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RESEARCH ARTICLE

The impact of state capacity on the cross-country variations in COVID-19 vaccination rates

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Abstract

The initial period of vaccination shows strong heterogeneity between countries' vaccinations rollout, both in the terms of the start of the vaccination process and in the dynamics of the number of people that are vaccinated. A predominant thesis for this observation is that a key determinant of the swift and extensive vaccine rollout is state capacity. Here, we utilize two measures that quantify different aspects of the state capacity: (i) the external capacity (measured through the soft power of the country) and (ii) the internal capacity (measured via the country's government effectiveness) and provide an empirical test for their relationship with the coronavirus vaccination outcome in the initial period (up to 31st March 2021). By using data on 128 countries and a two-step Heckman approach, we find that the soft power is a robust determinant of whether a country has started with the vaccination process. In addition, the government effectiveness is a key factor that determines vaccine roll-out. Altogether, our findings are in line with the hypothesis that state capacity determines the observed heterogeneity between countries in the initial period of COVID-19 vaccines rollout. As such, they are a stark reminder for the need for transparent and fair global response regarding fair and equitable availability of vaccines to every country.

Keywords State capacity · COVID-19 · Cross-country vaccination heterogeneity · Heckman selection

JEL Classification C54 · F51 · F63

Introduction

The COVID-19 virus created the most severe global economic crisis since the Global Depression. The recent innovation of COVID-19 vaccines brings hope that the World will exit from the pandemic soon. As a means to provide an equitable access to vaccines for every country, the World Health Organization created the COVAX system. However, the system has so far failed in its goal, and the initial period of vaccination shows strong

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heterogeneity between countries' vaccinations rollouts. This is observed both in the terms of the start of the vaccination process and in the dynamics of the number of people that are vaccinated. Concretely, in the first two months (until end-January 2021), the vaccination started only in 54 countries in the World, while vaccines were not accessible in most of the countries. The vaccination process started in most of the countries—160 countries (out of 204 countries for which there is data) at the end of March 2021, but there were high discrepancies among countries in speed of vaccination. In total 91 countries had lower than 10 administered COVID-19 doses per 100 people, while 13 countries had more than 50 administered COVID-19 doses per 100 people.[1]

A predominant thesis in the ongoing debate on the drivers of this heterogeneity is that a key determinant of the swift and extensive vaccine rollout is *state capacity*. This variable is not strictly defined in the literature but is generally portrayed as a potential source of strength that can fundamentally shape the implementation and the final impact of social, health and economic policies (Cingolani et al., 2015). As such it has attracted renowned interest in studies of economic development over the past decade (see for example, (Acemoglu et al., 2015; Besley & Persson, 2010; Cingolani, 2018; Khemani, 2019; Williams, 2018).

In our work, we bridge the gap between the theoretical debate and empirical evidence by conducting a thorough econometric analysis on the impact of state capacity on the ability of a country to start and implement the vaccination process. For this purpose, we utilize country level data that covers the initial period of the vaccination process, up to March 31st, 2021 and model the final outcome (the total number of administered vaccines per capita at the final date). Evidently, the data is censored, i.e., some countries display 0 vaccination rate. To circumvent this problem, we assume that countries undergo a process of negotiation with vaccine providers and accept an offer only if it suits their economy. This allows us to describe the vaccination outcome as a two-step Heckman selection model. In the first step, we model the probability that a country has started with the vaccination process by using all countries in the sample. In the second step, we model the vaccination rate only for the countries that have started with the vaccination process.

We follow the literature and view the importance of the state capacity in two dimensions that determines COVID-19 vaccination success. The first is external capacity which describes the ability of the state to influence outcomes outside of its territory. In this case, state capacity determines the likelihood that the country will secure reception of vaccines in a time period when vaccine supply is much lower than demand (i.e., a non-censored observation). The second is the internal state capacity. The internal capacity is relevant after the vaccines are received and it determines the speed of vaccination among a country's population.

The impact of the external state capacity on the supply of vaccines is usually based on the soft power of the country. Nye (2004) defines soft power as the capacity for shaping the preferences of others through appeal and cooperation. While there is no widely accepted measure of the soft power and different rankings focused on different elements of interest, in this paper, we use the soft presence of the country according to the Global Presence Index. This index measures the soft power of the countries in the World based on various indicators including official development assistance to another countries, migrations, tourism, international patents, and others (Olivié & Gracia, 2020).

[1] Source: Ourworld in data, https://ourworldindata.org/covid-vaccinations.

We measure the internal state capacity with the World Bank's indicator of government effectiveness. The indicator captures perception about the quality of policies formulation and implementation. As a consequence, it has been widely used as an indicator of the administrative capacity (for example, Lee & Whitford, 2009 and Hanson & Sigman, 2013).

