Vaccine Diplomacy: The Role of US Bilateral Relations in COVID Vaccine Procurements

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I. Introduction

With the severe economic, social, and health of the COVID-19 pandemic, the development, production, distribution, and administration of vaccines became a global priority. Vaccines were considered the primary tool in controlling the spread and mitigating the effect of COVID-19. They were crucial to reducing morbidity and mortality rates and restoring social and economic activities. Guidry et al. (2021) argue that vaccine distribution has historically been characterized by inequality due to the inability of low-income nations to produce or purchase enough vaccines to immunize their people fully. Similar to previous vaccines and health outbreaks, the high cost of vaccine production prevented many countries from developing their own COVID-19 vaccines (Plotkin et al., 2017). Therefore, to bridge the gap between the vaccine-have-nots and vaccine-haves, powerful nations with early access to doses donate some of their supplies to countries with insufficient access and surging virus cases.

As of April 2021, most vaccine donations were small doses, 200,000 or less (Kiernan et al., 2021). All rolled-out vaccines required a two-dose regimen. Therefore, the 200,000 vaccines are just enough to immunize 100,000 people. However, the averages do not reflect the disparities in allocating COVID-19 vaccines to nations. Analysis by Kiernan et al. (2021) shows that donor nations, specifically the United States, did not distribute vaccines based on the severity of COVID-19 infections or population size. So, what was driving COVID-19 vaccine allocation if countries were not receiving vaccines based on their disease burden? To add to it, what was the primary reason(s) for countries like the United States (US) to commit/make those donations when their own internal needs were far from fulfilled.

In this paper, we examine the allocation of vaccines by the US from December 2020 to March 2021. Our study examines the unequal access to vaccines among countries, regions, and populations and the role of vaccine diplomacy, which refers to the use of vaccines to promote national interests, geopolitical influence, and strategic alliances. Vaccine diplomacy takes many forms. It includes bilateral agreements, donations, loans, exports, and trade partnerships. In this paper, we will focus on the role of foreign direct investment (FDI) and trade relations in COVID vaccine allocation and how they shape the dynamics of vaccine diplomacy.

Vaccine Diplomacy

Vaccine diplomacy refers to using vaccines as a tool of foreign policy, diplomacy, and strategic alliances. Vaccine diplomacy can take many forms, including donations, bilateral agreements, exports, and partnerships. It can serve various goals, such as advancement in public health, growth of political influence, promotion of economic interest, and strengthening national security. Vaccine diplomacy has a long history that dates back to the Cold War era when vaccines were used as a cultural exchange and means of soft power (Hotez, 2014).

In the context of COVID-19, vaccine diplomacy become an aspect of the worldwide response to the pandemic. Nations and organizations have engaged in numerous forms of vaccine diplomacy. For instance, the COVAX facility aims at providing equitable access to vaccines for developing countries and the vaccine sharing initiatives, such as the US, UK, and EU's vaccine donations to other countries. However, Puyvallée and Storeng (2022) find that even with COVAX, there was unequal distribution of the vaccine. In this paper, we use FDI inflows and trade relations to show how economic interests have driven vaccine diplomacy as countries and companies seek to secure their supply chains, protect their investments, and gain a competitive advantage in the global market.

FDI refers to the investment by a firm or an individual from one nation into a business or a project in another country, with the objective of profit generation, transfer of technology, or access to resources. On the other hand, trade relations refer to the exchange of products and services between countries through trade policies such as customs tariffs or free trade agreements (OECD, 2023).

Inequality in Vaccine Distribution

In response to the COVID-19 pandemic, scientists, pharmaceutical companies, and governments mobilized their resources to develop, test, and manufacture vaccines against the virus. The vaccines have been hailed as a breakthrough in the fight against the pandemic and a symbol of global cooperation and solidarity. However, the rollout of the vaccines has been marked by unequal access, distribution, and allocation among countries and populations (Puyvallée and Storeng, 2022). According to the World Health Organization (WHO), as of April 2023, only 34% of the world's population had been fully vaccinated against COVID-19, with significant disparities across regions and income levels. Unequal access to vaccines was an even bigger problem in the first few months of the first COVID-19 production. Nations did not receive vaccines based on their population size. For instance, an analysis by Kiernan et al. (2021) shows that by April 2021, some small nations, especially in the Caribbean, had received doses for almost 10% of their population. On the other hand, more populous countries had only received vaccines to immunize less than 1% of their people.

Moreover, it is evident from the data that countries did not receive vaccines based on their existing COVID-19 burden. Undoubtedly, the number of infections for many countries before April 2021 was much higher than reported. Some countries like Afghanistan and Cambodia received donations in excess of their recorded cases, while hard-hit nations like India got fewer doses (Kiernan et al., 2021). So, if countries were not receiving COVID vaccines based on equity or need, what factors drove donors like the US? In the first quarter of 2021, low- and middle-income countries (LMICs) faced significant challenges accessing vaccines due to limited production capacity, supply chain constraints, and high prices. This has led to concerns about vaccine inequity and the role of vaccine diplomacy.

