveys asked about when production is stopped or closed, lack of intermedium inputs, dependence from imports or any change in orders, also, about liquidity, changes in demand (foreign and domestic), supply chain disruptions or lack of personal. With all this data they generate a chart where the impact is explain shown in figure 3.6. Firms with negative impact had both decrease in orders and supply chain disruptions, shifts in demand and supply (see Figure 3.6.). About prices firms with problems in demand are more likely to plan a decrease in prices. From this approach we can expect that COVID-19 will have a negative impact in production, supply chain and demand.

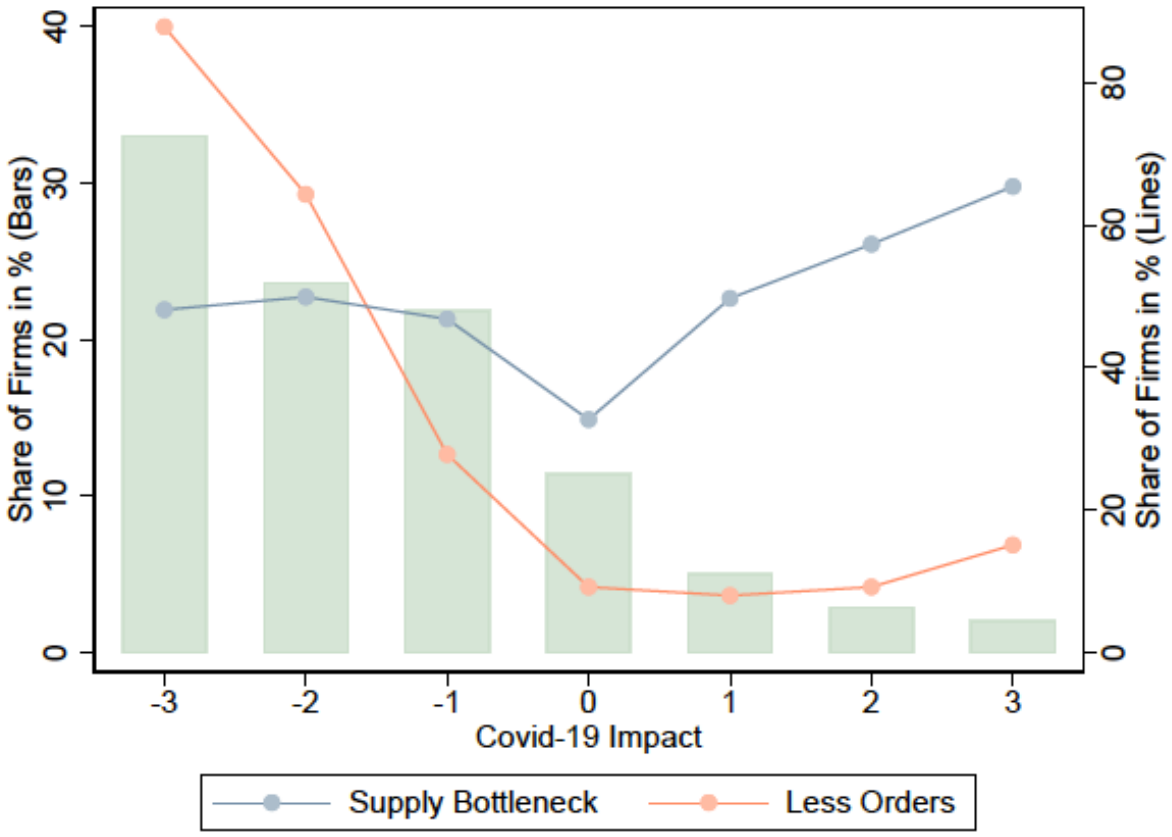


Figure 3.6. Impact of COVID-19 and adverse supply and demand shifts
Source: Balleer, *et al.* 2020.

From the information above, some expected signs can be attribute according to the impact that could be obtained in US bilateral trade, see table 3.1. Because of previous studies that confirm the theory under the gravity model that when the economic masses increase bilateral trade increase (Baltagi et al., 2014; Benedictis & Taglioni, 2011), we expect a positive sign in GDP variables. Dell'Ariccia (1999) and Njoroge (2020) showed that the volatility of exchange rate can negatively affect trade, a negative sign could be expected, Free trade agreements are characterized for stimulate the trade between countries through wide variety of products, a positive impact is expected. In terms of the relief stimulus given by the governments of each country because these result in extra income to consumers should give us positive impacts, even if they could be different

when direct payments are made and when other kind of help is given as vouchers that are design to be spend in specific goods and services. In the other hand, COVID-19 variables, because of all the negative effects described before in this document, as businesses closures, disruptions in supply change and changes in demand, a negative sign is expected.

Table 3.1. Expected sign (+ or -) for independent variables.

Independent Variable	**Expected sign (+ or -)**	
	US Exports	**US Imports**
GDPust	(+)	(+)
GDPit	(+)	(+)
ERiust	(-)	(+)
COVust	(+/-)	(+/-)
COVit	(+/-)	(+/-)
DISTusit	(-)	(-)
COMLANGusit	(+)	(+)
FTAusit	(+)	(+)
DPIit	(+)	(+)
DPIust	(+)	(+)
OTHERit	(+)	(+)

The origin of the gravitational model dates to 1962 when Jan Tinbergen had the idea of creating an econometric model considering that there were no impediments in trade and determining the pattern that would follow, based on Newton's law of universal gravitation. Concluding that trade flows are directly related to the economic size of the countries trading measured by the Gross Domestic Product and inversely related to distance between them (Benedictis & Taglioni, 2011). This concept perfectly fit the Newton's Law, gravity force between two objects is directly proportional to the product sizes and inversely proportional to the square of the distance between each other (Golovko & Sahin, 2021). Navarrete and Tatlonghari (2018) supported by Eita (2016) and Benedictis and Taglioni (2011) defined the standard gravity model equation as follows:

$$X_{ij} = \frac{G(M_i M_j)}{D} \quad (1)$$

where X_{ij} is bilateral trade flow, G is a constant, and M_i is the economic size of country i, M_j is the economic size of the country j, and D is geographic distance between i and j.