After controlling for a large set of potential socio-economic and COVID-19 specific confounders, we find that the soft power of country is robust determinant of vaccines receipts and start of the vaccination process in the initial period, which is characterized with very limited vaccines supply from producers. In addition, our results suggest that after the vaccines' supply is secured, the internal state capacity, measured by the government effectiveness, is a key factor that determines vaccine roll-out. Altogether, our findings are in line with the hypothesis that state capacity determines the observed heterogeneity between countries in the initial period of COVID-19 vaccines rollout.

The rest of the paper is structured as follows. In "Background and motivation" section we present several statistics in order to highlight the background and the motivation to our work. In "Method" section, we describe the econometric model. "Econometric results" section continues with the description of the data used for testing of our hypotheses. In "Main results" section we present our main findings. "Conclusion" section sets out our conclusions.

Background and motivation

To motivate our research, we begin by providing a detailed descriptive analysis for the observed dynamics of the COVID-19 vaccination rates between countries.

First, Fig. 1 provides boxplots that depict the differences in the magnitude of the Soft presence index between the countries that started with the vaccination process and those that have not started up to 31st March 2021. It can be observed that the group of countries that started the vaccination process not only have a higher median, minimum and maximum, but also its first quartile is almost equal to the third quartile of the group of countries that did not start the vaccination process. This suggests that, indeed, countries with larger soft presence are able to attain vaccines easier. In general, we believe that in a world system where vaccine distribution is equitable, there should not exist any dependence on availability of vaccines on soft presence. Therefore, we hypothesize that soft capacity implies more power to secure deals with producers of rare goods, and in this case—COVID-19 vaccines. The full list of countries that started vaccination by 31st March 2021 is given in the Appendix.

In Fig. 2, we present a scatterplot between the government effectiveness and the vaccination rate for all 117 countries that started with vaccination in the observed period. The plot uncovers a positive relationship between observed variables, implying that countries with higher government effectiveness achieved higher numbers of vaccinated persons, i.e., vaccination rate. This serves as a first sign that, indeed, countries with better internal administrative capacities also are better organized in the delivery of the vaccination.

The descriptive analysis indicates that indeed a large amount of the heterogeneity in the observed vaccination dynamics might be attributed to the role of state capacity.

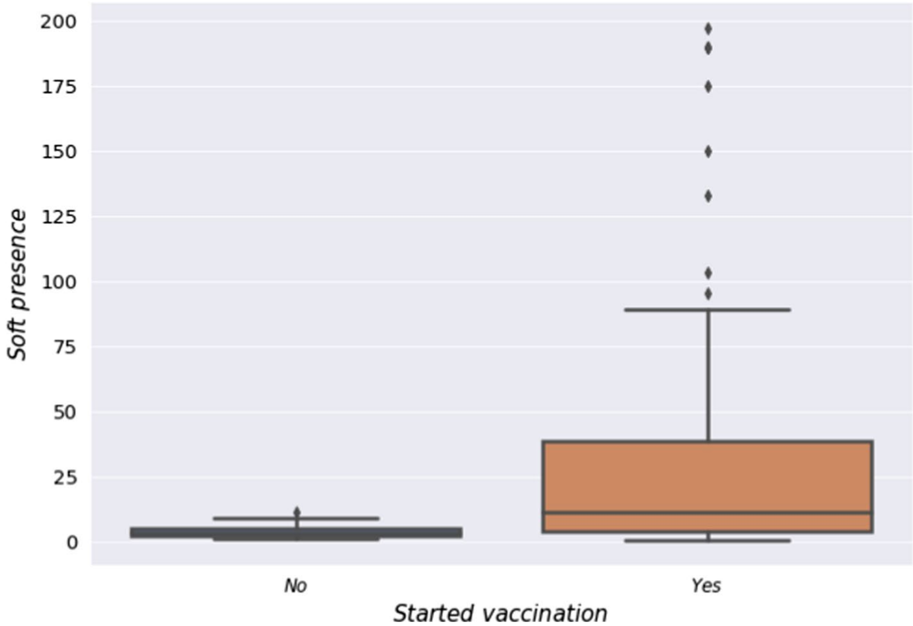

Fig. 1 Boxplots for the Soft presence index (Countries with soft presence above 200 are excluded)