Research Questions

We will argue that FDI and bilateral trade relations significantly determined which countries got COVID vaccines from the US and how much and when. Specifically, we will examine the following questions:

1. ***How did FDI shape the distribution and procurements of COVID vaccines among countries by the US?***

2. ***What role, if any, did trade relations play in determining whether a country receives COVID vaccines from the US?***

To answer these questions, we will review the relevant literature, examine the data on COVID vaccine production, distribution, and allocation, and analyze the case studies of vaccine diplomacy in various parts of the world. We will argue that bilateral trade relations and FDI are economical and political aspects that depict power relations. Also, we will discuss the implications of trade relations and FDI for global health security, sustainable development, and future crisis management.

Overall, this paper aims to contribute to the understanding of the role of trade relations and FDI, and vaccine diplomacy in shaping the access to and distribution of COVID-19 vaccines. By exploring the effects of vaccine diplomacy, we hope to provide knowledge on how to ensure equitable, effective, and sustainable provision of vaccines in future outbreaks.

II. Literature Review

The COVID-19 pandemic has generated a vast literature on vaccine development, distribution, and allocation, including a growing body of research on vaccine diplomacy and its economic, political, and social implications. In this literature review, we will examine some key concepts, debates, and findings related to vaccine diplomacy, foreign direct investment (FDI), and trade relations in the context of COVID-19.

History of Vaccine Diplomacy

The concept of "medical diplomacy" was first used by Peter Bourne. Bourne was the special assistant to the president for health matters in the Carter administration in 1978. Vaccine diplomacy can be better understood within the broader context of medical diplomacy. Bourne (1978) proposed that medicine and health could be critical in improving international relations. Specifically, humanitarian issues, particularly healthcare, could be a foundation for initiating dialogue and bridging diplomatic walls beyond traditional and more volatile concerns. During the Cold War, the United States and Russia collaborated to end the polio pandemic. Cuba was one of the first nations to employ medical diplomacy as a foreign policy tool. The socialist state, keen on establishing and expanding its soft power, dispatched nurses, doctors, and medical aid to various natural disasters, including Chile's earthquake in 1960 and the Ebola outbreak in West Africa in 2014. (Groll 2013; Gomez 2014).

Medical diplomacy grew into a recognized field of study called global health diplomacy. Kickbusch et al. (2007) argue that the development has been driven by the growing recognition that a wide range of health issues and their associated economic, social, and political implications now transcend national boundaries and need action by the global forces that influence the health of citizens. Cooper (2003) also noted that "In the past, it was enough for a nation to take care of itself. Today, this is no longer enough" (p. 12).

The concept of global health diplomacy is founded on the fundamental concepts of mutual benefit, cooperation, and interdependence. However, it has distinct conceptual meanings. Katz et al. (2011) argued that global health diplomacy could be categorized into three forms of interactions around international public health matters: (1) core diplomacy, which is concerned with formal negotiations among and between states; (2) multistakeholder diplomacy, which is associated with negotiations among or between countries and other actors, not strictly focused on binding agreements; and (3) informal diplomacy, which covers interactions between international public health actors and their counterparts in the field, such as the public, private-sector firms, non-governmental organizations, and host country officials,

In the context of COVID-19, vaccine diplomacy has taken various forms, such as bilateral agreements, donations, and partnerships. One of the most significant vaccine diplomacy initiatives is the COVAX facility, whose objective is to provide equitable access to vaccines for low- and middle-income countries (LMICs) and promote global solidarity. However, Puyvallée and Storeng (2022) highlight challenges the COVAX initiative has faced, including the high cost of vaccines, the shortage of supply, and the competition for limited resources. The authors raise concerns about the distribution and allocation of vaccines, arguing that some nations received more than their fair share while others were left behind.

The Chinese Vaccine Diplomacy

By March 2021, China had provided millions of free COVID doses to about 69 nations. It has also exported other vaccine doses to another 28 countries (Huang, 2021). Analysis by Hillman and Tippett (2021) shows that of the 72 nations to which China pledged, only one was not a member of its Belt and Road Initiative (BRI). The BRI is an ambitious worldwide infrastructure project which aims at strengthening trade and economic relations across 139 countries, increasing Chinese influence, and developing new investment opportunities. It should not be surprising that there is a link between BRI and donations. Vadlamannati and Jung (2023) found that the Chinese government has been promoting global health governance, international health cooperation, and disease surveillance under the "Health Silk Road," a strategy of the RBI, since 2015.

Lee (2023) explore China's efforts to expand its soft power through assistance with COVID-19 aid and vaccine donations. He finds that China's vaccine diplomacy was initiated in July 2020. It began with its first vaccine trial outside China in Brazil. As early as November 2020, Chinese vaccine companies started signing deals with numerous nations, primarily lower and middle-income nations, to provide them with Chinese-made vaccines. On December 21, 2020, Egypt became one of the first countries to receive vaccines from Sinopharm, a Chinese state-owned vaccine producer. Lee argues that the distribution of Chinese vaccines aligns with Beijing's public diplomacy efforts, which have primarily focused on Asia, Africa, and Latin America since the mid-1990s, focusing on neglected or deliberately isolated areas characterized by repressive regimes, overlooked or purposely isolated by Western nations. We can deduce from Lee's study that donors may have had underlying motives for allocating certain doses to specific countries. Could this have also been the case in the United States?

