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Ending Covid-19 Vaccine Apartheid through Vaccine Donations: The Influence of Supply Chains

Abstract

We study determinants of COVID-19 vaccine donations from recipients' perspective, especially considering supply chain and institutional weakness (corruption) aspects. Results, based on data from more than 131 nations, show that strengthened supply chains reduced donations. The impacts of corruption and logistics performance likely persisted from pre-COVID times. More corrupt nations received fewer donations per capita, ceteris paribus. The results with respect to economic prosperity supported efforts to end vaccine apartheid, and island nations received more donations, as did nations with more bilateral vaccine deals. Finally, donations received through COVAX were driven by qualitatively similar factors, except corruption did not matter.

JEL-Codes: L900, K420, I180.

Keywords: Covid-19, vaccine donations, equity, supply chain, corruption, logistics, international shipments, pandemic, government COVAX.

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1. Introduction

The onset of the COVID-19 pandemic in early 2020 created a worldwide health emergency. All nations were impacted, although the scale and timing of the spread of the virus varied (Baldwin and Weder di Mauro (2020), Barro (2022), Fernandes (2020), Kumar et al. (2020)). This prompted a global search and effort towards developing a vaccine to guard against the virus, and a few nations, over time, were successful in developing their vaccines. Some nations were unable to develop their own vaccines, either due to the expense/expertise involved or due to their unwillingness to wait for their own development/invention. This led to vaccine inequities, with calls in some sectors to end the vaccine apartheid in poorer nations (Bajaj et al. (2022)).

This created vaccine inequity around the globe (Sobo et al. (2022)), which persists even to this day when the pandemic has waned, but some variants keep emerging (https://www.cdc.gov/coronavirus/2019-ncov/variants/index.html). Given the global spread of the virus, no nation was immune from cross-national transmissions. Donating vaccines for personal (health) safety, benevolence, or for strategic reasons has been quite frequent from the handful of nations with their own vaccines (USA, UK, China, India, Russia). These donations came about via bilateral efforts[1] or multilateral efforts (e.g., via COVAX – de Bengy Puyvallée and Storeng (2022), Storeng et al. (2021a,b)).[2] Besides showing international benevolence, vaccine donor nations (and potential donor nations) also had a vested interest in donating vaccines – they wanted to prevent/mitigate infections from cross-border transmissions due to global tourism and trade. Yet, the vaccine disparities around the world beg the question of why donations were not spread equally or fairly.[3]

In response to this, COVAX emerged as a mediator to seek vaccine donations and distribute them "fairly" among needy nations (Storeng et al. (2021, 2021b); https://www.unicef.org/supply/covax-ensuring-global-equitable-access-covid-19-vaccines). Nations were still free to form their bilateral or multilateral alliances for the purchase and/or donations of vaccines outside of COVAX. In practice, however, there were many irregularities in the implementation of the intent of COVAX (de Bengy Puyvallée and Storeng (2022); Storeng et al. (2021a., b); York (2021)).

In all this, supply chain issues have specially come to the forefront during the pandemic due to widespread infections, layoffs, and lockdowns (Arvis et al. (2023), also see Arvis et al. (2018), Ranney et al. (2020), Reiter and Stehrer (2023), Rowan and Laffey (2020)).[4] One of the focuses

[1] See https://www.paho.org/en/covax-americas.
[2] COVAX stands for COVID-19 Vaccines Global Access
[3] https://www.bloomberg.com/news/articles/2022-09-22/pfizer-us-revise-vaccine-contract-as-world-demand-plummets#xj4y7vzkg
https://www.kff.org/coronavirus-covid-19/issue-brief/u-s-international-covid-19-vaccine-donations-tracker/
https://ourworldindata.org/grapher/covax-donations
https://www.unicef.org/coronavirus/covid-19-vaccines-why-dose-donations-are-essential
https://www.reuters.com/business/healthcare-pharmaceuticals/us-cutting-global-donations-pfizer-covid-shots-demand-slows-2022-09-22/
[4] Goel et al. (2021b) examine a different effect of logistics by considering their effects on economic growth.

of this paper is to investigate what role that supply chain constraints played in channeling vaccine donations worldwide (beyond the political, economic, and social considerations).

We consider both vaccine donations through bilateral deals and donations through the COVAX program. There were some interesting differences in donations through the two programs. In our sample (as of September 2022), 43 nations received no donations through bilateral deals, while 40 countries received no COVAX donations. Furthermore, the top donation recipients under the two programs were largely different – Cambodia, Bhutan, and Fiji were the top three nations receiving vaccine donations (in per capita terms) through bilateral deals, while Bhutan, Rwanda, and Bangladesh were the top three COVAX donation recipients.

This paper uses data on more than 130 nations to study the significant drivers of vaccine donations (received by recipients), focusing especially on the role of supply chains.

Key questions addressed in this research are the following:

- What are the significant drivers of COVID-19 vaccine donations?
- Was equity an important consideration in the distribution of vaccinations among nations?
- How significant is the role of the different dimensions of supply chain obstacles in driving vaccine donations?
- Is institutional instability, captured by corruption prevalence, a significant impediment to vaccine donations?
- Are the drivers of COVAX donations different from those for donations through bilateral deals?