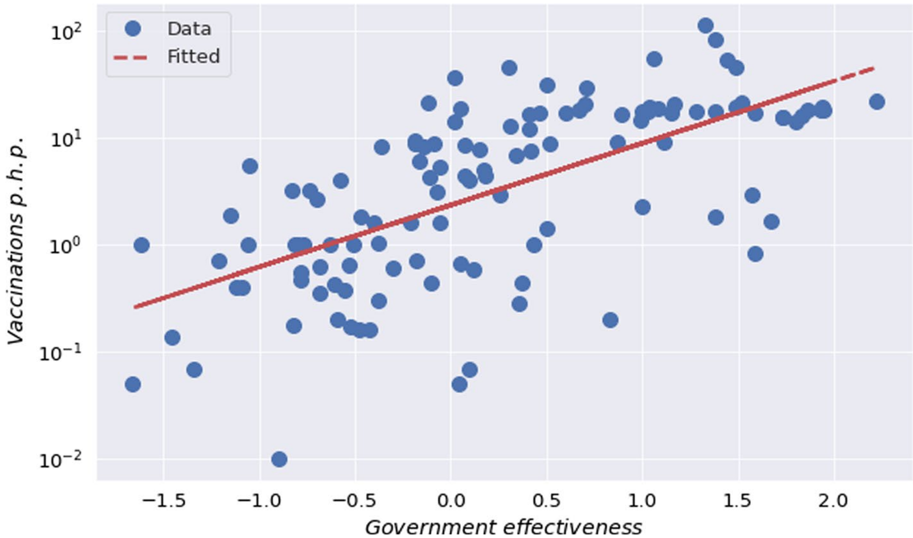

Fig. 2 Relationship between government effectiveness and vaccination rate. The line shows the linear relationship between the variables (significant at 1%)

Method

In order to provide a better econometric understanding on the role of state capacity in the COVID-19 vaccination dynamics we develop a simple framework based on the Heckman selection model. For this purpose, we assume that countries undergo a process of negotiation with a vaccine provider to determine the quantity and price of vaccines. This process involves a great deal of geopolitics and, in the sense that most of the countries negotiate only with vaccine providers which are recognized by its geopolitical allies. This is evident by the fact that many countries from Eastern Europe in the observed period declined offers of Sinovac from China or Sputnik V from Russia, while failed to secure Western vaccines made by BioNTech-Pfizer, Moderna and AstraZeneca.[2] In addition, there might be skepticism in the quality of certain vaccines. For simplicity we assume that these aspects are translated in the price of the vaccine. The resulting outcome for country i is the offer for the number of vaccinations per hundred population v_i^*, which is unobserved. If the offer is above a certain threshold that is acceptable for the price, the country will accept the offer. Moreover, the start of vaccination is conditioned with physical distribution of the vaccines in the observed period.[3] Evidently, there is a bias in the selection of the sample countries used for modeling the COVID-19 vaccination dynamics, as not everyone was able to efficiently negotiate with vaccine providers and to secure receipt of the vaccines.

A simple way to correct for this bias is to utilize the previously mentioned Heckman selection model (Heckman, 1974; Winship, 1992). The model represents a simple two-step approach. In the first step of the estimation procedure, the researcher models the sampling probability of each observation. In our case, this is the selection equation, where we quantify the probability that a certain country has started with the vaccination process. This is modeled as a probit regression of the form

$$Prob\left(V_i = 1 | X_{1i}, Z_{1i}\right) = \Phi\left(\beta_1 X_{1i} + \gamma Z_{1i}\right),$$

where V_i is an indicator variable which takes value 1 if country i has started with the vaccination process, and zero otherwise; X_{1i} is a vector of potential socio-economic variables that determine the value of V_i, with β_1 being their marginal effects; and Z_{1i} are control variables that are specific to the COVID-19 dynamics in the country, with γ being their marginal effect.

The second step models the observed vaccination rate by correcting the bias in the random error u_i of the regression using the conditional expectation of the error estimated in the first step. Formally, the second step of the equation is specified as

$$E\left(v_i | X_{2i}, Z_{2i}, V_i = 1\right) = \beta_2 X_{2i} + \delta Z_{2i} + E(u_i | \beta_2 X_{2i} + \delta Z_{2i}).$$

In the equation, X_{2i} is a vector of potential socio-economic variables that determine the vaccination rate of a country which has started the vaccination process, with β_2 being their marginal effects; and Z_{2i} are control variables that are specific to the vaccination rate dynamics in the country.

[2] See the report available at https://ecfr.eu/article/the-geopolitics-of-covid-vaccines-in-europes-eastern-neighbourhood/.

[3] In order to force pharmaceutical companies to fulfil COVID-19 contracts, European Union has introduced a temporary export regime for COVID-19 vaccines on January 30th, 2021.

Data

We obtained COVID-19 number of vaccinations per hundred population data from Our World in Data in Data—Coronavirus (COVID-19) Vaccinations database.[4] The explanatory variables were taken from various sources, as will be explained in the following. For each variable, unless otherwise specified, we take the last available data point as our observation, with the note that we do not take data that came out after March 31st 2021. This is because we want to emphasize the role of the country's capacity in being able to deliver COVID-19 vaccines in the initial period of the vaccination process.