This equation can be normalize obtaining:

$$x_{ijt} = G\left(\frac{M_{it}}{M_{it^0}}\right)\left(\frac{M_{jt}}{M_{jt^0}}\right)\left(\frac{D_{ijt}}{D_{ijt^0}}\right) \quad (2)$$

where X_{ij} is bilateral trade flow, G is a constant, and M_{it} is the economic size of country i in a t period, M_{jt} is the economic size of the country j in a t period, D_{ijt} is geographic distance between i and j in a t period. M_{it^0} is the economic size of country i in a t^0 period, M_{jt} is the economic size of the country j in a t^0 period, D_{ijt} is geographic distance between i and j in a t^0 period and $t^0$is the base period value 2015Q1.

Considering that distance between i and j between periods does not change, we can rewrite this equation as:

$$x_{ijt} = G\left(\frac{M_{it}}{M_{it^0}}\right)\left(\frac{M_{jt}}{M_{jt^0}}\right) \quad (3)$$

Chapter 4. Empirical Methods

4.1. Data

This study is using a panel data, the countries to be used in this study were determined considering the US year to date top 15 exporting countries and the US year to date top 15 importing countries in April 2022 according to the United States Census Bureau, resulting in 21 countries in total however, Taiwan was dropped off because of completely absence of data, considering it is not accepted by Popular Republic of China, that's probably a motive to not being include in dataset, more a political issue. In addition to US, in total 20 countries were used, listed in Table 4.1.

Table 4.1. List of Top US Trading Partners – April 2022, Year-to-Date used in the study.

Top US Trading Partners	Percent of Total Exports (%)	Percent of Total Imports (%)
Australia	1.4	0.5
Belgium	1.9	0.8
Brazil	2.6	1.1
Canada	17.4	13.5
China	7.3	17.0
France	2.2	1.7
Germany	3.6	4.2
India	2.4	2.6
Ireland	0.9	2.5
Italy	1.4	2
Japan	4	4.7
Korea South	3.5	3.5
Malaysia	0.9	1.7
Mexico	15.9	13.8
Netherlands	3.4	1.1
Singapore	2.2	1.0
Switzerland	1.2	2.4
Thailand	0.8	1.8
United Kingdom	3.7	1.8
Vietnam	0.6	3.8

Source: (United States Census Bureau, 2022)

The time periods were quarters from 2015 through 2021 having in total 24 periods of time. The Gross Domestic Product (GDP) values were taken from International Financial Statistics (IFS) of the International Monetary Fund, quarterly, nominal, unadjusted in millions of domestic currencies. Also, from IFS were used the exchange rate values, quarterly, in domestic currency per US dollar, period average. Exports and Imports of goods were taken from US Census Bureau in millions of US dollars on a nominal basis not seasonally adjusted, monthly. COVID - 19 data was obtained from World Health Organization Covid Dashboard where we consider new cases and calculate it in quarters from daily data. For research purpose and due to data limitations Hong Kong has been included as a part of mainland China and the Exchange Rate for mainland China have been used for both. Data obtained in measures of time other than quarters was averaged or estimated to get it in quarters. Any monetary values obtained in domestic currencies were converted into US dollars. To have more realistic data all nominal values were converted into 2021Q4 real values using Consumer Price Indexes from IFS. Some missing values were calculated with an extrapolation creating a trendline forecast linear and displaying the equation that gave us the change between periods. To facilitate the comparison and understanding, we created indexes to measure the relative change, in this case respect to our initial period 2015Q1 as showed in equation (4).

$$I_t = \frac{V_t}{V_\circ} \tag{4}$$

Where, I_t represents the index in the period *t*, $V_\circ$ is the value in the initial period and V_t is the value in the period *t.*

New COVID-19 cases were represented as a percentage of the population calculated as explained in equation (5), population data was obtained from the World Bank.

$$\%_t = \frac{V_t * 100}{P_t} \quad (5)$$

Where $\%_t$ represents the percentage of COVID-19 new cases in the period *t*, V_t the value or number of COVID-19 new cases in the period *t* and P_t the population value in the period *t*.

Stimulus by the countries during COVID-19 crisis were taken from Alpert (2022) and the International Monetary Fund (2021), classified as Direct Payment to Individuals and Other that include monetary and macro-financial measures and policies, other kind as wage, tax, credit, loans to individuals and businesses and direct help with food, energy, and other bills.

Free Trade Agreement information are from the Office of the United States Trade Representative (2022). Distance between US and every trader partner were taken in km considering the most populated city from The Centre d'Études Prospectives et d'Informations Internationales (CEPII)(2021). Also, from CEPII (2021) the common official or primary language shared between US and trader partners.