FDI and Vaccine Distribution

A recent study by Vadlamannati and Jung (2023) examined the effect of donor strategic concern on bilateral foreign assistance. Their research used 108 nations that are participants of BRI. They found that countries with foreign investment flow into BRI projects were highly likely to receive vaccines from China. The COVID-19 pandemic disproportionately affected developing nations. Low and middle-income countries were hit hardest by the COVID pandemic. Many new and ongoing projects were discontinued or halted due to the coronavirus. Similarly, construction and infrastructure BRI projects were adversely affected due to disrupted global supply chains and travel restrictions. Therefore, those nations that successfully managed their spread of infections and alleviated any economic problems could resume their BRI projects. Vadlamannati and Jung (2023) argue that allocating vaccines to BRI partners increased their commitment to continuing BRI projects which would have otherwise been postponed or halted. They concluded that China strategically prioritized BRI countries to secure economic ties and promote their partnership by ensuring member nations have the support needed to manage COVID-19 infections. We predict that the US vaccine allocation by the US was also driven by the strategic goal of securing their investment in various countries. Also, we argue that the vaccine procurement depended on trade between the US and receiving country. Thus, we claim that:

H1.1: the higher the measure of outflows out of the US to the partner country, the higher the probability of receiving vaccines in our timeframe

H1.2: the higher the measure of outflows out of the US to the partner country, the higher the number of vaccines received in our timeframe

Trade Relations and Vaccine Allocation

According to Wouters et al. (221), one of the factors that contributed to the unequal distribution of vaccines in early 2021 was national procurement. Many high-income nations gained priority access to vaccines through advanced trade agreements with producers rather than purchasing doses via COVAX. The agreements aimed at securing enough COVID vaccines to cover most or all the nations' adults. Wouters et al. (2021) report that by March 2021, high-income nations, who represent 16% of the world's population, had pre-order agreements of about 4.2 billion doses. Within the first three months of 2021, these countries had secured about 70% of all produced COVID vaccines from the top five developers. Wouters et al. (2021) further argue that the trend of direct purchases started with high-income nations but other states quickly followed suit. The number of favorable trial results increased the incentive for countries to procure vaccines through direct purchase agreements. Data by Duke Univerity indicates that by February 3, 2021, more than 62 nations had signed trade agreements with vaccine developers. Thus, we claim that:

H2.1: the higher the measures of trade, the higher the probability of receiving vaccines in our timeframe

H2.2: the higher the measures of trade, the higher the number of vaccines received in our timeframe

III. Model Specification and Data Collection

We are interested in finding the best vaccine distribution model that can explain the most in the variation of our outcome variable: (i) the probability of obtaining US-related COVID-19 vaccine in the interval from December 2020 to March 2021, and (ii) the number of vaccines in bilateral deal in that same period. While there is currently no firm theory that assists us in deriving a vaccine distribution model, we will take a kitchen-sink approach first and finalize our best model in the later section. We also base our choices of variables on the most recent paper on the political economy of Chinese vaccine distribution (Vadlamannati and Jung, 2023).

For now, we have the following list of relevant variables that is relevant in the pandemic context and our hypothetical trade relationship:

1. The direct investment from US firms in each country (FDI inflow): we average the value from 2015-2019;
2. GDP per capita, which we think is a good proxy for wage, and development factors for each country: average value from 2015-2019;
3. Population size in the year 2019;
4. Democracy rating by Polity V in the year 2019;
5. Relative trade: the dyadic trade flow with the US over the total trade flow of the US;
6. Free Trade Agreement dummy: "1" for countries with FTA agreement with US, "0" otherwise. We also include Japan as if it has an FTA agreement with US;
7. European Union dummy: "1" for countries in EU, "0" otherwise;
8. Manufacturing partner: "1" for countries that have collaborated in developing COVID-19 vaccine with US firms, "0" otherwise;
9. Distance between the capital of partner country and Washington DC (US);
10. Total infected cases per million: we believe it can capture the transmission or infection rate of COVID-19;
11. Number of death by COVID-19: we also believe it is relevant in explaining the vaccine distribution: more past deaths could mean more urgency in tackling the pandemic.

The trade-related variables are taken from World Development Indicators, and the information on the vaccine distribution is taken from two primary sources of the International Monetary Fund - World Health Organization Duke Global Health Innovation Center (Duke University). In our preliminary analysis, we may focus more on IMF data source. In our next section, we also double check our estimated coefficients with data from Duke University as there is a small discrepancy among tracking data by both sources.