In the first step of the model specification, we include two control variables that may govern the probability that a country has started with the vaccination process. They are the log of the registered COVID-19 cases up to the last date of observation and the log of the average daily government response index since the first registered case and up to the last date of observation. The first variable quantifies the magnitude of the health crisis in the country, whereas the second one is an estimate for the government behavior aimed at reducing the impact of the crisis. The data for the registered Cases were taken from the Our World in Data Coronavirus database.[5] The government response index was calculated using the methodology described in [16] with input data from the Oxford Government Response Tracker.[6] In addition, the socio-economic variables that may drive the observation of whether a country has started with the vaccination process and are included in our model are: the log of the GDP per capita of the country—measures the economic power of the country; the log of exports per capita—quantifies the presence of the country in the global trade market; the log of the health expenditures per capita—provides an proxy for the capacity of the health sector in the country, and the log of the Military expenditures per capita—determines the hard power of the country. The logarithmic transformation of the variables allows us to reduce the potential impact of outliers. Finally, in the specification we include the Soft presence index. The index assesses a country's ability to influence outcomes outside of its territory—efforts and means versus results, sector profile of presence, relation between presence and influence, or the distance between objective presence and subjective perception. As such, it is an adequate approximation for the degree of soft power of a country.

In the second step, besides the control variables included in the first step we also include the number of days since the first vaccination in the country. This quantity measures the duration of the vaccination process in the country. Moreover, in the second step we include each of the socio-economic variables except the soft power index, which is now substituted with our measure for the internal capacity of the country—the government effectiveness**.** This variable is taken from the World Bank's World Governance Indicator database. The variables in the database compile and summarize information from various data sources that report the views and experiences of citizens, entrepreneurs, and experts in the public, private and NGO sectors from around the world, on the quality of various aspects of governance. Therefore, they represent only approximation for the observed governance within a country and are characterized with error margins. In what follows, we will follow the standard practice in the

[4] Available at https://ourworldindata.org/covid-vaccinations.

[5] Available at https://ourworldindata.org/coronavirus.

[6] Available at https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker.

Table 1 Descriptive statistics

Variable	Started vaccination		
		No	Yes
Cases per million pop	Mean	3,302.34	31,433.42
	Std. dev	7,210.00	33,469.33
Government response	Mean	50.10	57.07
	Std. dev	13.60	12.81
Exports per capita in US dollars ppp	Mean	1,398.41	11,297.99
	Std. dev	3,473.67	25,321.74
Health expenditure per capita in US dollars ppp	Mean	145.34	1,320.33
	Std. dev	243.07	1,979.05
Military expenditures per capita in US dollars ppp	Mean	74.93	296.80
	Std. dev	211.12	460.28
Government effectiveness	Mean	− 1.14	0.17
	Std. dev	0.84	0.90
Vaccinations per hundred pop	Mean	//	14.77
	Std. dev	//	23.74
Share of population above 65 yrs	Mean	3.80	9.83
	Std. dev	2.46	6.46
Days since first vaccination	Mean	//	52.67
	Std. dev	//	33.92
GDP per capita in US dollars ppp	Mean	5,657.00	25,718.67
	Std. dev	12,168.87	24,054.11
Soft presence	Mean	4.53	80.48
	Std.dev	3.08	237.84

literature and utilize the average value of the indicator for quantifying the government effectiveness of a country.

Besides these variables, we also include the log of the share of persons above 65 years of age in the total population of the country as explanatory variables in the second step of the estimation. We expect that countries with older populations also speed up with the vaccination process as they are the most susceptible group to the disease. Data sources, variable descriptions and their abbreviations are presented in more detail in Appendix, Table 4.

Column 1 of Table 1 gives the mean value for each variable included in the sample. Columns 2 and 3 of the same table, give the summary statistics divided by group of countries which respectively have started and have not yet started the vaccination process. Interestingly, the countries which started with the vaccination process also reported a higher number of registered cases per capita and had a stricter government response. Moreover, they had higher GDP, larger exports as well as health and military expenditures per capita, older population and had more efficient government. All of this suggests that there are significant discrepancies in the economic performance of the countries which started with the vaccination process and those that have not.

Econometric results

Main results

Mirroring our theoretical model, the empirical analysis follows the described two-step process. In the first step, we quantify the probability for the start of the vaccination process in the observed period. The second step models the observed vaccination rate.