4.2. Model

Two gravity models will be use, with two different dependent variables, US exports and US imports. The gravity model can be augmented using non-economic values, in this case our explanatory or independent variables described in Table 4.2., models used are:

$$EXP_{usit} = \beta_0 + \beta_1 GDP_{ust} + \beta_2 GDP_{it} + \beta_3 ER_{iust} + \beta_4 COV_{ust} + \beta_5 COV_{it} + \beta_6 DIST_{usit} + \beta_7 COMLANG_{usit} + \beta_8 FTA_{usit} + \beta_9 DPI_{it} + \beta_{10} DPI_{ust} + \beta_{11} OTHER_{it} + \varepsilon_t \quad (6)$$

$$IMP_{usit} = \beta_0 + \beta_1 GDP_{ust} + \beta_2 GDP_{it} + \beta_3 ER_{iust} + \beta_4 COV_{ust} + \beta_5 COV_{it} + \beta_6 DIST_{usit} + \beta_7 COMLANG_{usit} + \beta_8 FTA_{usit} + \beta_9 DPI_{it} + \beta_{10} DPI_{ust} + \beta_{11} OTHER_{it} + \varepsilon_t \quad (7)$$

Table 4.2. Variables Description

Dependent Variable	Description
EXPusit	real US exports to country i, quarterly, unadjusted in millions of US dollars, in t period
IMPusit	real US imports from country i, quarterly, unadjusted in millions of US dollars, in t period
Explanatory Variable	
GDPust	real gross domestic product of US, quarterly, unadjusted in millions of US dollars, in t period
GDPit	real gross domestic product of trader partners, quarterly, unadjusted in millions of US dollars, in t period
ERiust	real exchange rate values, domestic currency per US dollar, period average, in t period
COVust	new cases of COVID-19 in US, quarterly, in t period
COVit	new cases of COVID-19 in trader partners, quarterly, in t period
DISTusit	distance in km between most populated city of US and country i, in t period
COMLANGusit	common official or primary language shared between US and country i, dummy, in t period.
FTAusit	free trade agreements between US and trader partners dummy, in t period
DPIit	direct payment to individuals in trader partner countries dummy, in t period
DPIust	direct payment to individuals in US dummy, in t period
OTHERit	other help and stimulus given by trader partners countries dummy, in t period

4.3. Estimation Procedure

All the estimations in this study had been made using STATA version 17.0 as statistic software.

a. Generalized Least Square (GLS)

The Generalized Least Square is a generalization of the Ordinary Least Square (OLS) used to estimate coefficients of a linear regression, OLS minimized the sum of squared residuals, the difference with GLS is that the original residuals are rescaled before being squared and summed. GLS is used when OLS is failing in one of the Gauss-Markov theorem assumptions, it means is not the best linear unbiased estimator (Taboga, 2021). These assumptions are the random variable is independent of the independent variable, the random variable has a mean of zero, errors associated with any two pints in the population are independent of one another and the covariance

between any two errors is zero, the random variable has a finite variance (Thomson & Emery, 2014). An heteroskedasticity test was made for the data in this study and there is heteroskedasticity in the data meaning that errors can have different variances. Correlation was tested using the Wooldridge test and there is autocorrelation in the panel data, this means that covariances between errors can be different from zero. There is a failure into Gauss-Markov theorem assumptions because of heteroskedasticity and autocorrelation in the data.

Santos Silva and Silvana Tenreyro (2005) discussed some reasons where least square is not appropriate, when the dependent variable can be zero because there is not logarithm for zero, is unfeasible and even if the dependent variable is positive the expected value of the logarithm of the error will depend on the covariates and that makes least squares inconsistent. Also, the conditional distribution of the error can affect the estimation because generally the error term will be heteroskedastic and that will lead to inconsistent estimators. The logarithm of the dependent variable in the least squares method create a correlation with the regressors. The GLS estimator is not appropriate to be used in estimation of multiplicative models (Santos Silva & Silvana Tenreyro, 2005). GLS model dropped all zero observations because the dependent variable is in log form (Shepherd, 2012).

Even if GLS is not the best, it was used for comparison purposes and the Hausman test compared both fixed and random effects as used by Martinez -Zarzoso and Nowak-Lehmann (2003) and the probability of chi^2 determine if the hypothesis null than random effect is appropriate is rejected or accepted, in this case the probability of chi^2 was more than 0.05, therefore we accepted the hypothesis null that it means random effects is appropriate in this case, the fixed effect omit variables creating biased results. A GLS regression was applied under random effects and adding a quarter variable to consider seasonality for comparison purposes.

b. Poisson Pseudo Maximum Likelihood

The PPML estimator take into consideration that the dependent variable could be not an integer because of all the econometric standards that permit the Poisson regression estimation. The Poisson regression gives less weight to the observations with larger variance. Shepherd (2012) mentioned three different advantages of using a Poisson estimator in gravity model. First, fixed effects can be entered as dummies. Second, it includes observations where the dependent variable called it exports, imports or trade is zero. Third, the interpretation of the coefficients is the same under OLS or GLS even if the dependent variable is not logarithmic. PPML has more observations because it does not drop the observations with zero as value. PPML has been consistent in many studies using gravity model, Larson, *et al.* (2018), applicated PPML to a gravity model to model international trade of forest products. Bilateral trade within the Central African Economic and Monetary Community (CEMAC) bloc determinants were evidenced through PPML and an augment gravity model (Eric *et al.*, 2020). Hussain (2017), worked in gravity model of Trade about Pakistan using PPML as estimator, indicating that PPML is consistent with gravity model, provides robust results, addresses common issues associated with panel data and it is as simple as OLS. In PPML the dependent variable is taken on level and explanatory variables are in logarithm.