IV. Descriptive Statistics

Table 1. Summary of variables

Variables	N	Mean	St. Dev.	Min	Max
id	194	97.541	56.216	1	195
FDI inflows	177	20.572	2.908	0.000	26.027
GDP per capita	188	8.684	1.430	5.443	12.127
Population size	194	15.409	2.662	5.394	21.087
Democracy (Polity V)	159	5.899	3.752	0	10
Death cases	194	6.350	3.247	0.000	12.657
Relative Trade	191	0.035	0.129	0.000	1.000
FTA US dummy	194	0.108	0.311	0	1
Distance	194	0.536	0.232	0.000	1.000
EU dummy	194	0.139	0.347	0	1
Partner dummy	194	0.031	0.174	0	1
Infected cases (per million)	186	8.841	2.233	1.503	11.916
Receiving vaccine dummy (IMF)	194	0.247	0.433	0	1
Bilateral deal vaccine (IMF)	194	3.729	6.693	0.000	19.083
Receiving vaccine dummy (Duke)	194	0.175	0.381	0	1
Bilateral deal vaccine (Duke)	194	2.818	6.176	0.000	19.083
Receiving vaccine dummy* (Duke)	194	0.196	0.398	0	1
Bilateral deal vaccine* (Duke)	194	3.160	6.500	0.000	20.030

(*) procurement & intent to purchase

Before explaining all our interested variables, we should note that we have standardized all of the measurement scales of our variables. Our data comprises 194 countries and/or regions, out of which 177 had investments from the US. Looking at the overall table of summary statistics, we do not see any potential outliers or abnormal data points in our sample.

We should note that, however, because of logarithm function, we have to remove the following countries that have reported "negative" FDI inflows (even with 5-year average value), which are Angola, Austria, Belgium, Iceland, Iraq, Qatar, Trinidad and Tobago, Yemen, and Marshall Islands.

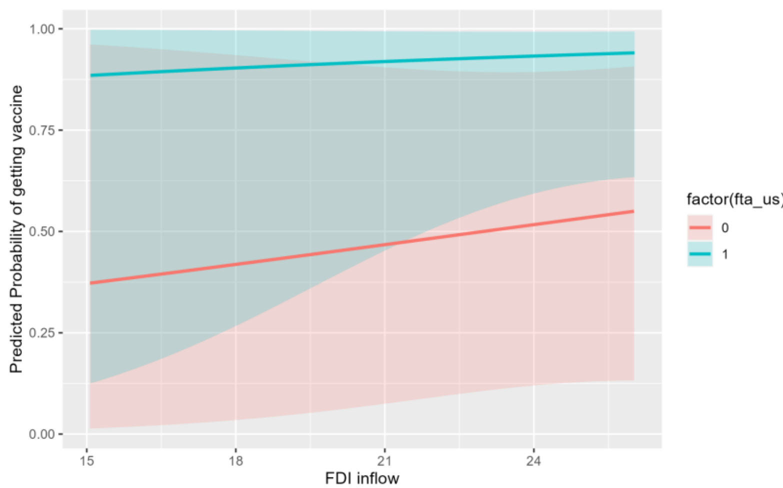
V. Initial Estimation Results: Kitchen Sink Approach

Since we have no solid theoretical framework to construct a vaccine distribution model, we will initially take a kitchen-sink approach for both logistic and OLS regression. Then we will apply lasso regression to get the best model out of our data.

Table 2. Logistic regression estimation

	Dependent variable:				
	Dependent variable: receiving COVID-19 vaccine				
	(1)	(2)	(3)	(4)	(5)
FDI inflow	0.254***	0.160*	0.029	-0.253	0.195
	(0.083)	(0.089)	(0.082)	(0.267)	(0.213)
FTA dummy with US		2.712***	2.689***	1.662**	1.683**
		(0.606)	(0.613)	(0.732)	(0.692)
GDP/capita			0.449***	1.213***	
			(0.172)	(0.415)	
Population size				0.219	0.152
				(0.268)	(0.213)
Democracy (Polity V)				0.092	0.092
				(0.078)	(0.074)
Death due to COVID-19				0.250	-0.052
				(0.224)	(0.204)
Relative trade				4.738	7.959
				(4.721)	(5.714)
Infected cases (per million)				0.119	0.627**
				(0.322)	(0.269)
European Union dummy				-4.358***	-3.473***
				(1.084)	(1.008)
Partner Vaccine Manufacturing dummy				1.160	0.652
				(1.322)	(1.416)
Observations	177	177	172	147	149
Log Likelihood	-94.758	-81.796	-77.515	-50.637	-55.846
Akaike Inf. Crit.	193.515	169.592	163.030	123.275	131.692
Note:					*p<0.1; **p<0.05; ***p<0.01

For the investment variable, in our first logit model, we see that investment from US firms correlates positively with the probability of getting COVID-19 vaccine in the times of extremely limited supply. However, the investment variable (FDI inflow) may not predict well the variation of the outcome as we include FTA dummy and GDP per capita. In fact, our full model tells us that investment variable has a "wrong" sign, but its 95% confidence interval does include 0, i.e., investment may not be a good predictor after all. Especially, when we include GDP per capita, the investment variable "loses" both substantive and significant effect. Economically speaking, we think that income predicting the chance of getting vaccine makes sense as it should be easier for more developed countries to strike a bilateral trade deal for vaccine procurement.



We are also looking at the predicted probability with respected to investment flow of each sub-sample of FTA dummy variable. On average, countries having FTA with US and receiving more investment form US firms tend to have higher probability of getting vaccine in this period, the 95% confidence interval of the investment effect in sub-sample also warns us that sub-sample effect may not be clear-cut.

For the FTA dummy variable, we see a consistently strong and significant effect: compared to countries not having free trade agreement with US, countries having free trade agreement have higher chance of getting COVID-19 vaccine.