Results, based on data from more than 131 nations, show that better/strengthened supply chains reduced donations, partly due to the ability of nations with better supply chains to make more effective use of vaccines. On the other hand, more corrupt nations received fewer donations per capita, ceteris paribus. In other results, we find that equity concerns were a factor in driving vaccinations, as they were inversely related to the level of economic prosperity of a nation. Island nations received more donations, ceteris paribus, as did nations with more bilateral vaccine deals. Furthermore, the impacts of pandemic severity, government size, and its form (i.e., type of democracy) were largely statistically insignificant. Finally, donations received from bilateral deals and those through COVAX were driven by qualitatively similar factors, except corruption perceptions did not appreciably impact COVAX donations.

The structure of the rest of the paper includes the empirical model in the next section, followed by a discussion of the data and the estimation methodology, results, and conclusions.

2. Empirical model

Based on the above discussion, we formulate three hypotheses that we will test with the empirical model outlined below.

H1: Greater supply chain obstacles increase vaccine donations, ceteris paribus.

Supply chain constraints would create bottlenecks in vaccine delivery. This would especially be significant in the face of increasing infections from the virus and given the short shelf life of the vaccines. This may then necessitate the delivery of a greater number of vaccines to achieve the same outcome than would be necessary in nations with fewer supply chain challenges. Some supply chain issues might pre-date the current pandemic (Elekdag et al. (2015); Nordås et al. (2006)), and we will also test for their influences.

H2: Greater institutional instability (corruption) would lower vaccine donations, ceteris paribus.

Greater corruption is associated with more opportunities for government officials to misuse their authority for personal gain and there is substantial evidence that this occurred with COVID-19 vaccines, including in the distribution process.[5] This may dissuade potential donors from offering COVID-19 vaccines to nations with a reputation of being more corrupt. Plus, donors would be reluctant to associate (or be seen to associate) with corrupt nations. The underlying logic is tied to the economics of white-collar crimes and to fraud in charitable organizations (Goel (2020); Harris et al. (2017); McDonnell and Rutherford (2018)).

H3: Less economically prosperous nations fared better in the distribution of vaccine donations among nations, ceteris paribus.

The importance of ensuring that vaccines are available to all nations, regardless of wealth, has been widely noted (Sobo et al. (2022)), not only as a moral imperative, but given that the pandemic knows no borders is in the self-interest of every nation as well. Yet, donor nations may be guided by political self-interest (Barceló et al. (2022)) and cultural considerations as well and global collaborations such as COVAX faced accountability and administrative challenges that have worked at cross-purposes with achieving equity goals (de Bengy Puyvallée and Storeng (2022); Storeng et al. (2021a., b); York (2021)).

The general form of the estimated equation is the following (with individual observations at the country level – see Table 1):

$DONATIONSpc_{,R}$ = f(Supply chain $dimensions_K$, DEATHS, GDPpc, Institutional instability (CORRUPTION), Government $system_J$, Government $role_M$, ISLAND) …(1)

Where

R = DONATIONSpc, COVAXpc

K = LogisticPERF, INFRAst, INTLship, TimelySHIP, GLOBALIZATION

J = DEMOCRATIC, AUTOCRATIC, NoCOLONY

M = GOVTsize, DEALS

[5] United Nations Office on Drugs and Crime (2021). Covid-19 vaccines and corruption risks: Preventing corruption in the manufacture, allocation and distribution of vaccines. https://www.unodc.org/documents/corruption/COVID-19/Policy_paper_on_COVID-19_vaccines_and_corruption_risks.pdf.

The main dependent variable is per capita vaccine donations received by a nation as of September 8, 2022 (DONATIONSpc). A number of nations did not receive any donations (either they had their own vaccines developed or were able to buy vaccines from others). Furthermore, the detail in the data does not enable a distinction between whether the donated vaccines were the first doses or the second doses in cases where the vaccine required two doses for full vaccination (e.g., the Moderna vaccine).

Donations via COVAX were another significant donation channel. According to de Bengy Puyvallée and Storeng (2022), "donated doses were an important source of COVAX's vaccine supply in 2021, accounting for 60% of the doses the initiative delivered (543 million out of 910 million). However, donations could not compensate fully for COVAX's persistent procurement struggles: it delivered less than half of the two billion doses it originally projected for 2021, a fraction of the 9.25 billion doses that were administered globally in 2021. Donor countries and vaccine manufacturers systematically broke COVAX's principles for maximizing the impact of dose-sharing, delivering doses late, in smaller quantities than promised, and in ad hoc ways that made roll-out in recipient countries difficult." Further, some donors even earmarked doses for specific recipients, complicating and potentially undermining COVAX's equitable allocation mechanism.

To account for this, we include vaccine donations per capita via COVAX as an alternative dependent variable. The correlation between DONATIONSpc and COVAXpc in our sample is 0.29, signifying that the two variables are capturing somewhat different ~~donation~~ channels of vaccine distribution. This modest correlation is partly since some vaccine donor nations did not participate in the COVAX program (see de Bengy Puyvallée and Storeng (2022)), along with the fact that donations were not the only source of COVAX supply.