Also, in terms of panel data PPML is consistent, Oberhofer and Pfaffermayr (2021) estimated the trade effects of Brexit (a referendum presented in United Kingdom) with panel data and structural gravity model, according with them, PPML has restrictions of multilateral resistances for estimation purposes, avoiding the estimation of a large set of dummy variable parameters, downward-biased estimates of the standard errors are showed with many dummies. In addition, PPNL takes care of unobserved heterogeneity across country, because it treats all dummies as functions of the structural parameters of the bilateral, time-varying trade friction indicators and the

observed data. Peru's foreign trade was analyzed through a panel data gravity model by Wang and Badman (2016). Acharya (2019) analyzed the determinants of Nepal foreign trade using panel data with a gravity model approach.

To be more precise, a PPML model was run to avoid heteroskedasticity (Eric *et al.*, 2020; Larson, *et al.*, 2018), autocorrelation and any problem with zeros in the data because there is not natural log for zero (Santos Silva and Tenreyro, 2006 as cited in Kea *et al.* 2019; Larson, *et al.*, 2018) also it addresses common issues associated with panel data, is consistent with gravity model and provides robust results (Hussain, 2017). In this model the dependent variable is taken on level and explanatory variables are in logarithm, adding a quarter variable to consider seasonality.

Chapter 5. Results

1. US Exports

Gross Domestic Income (GDP) is used to measure the economic size of the countries, in this case US and other 20 trader partner countries. GDP variables for US and trader partners are positives and significant for the dependent variable Exports in GLS and PPML models (see Table 5.1.) as expected (see Table 3.1.). This means that the greater the increase in economic size of the economy of the countries participating in bilateral trade, the greater the value of US exports and imports. These results are consistent with previous studies for example, Benedictis and Taglioni (2011), Maciejewski and Wach (2019), Wang and Badman, (2016) and Acharya (2019) where they affirm the positive relation between GDP and trade.

The exchange rate had been used as explanatory variable to explain trade, Wahyudi and Anggita (2015) found that the exchange rate had a significant effect on exports. Also, Dell'Ariccia (1999) and Njoroge (2020) showed that the volatility of exchange rate can negatively affect trade, in exports, the exchange rate is significant and negative and suggest that this effect is dominated by demand side factors (Harris & Matyas, 1998). In Table 5.1, the results for exports give a negative coefficient as expected (see Table 3.1.) but with no significance on the GLS model, however in PPML model shows a first level of significance to exchange rate.

Distance in both models is positive and highly significant in PPML, from the gravity model theory we get that distance is significant in trade between countries but inversely. In this case, this coefficient could be different because of the COVID-19 shock that generates restrictions on borders and because the proximity between countries could represent more risk of contagious is positive to have more distance. Also, ground transportation could have logistics problems or risk of contagious between contiguous countries as Canada and Mexico.

Common language shared between US and trader partners is positive in GLS and PPML models, however, only in PPML is significant, which makes sense because having the same language facilitates negotiations and agreements between companies in both countries promoting trade.

Free Trade Agreement (FTA) shows a negative sign with a significant effect on US exports in the PPML model, in the period 2015-2021 no changes were made in FTA of US with other countries, having an FTA does not imply a total benefit of free trade, sometimes it just represents an agreement where the clauses or measures governing trade between the two are raised. Having an FTA does not guarantee a greater trade flow, countries with valuable products can lose by having an FTA.

Similar results are shown for *DPIit, DPIust*, in both models, no significance. These results could be surprising (see Table 3.1.) because these payments were design to help the economic impact in the households and businesses, however, these stimuluses could be not enough to cover all the financial damage caused by COVID-19, also, because this is a dummy variable, even if the payment was not a lot, it was consider as 1 as any other country helping with larger amount.

OTHERit variable results to be negative and significant in both models, this sign is not expected because all monetary and macro-financial measures and policies, other as wage, tax, credit, loans to individuals and businesses and direct help with food, energy, and other bills were given to help mitigating the impact in the economy because of the COVID-19 shock. Maybe these stimuluses were not enough to cover the damage. From other point of view, most of those helps where given through loans, that people could use or not, even if interest rates were lower than before, not every business owner would like the idea of getting a loan that sooner or later they will have to pay, without knowing how long the pandemic was going to continue affecting supply and

demand, representing a risk. Also, these changes could weaken funding for international use focusing more on domestic market.

COVus results are positive for US exports, do not agree with the expected indicated in Table 3.1. in the GLS model there is not significance showed in Table 5.1, however, results from the PPML will be consider because is consistent with gravity model, provides robust results, addresses common issues associated with panel data (Hussain, 2017). These results means that when US has more new cases of COVID-19 the value of US exports increase this match perfectly the results obtained in US imports discussed later in this section. When there are more new cases of COVID-19 in trader partner countries US exports are less as expected (see Table 3.1.), this is indicated by *COVi* in the Table 5.1. A change in consumption could be the cause of these results, when US had more COVID-19 the consumption was less letting more products to export. But this point of view is not consistent with other studies as Bender, et al. (2022), where they studied the consumer behavior during the COVID-19 pandemic in US households with through surveys conducted in July 2020, they found that consumption was more, the food prepared and consumed at home food increased. Miller (2020) mentioned that "consumption has slumped as businesses close, and households hold off on major purchases because they are worried about finances and their jobs". Janssen *et al.* (2021), made a study about Denmark, Germany, and Slovenia where they found overall reduction in the consumption of fresh foods, but an increase in the consumption of food with a longer shelf life in Denmark and Germany. This shows how consumption can have different patterns, the idea of a decrease in consumption cannot be ruled out.