Table 3. OLS regression estimation

	Dependent variable:				
	Dependent variable: quantity of COVID-19 vaccine bilateral deal				
	(1)	(2)	(3)	(4)	(5)
FDI inflow	0.648***	0.408**	0.207	-0.251	0.877***
	(0.170)	(0.157)	(0.171)	(0.409)	(0.334)
FTA dummy with US		9.241***	8.688***	3.989***	4.756***
		(1.409)	(1.408)	(1.442)	(1.514)
GDP/capita			1.038***	2.788***	
			(0.355)	(0.637)	
Population size				0.404	0.233
				(0.353)	(0.370)
Democracy (Polity V)				0.179	0.236
				(0.139)	(0.145)
Death due to COVID-19				0.630*	-0.085
				(0.375)	(0.356)
Relative trade				5.869	9.499**
				(3.661)	(3.769)
Infected cases (per million)				-0.288	0.880*
				(0.502)	(0.448)
European Union dummy				-9.532***	-7.485***
				(1.662)	(1.686)
Partner Vaccine Manufacturing dummy				1.602	0.805
				(2.576)	(2.717)
Observations	177	177	172	147	149
R^2	0.077	0.260	0.291	0.501	0.432
Adjusted R^2	0.071	0.251	0.278	0.464	0.396
Note:					*p<0.1; **p<0.05; ***p<0.01

(1) We can also see the same pattern in the OLS models here: (i) the investment variable may not predict well the variation in the number of vaccines a country can deal with, (ii) the FTA dummy variable is a significant and robust predictor; however, its effect is not consistent every time we put more variables, (iii) we suspect GDP per capita matters most in vaccine distribution model, (iv) our full model shows significant positive effects for FTA dummy, GDP per capita, Death due to COVID-19, and adverse effect for European Union dummy.

(2) After an initial analysis, we employed LASSO regression to choose and present the best model and conclude our findings about trade and investment-related variables. This also helps in avoiding the problem of overfitting. We verified our outcome measurement of the IMF-WHO source with data published by Duke University on COVID-19 vaccine supply tracking.

Robustness and Final Model Specifications

(3) To further test the robustness of our models, we decided to apply additional checks that could unravel whether the conclusions we obtained in our last section hold. More specifically:

(4) We ran our models drawing our Dependent Variables from **2 alternative datasets** provided by the Duke Global Health Innovation Center (2020): the first one includes data about the Covid-19 vaccination doses *procured* by each country; the second one comprises data about the procured doses on top of the ones that were *intended to purchase*. While these datasets share similar sources to the one provided by the IMF (2020), differences in how vaccines were counted (by country) in each legitimate source warrant this additional step. Our DVs for these additional OLS models will still be the same: the number of vaccines procured by American companies.

(5) We tested the fit of our models and the effectiveness of our variables by utilizing a LASSO methodology. By doing this, we plan to obtain the best possible fit given our set of independent variables. Moreover, we will use LASSO to compare specifications where the GDP per capita variable is absent. By doing this, we want to test whether there are changes in overall fit or how the FDI variable influences our outcome.

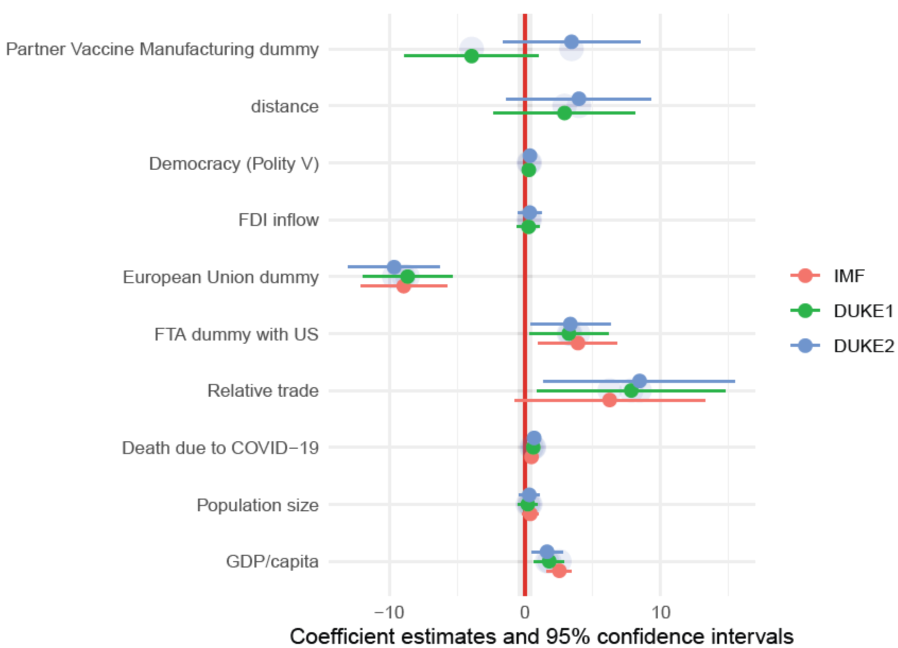
(6) Finally, we will use an alternative Independent Variable to test whether data about Covid deaths would yield the same results as implementing an infection rate variable (Mathieu et al., 2020). In our models, the infection rate will refer to the cumulative number of people infected by Covid per 1 million inhabitants of each specific country (as of March 2021). These values will be logged for standardization purposes.