The main explanatory variable is supply-chain constraints, that we consider across several dimensions. First, we consider an overall index of a nation's logistics performance (LogisticPERF). This index incorporates several dimensions that characterize logistics performance, including timeliness of deliveries, tracking of shipments, the quality of infrastructure, etc. (see Arvis et al. (2023) for details). Then, we include infrastructure (INFRAst), international shipment readiness (INTLship), and timeliness of shipments received (TimelySHIP), as different dimensions of logistics performance to see whether they had different influences on vaccine donations.[6, 7] Better supply chains would imply less wastage and, hence, lesser need for donations. This is especially relevant in the case of COVID-19 vaccines, due to their relatively short shelf life.

[6] These supply chain aspects mainly relate to transportation bottlenecks. There may be other issues like greater absenteeism that can affect supply chain aspects. Absenteeism would partly be captured in the timeliness of deliveries.

[7] Goel et al. (2020) have considered different logistics aspects in another context, unrelated to the pandemic (also see Goel et al. (2021b)).

A broader dimension of supply chain constraints is considered by including an overall index of a nation's globalization (including economic, political, and social globalization).[8] This consideration provides a useful robustness check of the logistics performance indices.[9]

Another constraint might be due to a weakness in institutional quality that would hamper the formation and execution of deals related to vaccine donations. We proxy for institutional quality by using an index of perceived corruption (CORRUPTION).[10, 11] Goel et al. (2021) early on during the pandemic hypothesized that the speed and scale of vaccine rollouts would be tied to corrupt activity.

It is quite possible that the global severity of the pandemic (via COVID-19 deaths for example – DEATHS) increased the urgency to donate as wealthier nations would not want to appear to be indifferent. On the other hand, in a raging pandemic, vaccine charity could very well begin at home (Barceló et al. (2022)). Broadly viewed, the consideration of COVID-19 deaths ties to the body of research on the effects of the pandemic (see, for example, Afonso (2023)).

We account for a nation's economic prosperity (GDPpc) due to the fact that wealthier nations might have a lesser need for donations (and might very well be vaccine donors) to achieve equity goals.[12] Such nations would also have a better logistical and health infrastructure, ceteris paribus.

We account for both the size (GOVTsize) and the scope/quality of the government (DEMOCRACY, AUTOCRACY). Larger governments might have better public health systems, better infrastructure and may even be buying vaccines themselves (rather than seeking donations). Yet, large government spending in many nations might be institutionalized, leaving governments less room to maneuver during emergencies like the pandemic. The quality of the government via the form of the government addresses the voice the public may have in government decision-making and the efficiency in governmental decision-making (Kickbusch (2021)). We consider democratic and autocratic government forms (with anocracies being the default category). We also account for a nation's colonial heritage by including a control for nations that were never colonized (NoCOLONY). It may be the case that vaccine donors tend to favor their former colonies in donating vaccines (de Bengy Puyvallée and Storeng (2022); also

[8] See https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html for details.
[9] Island nations pose somewhat different supply chain issues than other nations and that is discussed below (also see Arvis et al. (2007).
[10] We are aware that there are many dimensions of institutional quality, and that there are other measures (e.g., government effectiveness, rule of law, etc.). We are using corruption due to its multidimensional nature and the underlying measure of corruption is comparable across nations. Plus, the main focus of this work is not on this aspect.
[11] Given its multidimensional character, corruption can possibly impact logistics performance as well (Goel et al. (2020)). Such issues are less of a concern in a cross-sectional analysis.
[12] Of course, this cannot fully address how well equity considerations were met in achieving equal vaccine access. A poor nation may have received a relatively large allocation of vaccines, but due to graft, political favoritism, and other considerations, the vaccines were not equitably distributed within the receiving country.

see https://www.paho.org/en/covax-americas). Furthermore, colonies are likely to generally have better supply/transportation channels with their former colonizers.

Along another dimension involving the government's role, we consider per capita bilateral vaccine deals (DEALS). Different nations made various vaccine supply deals with other governments and private vaccine suppliers (de Bengy Puyvallée and Storeng (2022), Deutsch (2021)), and it is possible that besides lowering transaction costs, some of these deals were associated with clauses to also include some vaccine donations as part of the deal.

Finally, island nations, due to their unique geography, might be different from other nations (see Arvis et al. (2007)). In the context of vaccine donations, their relative insulation, without immediate neighbors might present different strategic considerations in vaccine donations than other nations. Further, these nations might also encounter some unique supply chain issues (e.g., via the absence of land trade routes).

3. Data and estimation

3.1 Data

Data on the number of COVID-19 vaccine doses that a nation received via bilateral donations and secured through the COVAX Facility are derived from the IMF-WHO COVID-19 Vaccine Supply Tracker, a database jointly established by the IMF and WHO. All vaccine types (e.g., AstraZeneca, Moderna, Pfizer, Sinovac, Sputnik-V) from all donor countries, including the US, India, and China, are reflected in the dataset.[13] The vaccine supply data was last updated on September 8, 2022. All vaccine data are expressed on a per capita basis in the analysis below.