Table 5.1. Coefficients, P values, standard deviation and significance using GLS and PPML for US exports

Independent	Dependent					
	Exports					
	GLS			PPML		
	Coefficient	s.d.	P>|z|	Coefficient	s.d.	P>|z|
GDPus	1.464***	0.169	0.000	1.553***	0.200	0.000
GDPi	0.443***	0.067	0.000	0.433***	0.059	0.000
ER	-0.165*	0.173	0.341	-0.452***	0.152	0.003
COVus	0.003*	0.004	0.422	0.010**	0.004	0.011
COVi	-0.002*	0.004	0.678	-0.008**	0.004	0.025
DISTusi	0.033*	0.032	0.304	0.035***	0.006	0.000
COMLANGusi	0.060*	0.054	0.269	0.056***	0.013	0.000
FTA	-0.044*	0.052	0.393	-0.029**	0.013	0.020
DPI	-0.003*	0.020	0.868	-0.043*	0.028	0.132
DPIus	0.018*	0.020	0.371	0.012*	0.027	0.656
Other	-0.120***	0.035	0.001	-0.122**	0.055	0.027
Constant	-0.289*	0.297	0.331	-0.287***	0.075	0.000

s.d. : standard deviation

Level of significance: *P < 0.01, **0.01 < P < 0.05 and *** P > 0.05

In overall, when US is the exporting country, according to the results the impact in trade is explained in the Figure 5.1, where there is a greater shift to the left in demand than in supply for the exporter because of larger number of new cases of COVID-19 in the importer country, there is a shift to the right of the excess of supply, increasing trade in world market at a lower price from T1 to T2. Because of the unknown specific impact on supply because of COVID-19 other scenario where supply shift to the left in exporter country is greater than in demand is illustrated in Figure 5.2. In Figure 5.2, when supply shift is greater than in demand, trade decrease from T1 to T2 when excess supply curve shifts to the left in the world market.

Looking into production, Haqiqi and Horeh (2021) suggest than there is a decline in agricultural output and this negative impact could be solve with more technology and international trade. The impact in agriculture come from shocks in food away from home and US has the largest

expenditures in food away from home and this category had been one of the most affected, shares of agriculture in total production is higher than other countries. However, part of this food away from home category is from restaurants and they presented a decline with COVID-19, but also these declines in production can be attributed to loss of income (Beckman & Countryman, 2021).

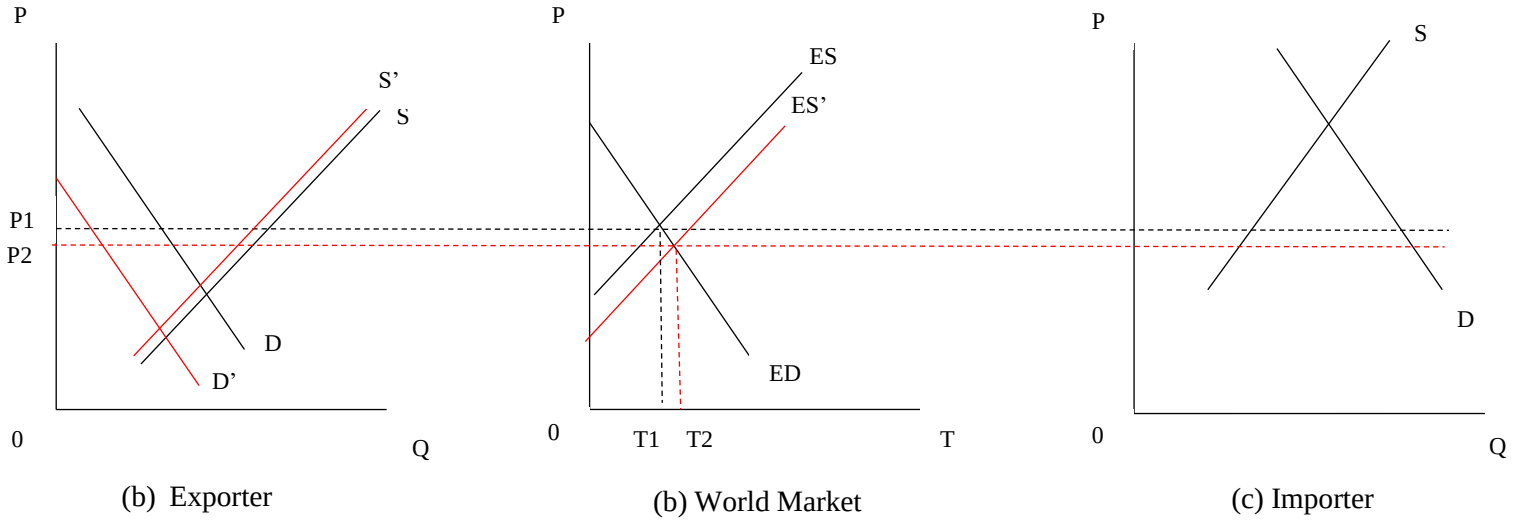


Figure 5.1. Impact of COVID-19 on Demand greater than on Supply in Exporting Country