Table 4. LASSO models w/ GDP per capita variable

	IMF	DUKE1	DUKE2
(Intercept)	−26.192***	−27.324***	−30.765***
	(6.334)	(6.730)	(6.870)
GDP/capita	2.528***	1.784**	1.622**
	(0.458)	(0.554)	(0.565)
Population size	0.393	0.204	0.314
	(0.296)	(0.363)	(0.370)
Death due to COVID-19	0.476*	0.607*	0.674**
	(0.205)	(0.234)	(0.239)
Relative trade	6.234+	7.824*	8.439*
	(3.536)	(3.482)	(3.555)
FTA dummy with US	3.899**	3.229*	3.337*
	(1.461)	(1.459)	(1.489)
European Union dummy	−8.935***	−8.648***	−9.638***
	(1.602)	(1.664)	(1.699)
FDI inflow		0.260	0.344
		(0.414)	(0.422)
Democracy (Polity V)		0.275+	0.360*
		(0.141)	(0.144)
distance		2.910	3.970
		(2.633)	(2.688)
Partner Vaccine Manufacturing dummy		−3.931	3.425
		(2.485)	(2.537)
Num.Obs.	138	138	138
R2	0.482	0.507	0.532
R2 Adj.	0.458	0.468	0.495
AIC	866.0	852.7	858.4
BIC	889.4	887.9	893.5
Log.Lik.	−424.981	−414.362	−417.207
F	20.315	13.053	14.415
RMSE	5.26	4.87	4.97

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Figure 1. LASSO models w/ GDP per capita variable



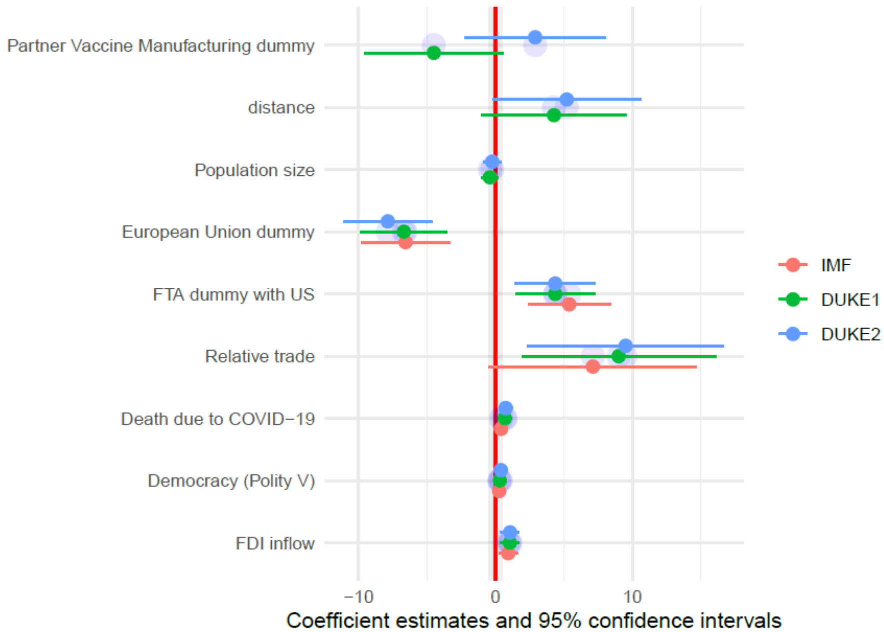
Addressing points (1) and (2), ***Table 4*** and ***Figure 1*** showcase OLS regression models based on the best set of variables provided by our LASSO's lambdas. The GDP per capita variable has been kept, and the models were run for the *actually procured* (DUKE1) and *actually + intended to procure* (DUKE2) datasets. As we can see, while the IMF-based model drops FDI flows, polity score, distance and the partner dummy, the same does not happen for the Duke datasets. At the same time, we can notice how the models' R squared increase, signaling how the fit tends to increase or, at the very least, it remains consistent regardless of the data analyzed. Variables for GDP per capita, deaths, relative trade, fta inclusion and our Europe dummy remain significant (although within different levels of confidence) and ultimately comparable.

Table 5. LASSO models w/o GDP per capita variable

	IMF	DUKE1	DUKE2
(Intercept)	−19.742**	−21.018**	−25.034***
	(6.770)	(6.671)	(6.756)
FDI inflow	0.930**	1.051**	1.063**
	(0.351)	(0.345)	(0.349)
Democracy (Polity V)	0.271+	0.319*	0.400**
	(0.155)	(0.146)	(0.148)
Death due to COVID-19	0.413+	0.683**	0.743**
	(0.221)	(0.241)	(0.244)
Relative trade	7.117+	9.006*	9.514**
	(3.833)	(3.587)	(3.633)
FTA dummy with US	5.386***	4.360**	4.365**
	(1.522)	(1.467)	(1.486)
European Union dummy	−6.572***	−6.698***	−7.866***
	(1.649)	(1.606)	(1.627)
Population size		−0.406	−0.240
		(0.320)	(0.324)
distance		4.274	5.209+
		(2.693)	(2.727)
Partner Vaccine Manufacturing dummy		−4.510+	2.899
		(2.568)	(2.601)
Num.Obs.	138	138	138
R2	0.403	0.467	0.501
R2 Adj.	0.375	0.429	0.466
AIC	885.6	861.6	865.1
BIC	909.0	893.8	897.3
Log.Lik.	−434.791	−419.782	−421.537
F	14.729	12.439	14.296
RMSE	5.65	5.07	5.13