Logistics Performance Index (LPI) data are drawn from World Bank sources. The overall Index and its various components are based on surveys of international logistics operators (global freight forwarders and express carriers) regarding their assessments of the logistic infrastructure of the countries with which they trade along with measures of the actual speed of global trade using supply chain tracking data.[14] LPI data are for 2018, the most recent year available at the time of this writing. In further robustness analysis considered below, we also consider an "Aggregate Logistics Performance Index", a weighted sum of the LPI for the years 2012, 2014, 2016, and 2018 to account for possible legacy effects of supply-chain bottlenecks on vaccine donations.[15]

[13] For further details on the methodology used to track vaccine supply, see https://www.imf.org/en/Topics/imf-and-covid19/-/media/Files/Topics/COVID/IMF-WHO/imf-who-covid-19-vaccine-supply-tracker-methodology.ashx.

[14] For further details on the methodology used to construct the Index, see https://lpi.worldbank.org/sites/default/files/2023-04/Methodology_LPI_survey.pdf.

[15] For further details, see https://lpi.worldbank.org/international/aggregated-ranking. The LPI is produced every two years.

Data on COVID-19 deaths are drawn from the WHO Coronavirus Dashboard and pertain to cumulative confirmed cases (per million population) reported to WHO as of January 1, 2022.[16] A challenge for this particular analysis is to select a specific date for this variable, as the vaccine supply data are only shown as the total for the period ending in September 2022. Actual vaccine donations could have occurred in any country at any date up to that point in time.

Choosing the beginning of 2022 as the date to measure COVID-19 deaths in a country is admittedly arbitrary. In a preliminary analysis, data on cumulative deaths at several other points in time during the pandemic were also considered, including October 2021, April 2022, and July 2022. Using these alternative dates as the record for COVID-19 deaths did not result in any meaningful changes in the conclusions drawn below.[17]

Our measure of corruption is drawn from the Transparency International Corruption Perceptions Index (CPI) for the year 2022. The index reflects the perceived level of public sector corruption in a country, as viewed by experts and businesspeople. Despite the well-known issues with accurately capturing the prevalence of corruption (Donchev and Ujhelyi (2014)), this index has been widely used in the empirical literature on the causes and effects of cross-national corruption (see Dimant and Tosato (2018)).[18]

In a separate robustness analysis considered below, we also consider lagged values of the CPI, including the year 2015 and the average for the years 2015-2019 to account for possible legacy effects of country-level perceived corruption on vaccine donations.

The classifications of political regimes are based on the "polity2" score on regime authority derived from the Center for Systematic Peace. Here regime authority is based on a 21-point scale, where country scores of – 10 to – 6 are designated as "autocracies" and country scores ranging from + 6 to +10 are classified as "democracies". Intermediate scores, - 5 to + 5, are considered to be "anocracies" (regimes with mixed democratic with autocratic features) and are taken to be the omitted category in the analysis below. Based on these classifications, 65 percent of sample nations were classified as democratic and 10 percent as autocracies (Table 1).

The remainder of the data pertaining to country-level control variables are drawn from reputed international sources that are routinely used in the extant literature. Details about the variables in the analysis, including definitions, summary statistics, and data sources are provided in Table 1.

3.2 Estimation

Given that the dependent variable using either (bilateral) donations (DONATIONSpc) or COVAX (COVAXpc) measure is left-censored at zero, a censored regression model is more appropriate as an estimation strategy as Ordinary Least Squares will yield biased and

[16] https://covid19.who.int/info

[17] Not surprisingly, the correlation among all four dates reflecting COVID-19-related deaths is quite high, in all cases it exceeds 0.96.

[18] For further information on the methodology used to construct the index, see https://images.transparencycdn.org/images/CPI_2022_Methodology.zip.

inconsistent results.[19] Accordingly, all models presented below are estimated using the Tobit procedure along with robust standard errors used for hypothesis testing.

First, baseline models using equation (1) are estimated, followed by models that take an expanded look at supply-chain considerations and the role of government in COVID-19 vaccine distribution. This is followed by several robustness tests using legacy measures of logistics performance and country-level corruption. We turn to these results next.

4. Results

4.1 Baseline models

Table 2 presents our baseline models. The overall fit of the different models is quite decent as shown by the F-statistics and pseudo-R^2.

We see that results support hypothesis H1 – nations with lower logistics performance get more vaccine donations. Better supply chains enable more effective use of vaccine stocks (donated or otherwise), reducing the need for (additional) donations. On the other hand, nations with better logistics are perhaps able to better afford to buy vaccines (partly through the cost savings from logistics efficiency).

Interestingly, we find that nations with greater corruption received fewer donations (Hypothesis H2). Corrupt nations, with weak institutional quality, might have issues with the formation of effective contracts, and the perceived equity issues with vaccine dissemination to the public are also likely to reduce donations. The results thus uniquely highlight the influence of institutional weaknesses in impacting vaccine donations (beyond the supply chain or logistical issues alone).

Covid-19 deaths did not significantly impact the donations of vaccines received. This finding may be seen as consistent with the inward-looking policies of donors, driven by their own health and political reasons (Barceló et al. (2022), Haffajee and Mello (2020)).

As expected, wealthier nations were less likely to be vaccine donation recipients, ceteris paribus, reflecting that equity is an important consideration when a country makes vaccine donations. The coefficient on GDPpc is negative and statistically significant in all three models in Table 2. This finding supports Hypothesis H3.