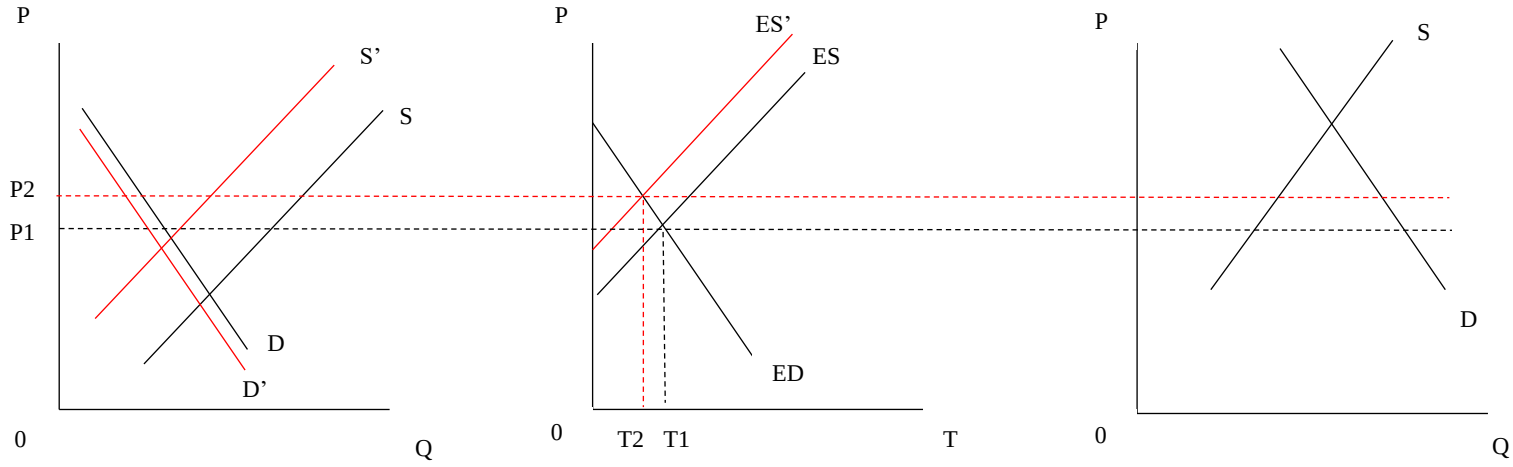


Figure 5.2. Impact of COVID-19 on Supply greater than on Demand in Exporting Country

2. US Imports

GDP variables for US and trader partners are positives as expected showed in Table 3.1, and significant for the dependent variable Imports in both GLS and PPML models (see Table 5.2.). The greater the increase in economic size of the economy of the countries participating in bilateral trade measured as Gross Domestic Income (GDP) in this case US and other 20 trader partner countries, the greater the value of US exports and imports. These results are consistent with previous studies found in the literature review where they confirm that the gravity model gives a positive relation GDP and trade (Benedictis & Taglioni, 2011; Maciejewski & Wach, 2019; Wang & Badman, 2016; Acharya, 2019)

Exchange rate results had a positive coefficient as expected (see Table 3.1.) significant in GLS and not significant in PPML as showed in Table 5.2, being positive makes sense because exchange rate is given in domestic currency per US dollar, US dollar has an advantage usually appreciation over other trader partners countries, making this positive for US imports, cheaper the products imported. This is the case in other regions, Dascal *et al.* (2002) report negative coefficient in imports and positive coefficients for exports in wine trade in European Union. Senadza and Diaba (2017) found no significant effects of exchange rate on imports, also in Rahman (2003) exchange rate has not effects on the Bangladesh's import, consistent with the results. According with Jafari *et al.* (2011) changes in exporter's exchange rate is higher than the similar effect on the importer's exchange rate.

Distance in both models is positive and highly significant in PPML, a positive sign contradicts the gravity model theory saying that trade flows are inversely related to distance between them (Benedictis & Taglioni, 2011). The COVID-19 shock could be modifying this coefficient because of restrictions on borders, ground transportation could have more logistics

problems or risk of contagious between contiguous countries as Canada and Mexico. The proximity between countries could represent more risk of contagious is positive to have more distance.

Even though common language shared between US and trader partners is positive and could facilitates negotiations and agreements between companies in both countries promoting trade in GLS and PPML models is not significant. The language is not a barrier between countries anymore, technology has provided tools removing this limitation. Also, it is important to notice that because of globalization of English has become a universal language.

Free Trade Agreement (FTA) does not show a significant effect on US imports, having no significance in these models is not a surprise because in the period 2015-2021 no changes were made in FTA of US with other countries.

Similar results are shown for the constant and stimulus variables, *DPIit, DPIust* and *OTHERit*, in both models, no significance. Government's intention with the relief stimulus were to help liquidity in businesses and income for households impacted by COVID-19, however, in the case of the variable *OTHERit* most of those helps where given through loans, that people could use or not, even if interest rates were lower than before, not every business owner would like the idea of getting a loan that sooner or later they will have to pay, without knowing how long the pandemic was going to continue affecting supply and demand. About direct payments given to individuals (*DPI*) this stimulus could be not enough to cover the losses in income of every individual in the country, without mentioning that not everybody qualifies for it. In addition, because this is a dummy variable, even if the stimulus was not a lot, it was considered as 1 as any other country helping with larger quantities.

The PPML results obtained for US imports for *COVust* are negative and significant in a first level as showed in Table 5.2. It means that when US have more new cases of COVID-19, US imports had a negative impact as expected (see Table 3.1.) and when there are more new cases of COVID-19 in trader partner countries, US imports are more because people in other countries are consuming less and having more products available to export and US exports are less as mentioned before, this is indicating by *COVit* in Table 5.2. This match the discussion mentioned before about US exports, a consumption effect could be the cause of these results, when US had more COVID-19 the consumption was less decreasing the quantity of imports. But this point of view can be controversial because some researchers as Bender, et al. (2022), affirm there was more consumption but in other side, because of precaution for uncertainty about the duration of the pandemic, many people saved money, dropping consumption (Miller, 2020). But consumption could have different behaviors depending on the goods, as reduction in the consumption of fresh foods, but an increase in the consumption of food with a longer shelf life (Janssen *et al*.,2021), that is a motive to think that having a decrease in consumption is possible if specific industries that contributed the most were having decrease in consumption.