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 2. LASSO models w/o GDP per capita variable



Moving forward with the analysis, ***Table 5*** and ***Figure 2*** represent the models obtained by running LASSO without considering GDP per capita as an independent variable. As we can see, FDI flows is not dropped in any model, and it is significant and positive in its substantive level. At the same time, regressions not considering the GDP per capita variable appear to have a worse fit: R squared values are generally lower. Even theoretically, one would imagine that macroeconomic factors would impact how and why countries should exchange and procure items such as vaccinations. Because of this, and considering how the GDP per capita variable might include some (if not most) of the effects of FDI on procurement, we believe that the first series of LASSO models could be considered the better ones in term of real effect on the dependent variable.

Table 6. Comparison between logit models: death vs. Infection variables

	(1)	(2)
(Intercept)	−7.688+	−11.879**
	(3.968)	(4.176)
FDI inflow	0.302	0.165
	(0.202)	(0.215)
FTA dummy with US	1.964**	1.665*
	(0.681)	(0.685)
Population size	−0.155	0.109
	(0.124)	(0.157)
Democracy (Polity V)	0.084	0.080
	(0.073)	(0.073)
Death due to COVID-19	0.290*	
	(0.121)	
Relative trade	5.865	8.147
	(6.095)	(6.011)
European Union dummy	−3.087**	−3.388***
	(0.997)	(1.005)
Partner Vaccine Manufacturing dummy	0.638	0.653
	(1.459)	(1.421)
Infected cases (per million)		0.551**
		(0.182)
Num.Obs.	150	138
AIC	136.1	128.3
BIC	163.2	154.6
Log.Lik.	−59.062	−55.151
F		3.917
RMSE	0.36	0.36

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7. Comparison between OLS models: death vs. Infection variables

	(1)	(2)
(Intercept)	−16.578**	−25.079***
	(6.301)	(5.943)
FDI inflow	0.942**	0.867**
	(0.330)	(0.330)
FTA dummy with US	5.406***	4.802**
	(1.487)	(1.496)
Population size	−0.232	0.177
	(0.286)	(0.284)
Democracy (Polity V)	0.241	0.232
	(0.146)	(0.144)
Death due to COVID-19	0.470*	
	(0.213)	
Relative trade	7.833*	9.358*
	(3.694)	(3.710)
European Union dummy	−6.711***	−7.434***
	(1.650)	(1.667)
Partner Vaccine Manufacturing dummy	0.758	0.788
	(2.735)	(2.707)
Infected cases (per million)		0.796**
		(0.273)
Num.Obs.	150	149
R2	0.418	0.432
R2 Adj.	0.385	0.400
AIC	953.9	944.6
BIC	984.0	974.7
Log.Lik.	−466.933	−462.312
F		13.320
RMSE	5.44	5.39

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Addressing our third point in the introduction of this section, ***Table 3*** and ***Table 4*** compare the original logit and OLS models that we had in our previous section (1) to the ones using the ‘infection’ variable instead of the one referring to total deaths (2). As we can see, both variables are significant and positive in both models (although the infection variable appears to be significant at the 99% level, rather than 95%). The fit in both instances appears to be close (Adj. R squared of 0.385 vs. 0.400), and the effect of our other independent variable remains substantively the same (in the logit model the FTA dummy slightly loses in significance).

Table 8. LASSO models with infection variable

	IMF	DUKE1	DUKE2
(Intercept)	−32.678***	−35.509***	−39.954***
	(6.663)	(6.322)	(6.455)
GDP/capita	2.437***	1.497*	1.268*
	(0.621)	(0.609)	(0.622)
FDI inflow	−0.063	0.479	0.584
	(0.432)	(0.407)	(0.416)
Population size	0.822*	0.575+	0.726*
	(0.352)	(0.337)	(0.345)
Democracy (Polity V)	0.215	0.310*	0.397**
	(0.149)	(0.142)	(0.145)
Infected cases (per million)	0.425	0.555+	0.661*
	(0.300)	(0.313)	(0.320)
Relative trade	7.007+	8.431*	9.274*
	(3.749)	(3.665)	(3.743)
FTA dummy with US	3.786*	2.891+	2.966+
	(1.494)	(1.471)	(1.502)
European Union dummy	−9.592***	−8.822***	−9.827***
	(1.734)	(1.685)	(1.721)
Partner Vaccine Manufacturing dummy	1.536	−3.918	3.421
	(2.673)	(2.521)	(2.574)
distance		1.523	2.589
		(2.577)	(2.632)
Num.Obs.	138	138	138
R2	0.482	0.493	0.518
R2 Adj.	0.446	0.453	0.481
AIC	871.9	856.5	862.2
BIC	904.1	891.6	897.4
Log.Lik.	−424.939	−416.246	−419.125
F	13.250	12.359	13.672
RMSE	5.26	4.94	5.04