The results of the Heckman selection model are presented in Table 2. Columns (1–2) give the model estimates with only the control variables included in the model, Columns 3–12, represent results with four different specifications for the COVID-19 vaccination process. In each model, the dependent variable of the first step is marked with *started*, while in the second step with *lvac*. The estimated coefficients of the first model, as given in Columns 1 and 2 show that the registered COVID-19 cases are significant in both steps and that the government response index is significant in the first step, while the number of days since the start of vaccination is significant in the second step. The positive coefficients imply that an increase in the registered COVID-19 cases in the country also increases the probability a country to start with the vaccinations in the observed period. Moreover, a higher number of registered COVID-19 cases speeds up the vaccination rate in the observed period. Also, stronger government response during the outbreak increases the probability for the start of vaccination, while as expected, more days since the start of vaccination lead to higher vaccination rate.

In the second model, given in Columns 3–4 of the same table, we add our measures of soft capacity to the estimation. The results reveal that the higher soft presence value of the country increases the probability that the country received vaccines and started with the vaccinations in the observed period. Also, the positive and significant government effectiveness coefficient implies that higher government effectiveness leads to higher vaccination rate in the country.

The third model (Columns 5–6) includes additional variables in both steps which serve as a simple robustness check for whether the capacity of the health sector or military power of the country impact the vaccination process. The estimated coefficients show that the capacity of the health sector in the country (the log of the health expenditures per capita) and the hard power of the country (the log of the military expenditures per capita) are not significant determinants of the probability country to started with vaccination in observed period, while the soft power is still significant and positive. Similarly, these additionally added variables do not display a significant effect on the vaccination rate in the country.

The fourth model (Columns 7–8) is augmented with economic and demographic variables. In the first step, it additionally includes the log of the GDP per capita and the log of the share of exports in GDP, while in the second step it additionally includes log of the GDP per capita and share of the population above 65-years as the riskiest population group. The estimated economic and demographic coefficients in both steps are not significant, implying that the economic income per capita and exports do not affect the probability of a country to start with the vaccination process and economic income per capita and share of elderly population do not influence the speed of vaccination. However, the estimated health expenditure coefficient becomes significant in the first step, which implies that countries with higher health expenditures per capita have higher probability to start the vaccination process. This can be explained by the fact that countries with higher health expenditures are in a better position to negotiate with vaccine producers, while some of these countries also have vaccine production facilities in their territories. We point out that

Table 2 Estimated Heckman selection models for the vaccination process

	Model 1		Model 2		Model 3		Model 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination
Cases (log)	0.223*	0.349***	0.118	0.304***	0.135	0.132	0.134	0.015
	(0.090)	(0.083)	(0.078)	(0.090)	(0.087)	(0.099)	(0.085)	(0.162)
Days	0.041***		0.042***		0.042***		0.041***	
	(0.005)		(0.005)		(0.006)		(0.006)	
Gov_response (log)	0.457	1.076**			1.000*	1.198**	0.949	1.993**
	(0.808)	(0.484)			(0.602)	(0.538)	(0.611)	(0.828)
Gov_eff			0.526***		0.831***		0.828***	
			(0.129)		(0.240)		(0.262)	
Soft_presence (log)				0.584***		0.587***		0.685***
				(0.186)		(0.190)		(0.259)
Health_exp_pc (log)					−0.150	0.286	0.030	1.940***
					(0.173)	(0.368)	(0.176)	(0.587)
Military_exp_pc (log)					−0.037	0.090	−0.100	−0.232
					(0.130)	(0.278)	(0.138)	(0.270)
Exports_pc (log)								−0.546
								(0.345)
Gdp_ppp_pc (log)							−0.124	−0.190
							(0.347)	(0.797)
Pop_65 (log)							−0.148	
							(0.184)	

Table 2 (continued)

	Model 1		Model 2		Model 3		Model 4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination
Constant	−5.245	−6.193***	−2.804***	−2.444***	−6.019**	−7.680***	−4.997	−11.114**
	(3.209)	(1.893)	(0.633)	(0.803)	(2.481)	(2.750)	(3.559)	(4.606)
Observations	152	152	129	129	121	121	118	118

Robust standard errors in parentheses

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

insignificance of the GDP per capita in this step should be taken with caution as it is highly correlated with the health expenditures (see Fig. 3 where we provide a correlation heatmap for every included variable). Nonetheless, the soft power remains positive and significant in the first step of the model, while government effectiveness remains positive and significant in the second step, thus suggesting that they are robust determinants on the observed variations between the countries in the vaccination process.

To summarize, the estimated coefficients in each of the Heckman selection models back our theoretical claims. In every case, the soft power increases the probability that a country will secure the receipt of vaccines in the initial period of the start of vaccination. The soft power matters more than economic power for securing the vaccine supply during the COVID-19 crisis. We argue that the reason for this is not only limited supply of the vaccines in the period from December 15th 2020 to March 31st 2021, but also the fact that the competition for vaccines is not between private subjects, but between governments, which use their diplomatic and other apparatus. In addition, it is important to note that more strong government response during pandemic in terms of lockdown restrictions and economic support measures mean more pressure on governments to find a way to secure the vaccines receipt in the initial period. Similarly, once the vaccines are secured, the speed of the vaccination depends on the government effectiveness to organize and execute the process of vaccinations.