Table 5.2. Coefficients, P values, standard deviation and significance using GLS and PPML for US imports

Independent	Dependent					
	Imports					
	GLS			PPML		
	Coefficient	s.d.	P>|z|	Coefficient	s.d.	P>|z|
GDPus	1.283***	0.221	0.000	0.850**	0.427	0.046
GDPi	0.467***	0.088	0.000	0.641***	0.101	0.000
ER	0.827***	0.228	0.000	0.458*	0.291	0.116
COVus	0.017***	0.005	0.001	-0.020***	0.007	0.006
COVi	-0.017***	0.006	0.002	0.024***	0.008	0.002
DISTusi	0.038*	0.049	0.435	0.068***	0.012	0.000
COMLANGusi	0.058*	0.082	0.481	0.023*	0.021	0.258
FTA	-0.071*	0.075	0.344	-0.035*	0.020	0.086
DPI	0.019*	0.026	0.456	0.075*	0.066	0.256
DPIus	-0.025*	0.026	0.343	-0.044*	0.057	0.435
Other	-0.007*	0.045	0.884	0.108*	0.074	0.146
Constant	-0.327*	0.445	0.462	-0.561***	0.136	0.000

s.d. : standard deviation

Level of significance: *P < 0.01, **0.01 < P < 0.05 and *** P > 0.05

In overall, when US is the importing country, according to the results the impact in trade is explained in the Figure 5.3, where there is a greater shift to the left in demand compared to supply of the importer because of larger number of new cases of COVID-19 in US, in the world market the excess demand shift to the left, resulting in a decrease in trade at a lower price from T1 to T2. In case of a greater shift to the left on supply compared with demand the impact on the world market is explained in Figure 5.4, where trade increase from T1 to T2 because of the shift to the right of the excess demand, this scenario is considered due to lack of knowledge about the impact in the supply side.

The supply chain had been one of the most affected on international trade, and it can be affected because of the changes in demand and health of labor, it would depend on each industry because some products are delivered in domestic markets including restaurants that were closed because

of COVID-19 but giving an opportunity to enter new markets selling directly to final consumers. In the other side many manufacturers were affected for lack of intermedium inputs as automobile enterprises some of them because of protectionism policies on importing countries to keep supplied domestic markets. Global supply chain suffered disruptions also because of the high demand of some products in specific as pharmaceutical, manufacturers were requiring more supplies and having a shortage.

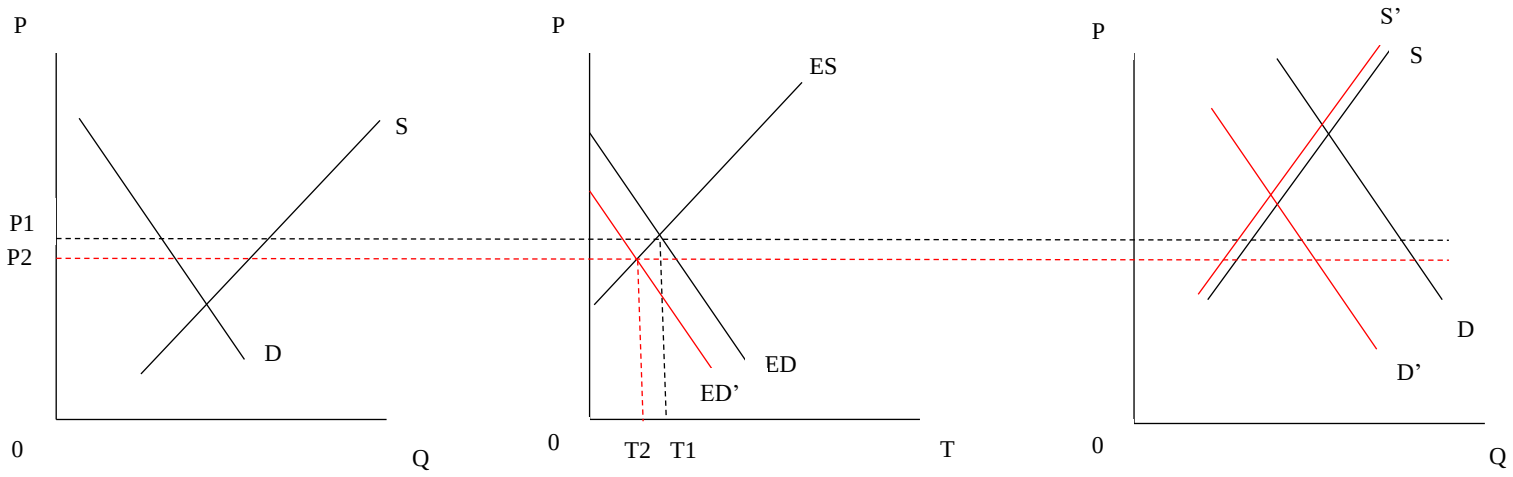
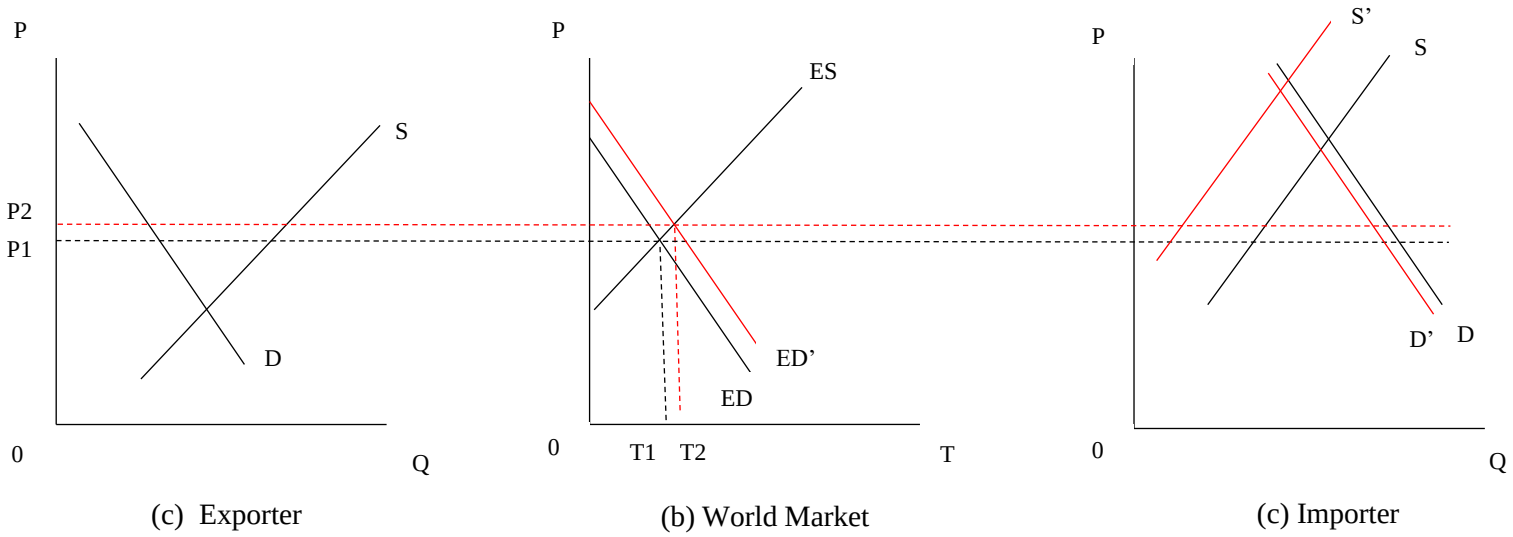