Finally, the form of the government, captured via identifiers for democratic and autocratic regimes – see Table 1, was no different from other nations when it came to receiving vaccine donations.[20]

[19] Not all nations received vaccine donations. In our dataset, 40 countries (out of 131 total) received zero donations during the period analyzed, and 43 countries had zero COVAX distributions. Furthermore, information on the source of donations received by each country does not seem to be publicly available.

[20] It could be the case that the form of the government of the vaccine donor nations might be relevant. However, given the relatively few donor nations and the opaqueness of the supply-side data, we are unable to focus on the behavior of donor nations.

4.2 Influence of dimensions of supply chain

We find that the three dimensions of logistics, INFRAst, INTLship, TimelySHIP, are consistent with those of LogisticPERF in Table 2 – nations with better logistics performance received fewer vaccine donations. Interestingly, more globalization resulted in fewer donations. This reinforces the other findings with respect to logistics.

In terms of relative magnitudes, the respective elasticities (all elasticities evaluated at the respective means) of DONATIONSpc with respect to INFRAst (Model 2.1), INTLship (Model 2.2), TimelySHIP (Model 2.3), and GLOBALIZATION (Model 2.3) are -4.20, -5.66, -3.48, and -5.75.

Island nations, ceteris paribus, received more donations, ceteris paribus. The results for the other controls are similar to what was reported in Table 2.

4.3 Influence of government involvement

Table 4 fleshes out additional dimensions of the role of the government by including government size (GOVTsize), colonial past (NoCOLONY), and bilateral vaccine deals (per capita), (DEALS), as regressors in alternative models.

Of the three, only DEALS show some significance (at the 10 percent level) – nations with more bilateral vaccine deals per capita, ceteris paribus, received more donations. This might have partly to do with the ease and familiarity of doing business (Elekdag et al. (2015)).[21] On the other hand, nations without a colonial past and those with larger governments were no different from others, ceteris paribus. The results for the other regressors confirmed earlier findings.

4.4 Influence of pre-COVID supply chain and institutional issues

It is possible that the legacy of bottlenecks from pre-COVID significantly impacted vaccine donations. Some logistical or institutional bottlenecks might be longstanding and have inertia, issues that might be hard to rectify in the short run. To address this aspect, we included pre-COVID measures of logistics and institutional constraints and report the corresponding results in Table 5. The results show that pre-COVID logistics constraints (LogisticsPERF2012-18; see Elekdag et al. (2015); Nordås et al. (2006)), and past corruption (CORRUPTION2015-19 and CORRUPTION2015) negatively impacted donations, consistent with the findings for these variables using more recent values in the other tables.

This unique finding has an important policy insight – it is not necessarily current constraints driven by pandemic infections and lockdowns that impacted donations, but nations severely impacted by these constraints before the pandemic were handicapped in receiving donations. So, blaming the pandemic for shortcomings entirely would not help matters.

4.5 Drivers of vaccine donations through COVAX.

[21] Corruption/bribery might also be at play in the formation and execution of bilateral deals (Goel et al. (2021)). We control for corruption perceptions in Table 4.

Table A2 in the Appendix uses donations received through COVAX as the dependent variable and replicates the models presented in Table 2. COVAX was supposed to disburse donations fairly to address vaccine inequities and address issues of nations donating vaccines for political or strategic reasons to further their own interest. The implementation of the COVAX program over time did not exactly adhere to its original intent (de Bengy Puyvallée and Storeng (2022)). Still, the use of COVAXpc donations provides a good test and a useful alternative view.

The results show that most of the results from Table 2 are supported in Table A1. A notable exception is the coefficient on CORRUPTION, which is now statistically insignificant. In other words, nations with heightened corruption were no different from others when it came to receiving COVAX donations (while those with bilateral deals were less likely to get donations if they were more corrupt). It could be the case that there was greater media, public, and multilateral government focus/scrutiny on COVAX disbursements that resulted in corruption not being a factor.[22] Alternatively, it may be the lack of transparency in the dealings of COVAX that the role of corruption failed to significantly emerge.

Interestingly, the parameter estimates for the GDPpc variable are significantly lower in absolute value in the case of COVAX vaccine distribution relative donations received by other means. These findings point to equity considerations being less of a factor in the distribution of COVAX vaccines relative to those received directly from donor nations. There is also evidence that the severity of the pandemic, measured by COVID-19 deaths, was actually negatively associated with COVAX vaccine distribution. The concluding section follows.

5. Conclusions

Concerns about global health and reducing health inequities during the COVID-19 pandemic have prompted nations to make some collective efforts in mitigating the severity and longevity of the pandemic (Kumar et al. (2020); Luo and Tsang (2020)). Since the invention and regulatory approval of COVID-19 vaccines by a few nations, a part of the global effort has been to sell/donate vaccines to other nations, either through bilateral deals, or via broader efforts (e.g., COVAX; also see Deutsch (2021), York (2021)). Yet, the continuing and uneven spread of the pandemic, along with persisting vaccine inequities imply that more needs to be done (see, for examples, Baldwin and Weder di Mauro (2020)); de Bengy Puyvallée and Storeng (2022); Fernandes (2020), Haffajee and Mello (2020); Ivanov (2020); Morelli and Seghezza (2021)). However, in order for that to happen, a better understanding of the drivers of donations is needed and this research is an effort towards that end.