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Similarly, ***Table 8*** represents the LASSO models we obtained by swapping the infection and deaths variables (with GDP per capita). Comparing it to ***Table 4***, we can observe how fewer variables have been dropped, but the R squared values are pretty much the same. The new variable appears to be less significant, possibly suggesting that sending vaccines might be less related to the status of infection than we originally thought. On the other hand, our FTA variable ends up losing in significance (while still being relevant at the 95% level) and the various models end up showing mixed result for our trade variables (for both the Duke datasets, relative trade is significant at the 95% level while the FTA dummy is not. GDP per capita remains a good predictor for our DVs, while FDI flows remain not significant. Overall, comparing these different models tells us that using deaths and infection as variables could have an impact. However, it is clear that our levels of significance may vary from model to model: in our first

LASSO analysis including our deaths variable yields good significance for FTA in every instance (same for relative trade excluding the first model); in our second only one of those variables is significant at the 95% level at the time.

VI. Discussion

Before delving into the interpretation of our results, first, we should address the main limitations and assumptions of our study. First, we are considering '*American-made vaccines'* as all vaccination doses produced by companies that can be partially considered American. The assumption here would be that those companies will have linkages and connections with American infrastructure (that could be influenced by FDI, Trade Agreements, trade volumes, etc.) and thus 'discriminate' while prioritizing the shipping of their products. In our opinion, this statement is fair since we are considering mainly economic variables. Second, while we do not have specific information about every single transaction made by COVAX (our dataset contains only their total number of acquired vaccines), we do not believe that their involvement could alter much of our results: the program itself, as presented in our introduction, did not ramp up until later in our analyzed year (2021) and was thus initially ineffective in distributing vaccines to low-income countries; the number of procured vaccinations would be relatively low at (250 million, but as we mentioned the program did not actually distribute those vaccines by April 2021) (Duke, 2020). Third, we did not deal with causality or addressed possible endogeneity yet, meaning that our models can still be improved.

Given the results obtained in our last section, we can conclude that trade ties may indeed influence the number of vaccines procured. Still, the substantive effect of this phenomenon would be hard to capture due to different interactions between outcome variables and different kinds of independent variables. On the other hand, our study reveals how FDI does not seem to yield much of an effect while including GDP per capita as a regressor. Following our results in the original models depicted by ***Table 2*** and ***Table 6***, we conclude that we fail to reject the null hypothesis for our **H1.1**. Coincidentally, we also fail to reject the null hypothesis for **H1.2** considering how *FDI flows* appear to be never significant in our OLS estimations. On the other hand, we can reject the null hypothesis for **H2.1** while considering our FTA dummy as the main IV, and we fail to do it when we consider relative trade: the probability of receiving vaccines at all does not seem to increase based on measures of relative trade with the United States. For

H2.2, using our original IMF models as the baseline (see IMF models in ***Table 4*** and ***Table 8***), we come to the same conclusions: we reject the null for the FTA variable and fail to reject it for relative trade. The estimated effect of having an FTA is also predicted to be equal to a coefficient of 3.786 (see ***Table 8***, IMF): given how we took log values for our DV, this means that *a country that has an FTA with the US will, on average and everything else being equal, get ~44 times more vaccination doses than countries who do not*. However, interpreting these results should be done cautiously: our robustness checks confirmed that, for the original models, adding infection rate instead of accounting for deaths does not change our results. On the other hand, running our models using different datasets reveals that the effect of FTA and relative trade is not clear-cut. While at least one of the trade variables is always significant at the 95% level, we have instances in which having an FTA with the US proves to yield an effect, while relative trade does not. The conclusion here would be that the estimated effects, albeit significant, might be somewhat lower than predicted.

VII. Conclusion

While the trade ties seem to positively affect the higher probability of procuring vaccines, we have limitations in terms of understanding why this would be the case: causality was not handled in this regard, and the effects could be attributed to geopolitical factors (alliances), or simply because the past infrastructure was developed more. FDI outflows seem to have an ambiguous effect as it is positively related to our dependent variable without factoring in the GDP/cap. It becomes non-significant when the GDP/cap is factored. GDP/cap could be the confounder that dictates the extent to which FDI affects procurement. Some other significant variables were polity and deaths. The main question that boiled up was if “The behavior of US is rational or not,” which perfectly captures the extent to which our research uses “Economic Thinking” in its analysis: we have to decide how to allocate scarce goods given a specific set of priorities based on utility. The humanitarian factors play a role but do not outweigh their economic counterparts. For future research, political factors can be introduced as controls (and probably as main IVs, given the suitable model). The substantive effect on which trade affects the procurement of goods should be studied more, and both causality and endogeneity should probably be addressed. All in all, we believe that this study represents a good starting point to understand how companies and countries respond to unexpected shocks (we could potentially connect our study to pandemics, shortages, or any other event that disrupts procurement networks), deciding which parties they want to deal with while providing the fastest response in the short term.

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