Figure 5.3. Impact of COVID-19 on Demand greater than on Supply in Importing Country



(c) Exporter (b) World Market (c) Importer

Figure 5.4. Impact of COVID-19 on Supply greater than on Demand in Importing Country

Chapter 6. Conclusions

COVID-19 had varying impacts in different sectors in the economy. However, international trade was affected because of border closures and new policies as protectionism to keep domestic markets supplied. In addition, the global supply chain that involves intermediate inputs coming from different parts of the world to finishing products, production was affected. Also, changes in consumption because of lockdowns impacted demand. Businesses shutting down because of lack of inputs or labor led to decreases in production, unemployment, and changes in income, affecting consumption. Also, because of changes in consumer behavior, prices could change according with demand.

The impact of COVID-19 in supply for both exporting and importing countries is expected to be negative, because of border closures, restrictions or polices as some protectionism to keep domestic markets supplies or businesses closures in countries where raw materials and intermedium inputs are produced, shortage in labor to process. Demand effects are also expected to be negatively impacted by changes in consumer behavior through changes in consumption because of lockdowns, either through household or business purchases.

In the case of US exports and US imports, this study evaluated the relation of COVID-19 new cases in US and trader partners, taking into consideration other factors that could affect trade flows, such as free trade agreements and relief stimulus. According to the results, GDP impacts trade flows, both exports and imports, as the gravity model suggests. COVID-19 had a significant impact on US exports and imports in both sides, both for the United States and trade partners. When the United States had more COVID-19 new cases, US exports increase and US imports decrease; when trade partners had more COVID-19 new cases, US exports decrease and US imports increase.

The results showing an increase in US exports when the infection increased could indicates that the consumption effect of COVID-19 was greater than the corresponding production effect. US imports are less when US had more COVID-19 cases. This could be an indicator of less consumption because of lockdowns, similar to the logic for US exports. With respect to COVID-19 cases in trade partners, COVID-19 seems to have a positive impact in US imports, more supply available from other countries, less consumption or more production in the trader partners. A negative impact was found on US exports when trader partner countries have more COVID-19 cases, suggesting less consumption or necessity of supplies from trader partners.

This research provides insight on the impact of COVID-19 on US bilateral trade. It also, suggests ways by which the trade shock generated by COVID-19 may have resulted from supply and demand effects. It is important to notice that in the scenario illustrated in figure 3.3, when there is a negative shock in demand because of COVID-19 in the exporting country, the trade is higher with other countries. Also, the scenario presented in figure 3.4, when impact of COVID-19 is negative in the supply curve for importing countries, trade increases, indicating that when the United States is the importer and has a shock in supply, trade increases.

Limitations in this study are related to data. Future analyses could be improved by more detailed data, including a longer time series. In addition, the time-periods used were quarters, and not every country measures or estimates data in this way. Also, the stimulus data was limited as the information was given as announcement of relief packages from the budget, involving different ways to distribute support but not specifying dates or quantities, and the information was not available in official government sites, it was a compilation made from international organizations.

Future analyses could consider policies about protectionism because it could critically affect trade, limiting the production and flows of goods around the world. In addition, the knowledge

base would benefit from future studies that consider more specific industries, as every industry has unique characteristics of its supply chain and would be impacted in various ways. In particular, future work could disaggregate trade into agricultural and non-agricultural to determine if there were varying impacts between the agricultural and non-agricultural sectors.

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