This paper focuses on the determinants of vaccine donations during the COVID-19 pandemic from the vaccine recipients' perspective. The main area of interest is on aspects of the supply chain in influencing vaccine donations along with documenting the importance of equity in

[22] Various scholars have noted the role of corruption in charitable contributions in a broader context (Goel (2020), McDonnell and Rutherford (2018)).

vaccine distribution. We also consider the influence of corruption as an indicator of institutional weakness and determine its impact on donations.

Results, based on data from more than 131 nations, show that better/strengthened supply chains reduced donations, conceivably because nations with better supply chains were in a position to make more effective use of vaccines. Nations with better supply chains would require fewer donations due to less wastable of existing vaccine stocks, and better mobilization of internal resources. On the other hand, adverse supply chains might lead to pockets of high infections and internal vaccine inequities in a nation, necessitating greater donations.

On the other hand, more corrupt nations, signifying institutional weaknesses, received fewer donations per capita, ceteris paribus. An interesting finding is that the impacts of corruption (proxying for weak institutions) and logistics performance might have persisted from the pre-COVID times (Table 5). Thus, not all the issues of logistics and/or corruption may appropriately be related to the woes caused by the current pandemic.

In other results, the results with respect to economic prosperity supported efforts to end vaccine apartheid, and island nations received more donations, ceteris paribus, as did nations with more bilateral vaccine deals. Furthermore, the impacts of pandemic severity, government size, and government form were largely statistically insignificant. Finally, donations received from bilateral deals and those through COVAX were driven by qualitatively similar factors, except corruption perceptions did not appreciably impact COVAX donations.

In terms of relative magnitudes, the elasticity of COVAXpc with respect to LogisticPERF was about half (in absolute value) compared to the corresponding elasticity of DONATIONpc (-2.87 (Models A2.1) versus -5.64 (Model 1.1), respectively). Given the larger COVAX organization and its efforts towards vaccine equity, it makes sense that vaccine donations distributed by COVAX were relatively less responsive supply-chain issues.

There are several policy implications from the analysis.[23] Nations focusing on improving logistics performance but not on controlling corruption might be inadvertently shortchanging themselves, at least in the context of vaccine donations, and in the fight against the pandemic. Furthermore, the legacy effects of supply chains and corruption imply that these issues have longer-term implications and policymakers should design relevant policies with an eye to longer terms implications (and not just be focusing on the immediate crises like the pandemic). The finding that more corrupt nations are receiving fewer donations might be used as corruption-control incentive by international bodies (e.g., The World Bank, WHO, IMF) to goad these nations towards better governance.

Second, it is instructive that vaccine donations are not significantly driven by pandemic severity (deaths), a nation having no colonial past, or the form/size of the government of the recipient nations. Rather, other factors seem to be at play. Policymakers seem to find the structure and size of the government less relevant in allocating vaccine donations.

[23] See Dragomirescu-Gaina (2021) for a discussion of other policy responses during the COVID-19 pandemic.

The negative sign on GDPpc is comforting in that the intent of donations in addressing vaccine inequities or vaccine apartheid is somewhat being addressed (although there might be some underlying qualitative issues such as some nations receiving vaccines with relatively short shelf lives, some nations receiving only the first vaccine dose for vaccines requiring two doses for complete immunity – York (2021).

Another policy lesson is that not all supply chain issues may be tied to the pandemic. We see that corruption and logistics effects from the pre-COVID level tend to have lingering effects on vaccine donations. Furthermore, corrupt deals seem easier to emerge in bilateral vaccine donations deals, rather than multilateral efforts such as the COVAX (Table A2). So while nations (both vaccine donors and vaccine recipients) might find bilateral deals more flexible and tailored to their specific circumstances, they have the greater potential to be associated with the social costs of corruption. These findings provide novel insights into vaccine benevolence during the current pandemic and could be instructive in shaping policies during future pandemics.

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Table 1
Variable definitions, summary statistics, and data sources