Robustness checks

In Table 3 we test the robustness of our results by performing four different checks. In the first check, we remove China and Russia, because in these countries vaccine intake and production have been based solely on the local public pharmaceutical companies. In principle, their external capacity should not be significant for getting these vaccines. In the first step of the model (for the start of vaccination), the estimated coefficient for the soft power remains significant, while government response is significant only on 10% level, while the number of registered COVID-19 cases are not significant. Similarly, the second step of the model (for the vaccination rate) confirms significance of the government effectiveness variable, as well as duration of the vaccination process, while the government response is significant only on 10% level.

In the second robustness check, we treat the European Union (EU) as a single country. The treatment is done by creating population weighted average for the two variables of interest: government effectiveness and soft power, as well as for the rest of control variables. The reasoning for this robustness check is that for the member countries in the EU, the process of acquiring vaccines has been led centrally by the European Commission, so one can think that the national external capacity should be irrelevant to explain the vaccination deal. The estimated coefficients of the model again confirm that soft power is significant and is positively related to the supply of vaccines. In addition, it is important to note that export capacity of the country as a measure of external economic power of the country also positively affects whether the country can secure vaccine supply in the initial period. In addition, the government effectiveness remains a robust determinant of the vaccination rate.

The robustness of the World Bank's governance effectiveness indicator is checked in the third and fourth model of Table 3. In these models we want to take into account the margins of error of the government effectiveness indicator. The third model presents the estimated results using the lower bound of the government effectiveness indicator, while the

Table 3 Estimated Heckman selection models (robustness checks)

	Model: w/out CHN & RUS		Model: EU as one country		Model: Gov. eff. lower bound		Model: Gov. eff. upper bound		Model: Over 20% vacc. pop. (end: April)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Vacc. over 20% of pop
Cases (log)	0.115	0.094	0.155*	0.374***	0.128	0.145	0.112	0.142	0.300***	0.761***
	(0.106)	(0.110)	(0.084)	(0.095)	(0.088)	(0.112)	(0.086)	(0.111)	(0.105)	(0.211)
Days	0.042***		0.045***		0.041***		0.040***		0.000	
	(0.007)		(0.006)		(0.006)		(0.006)		(0.006)	
Gov_response (log)	1.018*	1.034*			0.775		0.781		0.665**	1.818**
	(0.610)	(0.575)			(0.626)		(0.645)		(0.325)	(0.795)
Gov_eff	0.780***		0.707***						0.442***	
	(0.248)		(0.160)						(0.164)	
Gov_eff_lower					0.024***					
					(0.008)					
Gov_eff_upper							0.027***			
							(0.009)			
Soft_presence (log)		0.595***		0.780***		0.586***		0.612***		0.383**
		(0.199)		(0.192)		(0.205)		(0.208)		(0.158)
Health_exp_pc (log)	−0.116	0.387	−0.277	0.412	−0.096	0.383	−0.042	0.373	−0.232	0.015
	(0.178)	(0.524)	(0.323)	(0.537)	(0.177)	(0.498)	(0.157)	(0.502)	(0.163)	(0.306)
Military_exp_pc (log)	−0.027	0.173	−0.266	−0.639**	−0.021	0.137	−0.034	0.128	0.236**	−0.013
	(0.130)	(0.255)	(0.169)	(0.285)	(0.132)	(0.241)	(0.132)	(0.245)	(0.111)	(0.450)
Exports_pc (log)		−0.159		0.760**		−0.154		−0.124		0.895
		(0.225)		(0.339)		(0.221)		(0.221)		(0.756)

Table 3 (continued)

	Model: w/out CHN & RUS		Model: EU as one country		Model: Gov. eff. lower bound		Model: Gov. eff. upper bound		Model: Over 20% vacc. pop. (end: April)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Started vaccination	Vaccinations p.h.p. (log)	Vacc. over 20% of pop
Constant	−6.111**	−6.446**	−2.691***	−6.257***	−6.248**	−2.562**	−7.009***	−2.697**	−2.591	−24.361***
	(2.470)	(2.868)	(0.771)	(1.599)	(2.631)	(1.115)	(2.714)	(1.145)	(2.524)	(6.880)
Observations	117	117	97	97	120	120	120	120	128	128

Robust standard errors in parentheses

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

fourth model uses the upper bound of this indicator. The results suggest that in both cases, government effectiveness influences the vaccination rate in a country.