Variable	Mean (std. dev.)	Source
Vaccines from bilateral donations, per capita, as of September 8, 2022. [DONATIONSpc]	0.21 (0.39)	[1]
Vaccines from COVAX, per capita, as of September 8, 2022. [COVAXpc]	0.43 (0.46)	[1]
Cumulative confirmed COVID-19 deaths reported to WHO as of January 1, 2022 (per one million population, in logs). [DEATHS]	6.15 (1.73)	[2]
Corruption. Corruption Perceptions Index, 2022, 2015, 2015-2019. Index values range from 0 to 100 with higher values indicating more corruption. [CORRUPTION2022, CORRUPTION2015, CORRUPTION2015-19]	54.37 (18.98) 54.57 (20.93) 54.78 (20.15)	[3]
GDP per capita (constant 2015 US$, in thousands), 2021. In logs. [GDPpc]	16.54 (21.09)	[4]
Logistics Performance Index, 2023. Index ranges from one to five, where higher values reflect countries that are more logistics friendly. [LogisticPERF]	3.00 (0.59)	[5]
Infrastructure quality. Logistics Performance Index – Infrastructure Quality Score, 2023 (quality of trade- and transport-related infrastructure). Index ranges from one to five, where higher values reflecting better trade- and transport-related infrastructure. [INFRAst]	2.93 (0.73)	[5]
International shipments. Logistics Performance Index – Ease of International Shipments Score, 2023 (the ease of arranging competitively priced international shipments). Index ranges from one to five, where higher values reflect greater ease of arranging competitively priced international shipments. [INTLship]	2.94 (0.51)	[5]
Shipment timeliness. Logistics Performance Index – Timeliness of Shipments Received Score, 2023 (the frequency with which shipments reach consignees). Index ranges from one to five, where higher values reflect a better track record of shipments reaching consignees within the scheduled or expected time. [TimelySHIP]	3.25 (0.57)	[5]
Pre-COVID Aggregate Logistics Performance Index - Weighted LogisticPERF for the years 2012, 2014, 2016, 2018. [LogisticPERF2012-18]	2.88 (0.56)	[10]
Democratic Regime – Binary variable = 1 if "Polity Score" in the country for 2018 is classified from +6 to + 10 on a regime authority spectrum that ranges from -10 to + 10, (= 0 otherwise). [DEMOCRACY]	0.65 (0.48)	[6]
Autocratic Regime – Binary variable = 1 if "Polity Score" in the country for 2018 is classified from -10 to - 6 on a regime authority spectrum that ranges from -10 to + 10, (= 0 otherwise). [AUTOCRACY]	0.10 (0.31)	[6]
Island nation - Binary variable = 1 if a nation is an island, = 0 otherwise. [ISLAND]	0.14 (0.34)	[7]

Globalization – KOF Globalization Index, 2022. Index ranges from 0 to 100 where higher values reflect greater economic, social, and political globalization. [GLOBALIZATION]	63.54 (14.60)	[8]
Government Size – General government share of final consumption expenditure (% of GDP), 2021. [GOVTsize]	16.85 (5.07)	[4]
Colonial heritage – Binary variable = 1 if the country has never been colonized by any European power, = 0 otherwise. [NoCOLONY]	0.072 (0.26)	[9]
Vaccines from bilateral agreements, per capita, as of September 8, 2022. [DEALS]	1.14 (1.90)	[1]

Notes: Statistics pertain to observations used in the first model where the variable appears.
Sources:
[1]. IMF-WHO COVID-19 Vaccine Tracker, https://www.imf.org/en/Topics/imf-and-covid19/IMF-WHO-COVID-19-Vaccine-Tracker. (accessed May 2023). Supply Tracker: This tracker was last updated on September 8, 2022. They have archived the information and will no longer provide updates.
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Table 2
COVID-19 vaccine apartheid and donations:
Supply chain issues facing recipients
Baseline models

(Dependent variable: DONATIONSpc)

Model →	**[1.1]**	**[1.2]**	**[1.3]**	**[1.4]**
Logistics performance [LogisticPERF]	-0.395** (2.8)	-0.321** (2.5)	-0.397** (3.0)	-0.391** (3.0)
COVID-19 Deaths [DEATHS]	0.019 (0.8)	0.014 (0.5)	0.015 (0.7)	0.019 (0.7)
Perceived corruption [CORRUPTION]	-0.014** (2.4)	-0.014** (2.2)	-0.015** (2.4)	-0.015** (2.5)
GDP per capita [GDPpc]	-0.024** (3.6)	-0.026** (3.6)	-0.025** (3.7)	-0.026** (3.6)
Democratic regime [DEMOCRACY]		-0.056 (0.5)		-0.042 (0.3)
Autocratic regime [AUTOCRACY]			0.164 (1.2)	0.138 (0.8)
F-statistic	7.04**	5.29**	4.63**	4.69**
Pseudo R-squared	0.31	0.32	0.34	0.34
Observations (countries)	131	126	125	125

Notes: Variable definitions are provided in Table 1.
All models are fitted using the Tobit estimator with the left-hand censor for the outcome variable set at zero.
Constant term included in all models but not reported to conserve space.
The numbers in parentheses are t-statistics in absolute value based on robust standard errors.
* denotes statistical significance at the 10% level, and ** denotes significance at the 5% level (or better).

Table 3
COVID-19 vaccine apartheid and donations:
Dimensions of supply-chain constraints

(Dependent variable: DONATIONSpc)

Model →	**[2.1]**	**[2.2]**	**[2.3]**	**[2.4]**	**[2.5]**
Infrastructure quality [INFRAst]	-0.301** (3.0)				
Ease of international shipments [INTLship]		-0.404** (3.6)			
Frequency the shipments reach consignees [TimelySHIP]			-0.225* (1.7)		
Island nation [ISLAND]				0.232** (2.0)	
Globalization [GLOBALIZATION]					-0.019** (3.6)
Perceived corruption [CORRUPTION]	-0.014** (2.4)	-0.013** (2.2)	-0.013** (2.1)	-0.010* (1.9)	-0.014** (2.6)
COVID-19 Deaths [DEATHS]	0.015 (0.6)	0.019 (0.7)	0.024 (0.8)	0.041 (1.5)	0.095** (3.6)
GDP per capita [GDPpc]	-0.025** (3.7)	-0.027** (3.7)	-0.030** (3.9)	-0.034** (4.4)	-0.022** (3.7)
Democratic regime [DEMOCRACY]	-0.054 (0.4)	-0.028 (0.2)	-0.076 (0.6)	-0.110 (1.0)	-0.076 (0.7)
Autocratic regime [AUTOCRACY]	0.144 (0.8)	0.130 (0.8)	0.086 (0.5)	0.063 (0.4)	0.026 (0.2)
F-statistic	4.15**	5.27**	4.13**	4.32**	7.60**
Pseudo R-squared	0.34	0.36	0.32	0.30	0.34
Observations (countries)	125	125	125	154	154

Notes: See Table 2.