In the last model of Table 3 we change the dependent variable of the first step to a new variable which indicates if the country has administered vaccinations in over 20 percent of the population with a single dose of COVID-19 vaccine by the end of April 2021 (30 April 2021). Here, the idea here is to consider only the countries that succeeded in delivering a certain level of immunization during the initial vaccination process and to exclude the rest of the countries. The estimated results of this model strongly confirm that soft power and government effectiveness are significant predictors of the vaccination process.

Conclusion

We investigated the potential impact of state capacity on the ability of a country to start and implement the vaccination process in the initial COVID-19 vaccination period spanning from December 15th 2020 to March 31st 2021. This was done by considering variables that can determine the likelihood for a country to secure reception of vaccines in a time when vaccine supply is much lower than demand, as well as the variables that possibly affect the speed of the vaccination once the vaccines are received. By utilizing a Heckman two-step selection approach, in the first step, we quantified the probability for a certain country to start with the vaccination process in the observed period, based on the sample of 204 countries. In the second step, we modeled the observed vaccination rate in the countries that started with vaccination. The results of the model showed that soft power, as indicator of external power of country, increases the probability that a country will secure the receipt of vaccines in the initial period of the start of vaccination. Moreover, once the vaccines are secured, we found that the speed of the vaccination is related with the government's effectiveness to organize and execute the process of vaccinations, as well as the time of the realization of the process. On the other hand, the country's policy response, total health expenditures, military expenditures, and proportion of the population above 65 years age are not significant. We also performed robustness checks, which were in line with the baseline results.

The results of this paper put a new light on the already known wisdom that the role of the state is crucial in a severe crisis, such as world wars, systemic economic crises and pandemics. In this aspect, we believe that the reason for the insignificance of the other explanatory variables is a result of the fact that the internal capacity of a country does not single handedly depend on the human and physical infrastructure. Instead, it is dependent on the efficient coordination and synchronization between every constituent in the implementation of the activities that are aimed at reducing the impact of the COVID-19 pandemic.

This time, during the COVID-19 pandemic, the vaccine rollout is a game changer as it reduces the health risks and directly impacts the speed and extent of economic recovery. Obviously, all countries around the world entered in a strong competition for vaccine receipt and implementation of the vaccination process in the initial period. However, countries are subjected to various political and socio-economic circumstances. Therefore, the extent to which a country was able to conduct efficient coordination and synchronization varied from one country to another. Unfortunately, this indicates that in the absence of a stabilizing force whose aim is to secure fair distribution of the vaccines in the countries around the world, a great discrepancy will arise between the countries in both the access to vaccines and the rate at which they are distributed. This, in turn, may lead to dire economic consequences.

To deal with this issue, the COVAX global response system was invented. Nonetheless, the COVAX started to deliver vaccine almost at the end of the observed period. The first vaccines through this system of the global response were delivered in Ghana on February 24, 2021. In this aspect, the results of this paper are a stark reminder for the need for transparent and fair global response regarding fair and equitable availability of vaccines to every country.

Appendix

See Tables 4, 5.

Table 4 List of countries that started vaccination by 31st March 2021

Country	Country	Country	Country	Country
Afghanistan	Cote d'Ivoire	Indonesia	Morocco	Serbia
Albania	Croatia	Iran	Mozambique	Singapore
Algeria	Cyprus	Iraq	Myanmar	Slovakia
Angola	Czechia	Ireland	Namibia	Slovenia
Argentina	Denmark	Israel	Nepal	South Africa
Australia	Dominican Republic	Italy	Netherlands	South Korea
Austria	Ecuador	Jamaica	New Zealand	Spain
Azerbaijan	Egypt	Japan	Nicaragua	Sri Lanka
Bahrain	El Salvador	Jordan	Niger	Sudan
Bangladesh	Estonia	Kazakhstan	Nigeria	Sweden
Belarus	Finland	Kenya	Norway	Switzerland
Belgium	France	Kuwait	Oman	Thailand
Bolivia	Gabon	Laos	Pakistan	Tunisia
Bosnia and Herzegovina	Georgia	Latvia	Panama	Turkey
Botswana	Germany	Lebanon	Papua New Guinea	Uganda
Brazil	Ghana	Lithuania	Paraguay	Ukraine
Bulgaria	Greece	Luxembourg	Peru	United Arab Emirates
Cambodia	Guatemala	Malaysia	Philippines	United Kingdom
Canada	Guinea	Mali	Poland	United States
Chile	Honduras	Mauritius	Portugal	Uruguay
China	Hungary	Mexico	Qatar	Uzbekistan
Colombia	Iceland	Moldova	Russia	Venezuela
Costa Rica	India	Mongolia	Saudi Arabia	Vietnam
			Senegal	Zimbabwe