Table 4
COVID-19 vaccine apartheid and donations:
The role of government

(Dependent variable: DONATIONSpc)

Model →	**[3.1]**	**[3.2]**	**[3.3]**
Logistics performance [LogisticPERF]	-0.270** (2.6)	-0.389** (3.0)	-0.416** (3.2)
Government share of GDP [GOVTsize]	0.002 (0.2)		
Colonial heritage [NoCOLONY]		-0.067 (0.4)	
Bilateral Vaccine Deals [DEALS]			0.057* (1.7)
COVID-19 Deaths [DEATHS]	-0.004 (0.2)	0.016 (0.6)	0.018 (0.7)
Perceived corruption [CORRUPTION]	-0.011** (2.2)	-0.015** (2.5)	-0.016** (2.5)
GDP per capita [GDPpc]	-0.025** (3.5)	-0.026** (3.7)	-0.030** (3.8)
Democratic regime [DEMOCRACY]	0.071 (0.7)	-0.042 (0.3)	-0.056 (0.4)
Autocratic regime [AUTOCRACY]	0.047 (0.4)	0.149 (0.8)	0.147 (0.8)
F-statistic	3.45**	4.09**	4.35**
Pseudo R-squared	0.40	0.34	0.36
Observations (countries)	111	125	125

Notes: See Table 2.

Table 5
COVID-19 vaccine apartheid and donations:
Effects of Pre-COVID constraints

(Dependent variable: DONATIONSpc)

Model →	**[4.1]**	**[4.2]**	**[4.3]**
Pre-COVID Aggregate Logistics Performance Index [LogisticsPERF2012-18]	-0.423** (3.0)		
Logistics performance [LogisticPERF]		-0.319** (2.7)	-0.323** (2.7)
COVID-19 Deaths [DEATHS]	0.035 (1.6)	0.006 (0.2)	0.007 (0.3)
Perceived corruption [CORRUPTION]	-0.012** (2.0)		
Pre-COVID Average perceived corruption, 2015-2019. [CORRUPTION2015-19]		-0.010* (1.8)	
Perceived initial corruption, 2015. [CORRUPTION2015]			-0.009* (1.8)
GDP per capita [GDPpc]	-0.020** (3.1)	-0.022** (3.4)	-0.022** (3.4)
Democratic regime [DEMOCRACY]	-0.041 (0.4)	0.050 (0.5)	0.054 (0.5)
Autocratic regime [AUTOCRACY]	0.116 (0.8)	0.198 (1.1)	0.216 (1.2)
F-statistic	6.07**	4.59**	4.53**
Pseudo R-squared	0.33	0.34	0.34
Observations (countries)	150	124	124

Notes: See Table 2.

Appendix

Table A1
Countries in Data Set

Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, The Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Dem. Rep. Congo, Rep. Congo, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Djibouti, Dominican Republic, Egypt, El Salvador, Estonia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Kazakhstan, South Korea, Kyrgyz Republic, Lao PDR, Latvia, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Namibia, Netherlands, New Zealand, Nicaragua, Niger, North Macedonia, Norway, Oman, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Saudi Arabia, Serbia, Singapore, Slovak Republic, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Tajikistan, Thailand, Togo, Trinidad and Tobago, Türkiye, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vietnam, Zimbabwe

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N = 131, Based on Model 1.1 dataset.

Table A2
COVID-19 vaccine apartheid and donations:
Drivers of COVAX donations

(Dependent variable: COVAXpc)

Model →	**[A2.1]**	**[A2.2]**	**[A2.3]**	**[A2.4]**
Logistics performance [LogisticPERF]	-0.412** (3.7)	-0.362** (3.2)	-0.384** (3.9)	-0.379** (3.7)
COVID-19 Deaths [DEATHS]	-.132** (7.0)	-.140** (7.0)	-.136** (7.6)	-.132** (7.1)
Perceived corruption [CORRUPTION]	0.002 (0.6)	0.004 (1.3)	0.003 (1.3)	0.003 (1.0)
GDP per capita [GDPpc]	-0.008** (2.1)	-0.006* (1.7)	-0.006* (1.7)	-0.006* (1.8)
Democratic regime [DEMOCRACY]		0.032 (0.4)		-0.048 (0.6)
Autocratic regime [AUTOCRACY]			-0.112 (1.0)	-0.142 (1.1)
F-statistic	97.78**	78.98**	83.19**	70.46**
Pseudo R-squared	0.65	0.68	0.72	0.72
Observations (countries)	131	126	125	125

Notes: See Table 2.