Table 5 Data sources and description of variables

Variable	Code	Definition	Data Source	Note
COVID-19 cases p.m.p	Cases	Confirmed COVID-19 cases per million population	Our world in data, Coronavirus	Measured in logs
Started vaccination	/	Indication whether the country has started with the vaccination procedure	Our world in data, Coronavirus	Binary
Vacc. over 20% of pop	/	Indication whether the country has vaccinated over 20% of its population	Our world in data, Coronavirus	Binary
Vaccinations p.h.p	/	COVID-19 vaccination does administered per hundred people	Our world in data, Coronavirus	Measured in logs
Government response	Gov_response	Oxford's daily government response index measures the variation in daily government responses to COVID-19	Oxford COVID-19 government response tracker, blavatnik school of government	Measured in logs
Days	Days	Number of days between the first vaccine and last available data for vaccinations p.h.p	Our world in data, Coronavirus	
GDP	Gdp	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products	WDI, World Bank	Measured in logs
GDP per capita, PPP	Gdp_pc_ppp	This indicator provides per capita values for gross domestic product (GDP) expressed in current international dollars converted by purchasing power parity (PPP) conversion factor	WDI, World Bank	Measured in logs
Exports per capita	Exports_pc	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world	WDI, World Bank	Measured in logs
Health expenditures per capita	Health_exp_pc	Level of current per capita health expenditure	WDI, World Bank	Measured in logs
Military expenditures per capita	Military_exp_pc	Military expenditures data from SIPRI are derived from the NATO definition, which includes all current and capital expenditures on the armed forces	WDI, World Bank	Measured in logs

Table 5 (continued)

Variable	Code	Definition	Data Source	Note
Government effectiveness	Gov_eff	Captures perceptions of the quality of public services, civil service and the degree of its independence from political pressures, quality of policy formulation and implementation, and credibility of the government	WGI, World Bank	
Population (65 +, % of total)	Pop_65	Population ages 65 and above as a percentage of the total population	WDI, World Bank	Measured in logs
Soft presence	Soft_presence	Soft presence is measured through migration, tourism, sports performance in international competitions, international patents, articles published in scientific journals, or official development assistance, among other indicators	Elcano royal institute	Measured in logs

See Fig. 3.

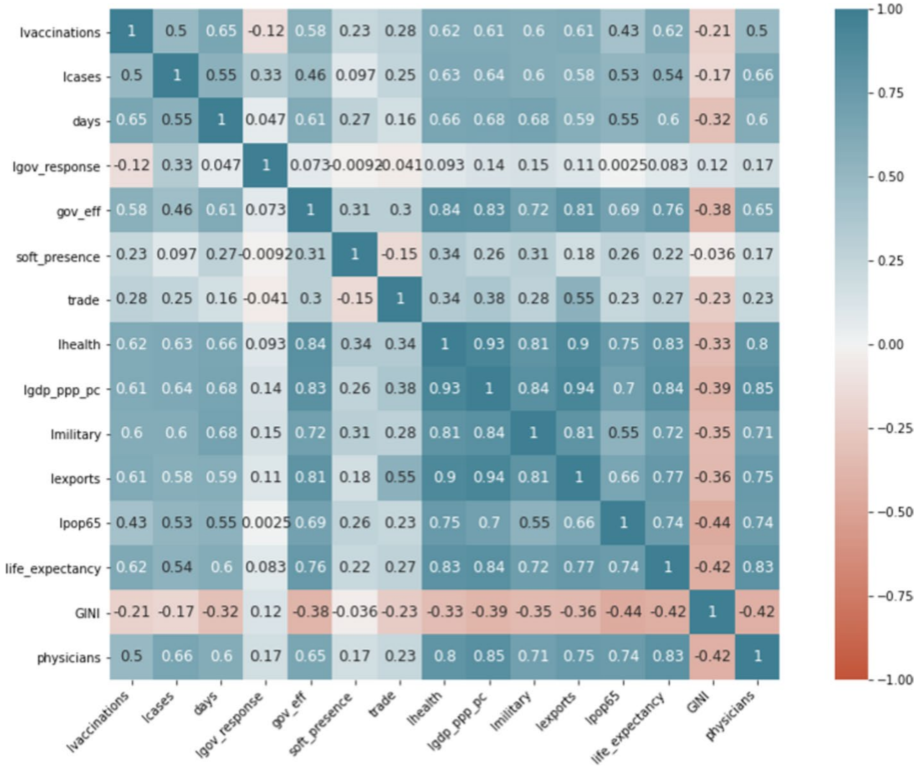

Fig. 3 Correlation matrix between the studied variables

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Declarations

Conflict of interest The authors declare no conflict of interest and no competing interest.

Data availability All data is available at https://github.com/pero-jolak/covid-vaccinations-paper

Code availability All code is available at https://github.com/pero-jolak/covid-vaccinations-paper

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