Economic and social factors affecting the speed of Covid-19 vaccination around the world

Ricardo Tovar-Silos
Lamar University

ABSTRACT

The following article explores preliminary results on the Covid-19 vaccination efforts of different countries to identify what economic and social factors affect the efficacy of these campaigns. Using different data analysis techniques such as correlation and regression analysis, we present some important results. Five potential predictors of the vaccination rates are analyzed. The impact of the population size and the density of population was studied. Also, different indicators of the wealth of a country (GDP per capita and the Index of Human Development (HDI)) and an indicator of political regime were identified as potential predictors of vaccination rates. It was found that the density of the population has been the most important predictor of vaccination success. GDP per capita and the HDI, although statistically significant, have shown a rather limited predictive power over vaccination rates.

Keywords: Covid-19 Vaccine, economic factors, social factors, population density, GDP per capita, political regime, Human Development Index.

INTRODUCTION

The main goal of this paper is to explore the observed variations in the vaccination efforts against Covid-19 of different countries around the world. It is hypothesized that there are important economic and social factors, intrinsic to each country, that have significantly influenced the success of these vaccination campaigns. Several academic articles have documented the impact of social and economic factors on the Covid-19 mortality rate with mixed results. In this study, it is argued that some of these factors may also affect the speed of vaccination campaigns. The findings of this paper may be of critical use for policymakers, especially for the World Health Organization (WHO), which must issue recommendations and make efforts to guarantee that all countries gain equitable access to a proper number of inoculations against Covid-19. Given the interrelated nature of trade and tourism around the world, it would be a fallacy to think that individual country efforts will be enough to end with this pandemic and strong coordination is necessary to achieve this goal.

Shahbazi (2020) showed that a positive relation exists between Covid-19 incidence and mortality rate and the Human Development Index (HDI). This result may sound counterintuitive at first, but it is explained by the characteristics that more affluent nations share. First, the mechanism to accurately track the number of cases is more effective in developed nations. Second, rich nations have a greater percentage of elderly population which translates into a greater number of cases and deaths as opposed to what apparently occurs in less developed countries. In another paper, Fountulakis et al (2020), show that in a sample of forty European countries only the “days since first national death for the implementation of ban of all public events” was significant in explaining the differences among mortality rates. Other variables that they studied are demographics, vulnerability factors and characteristics of the national response. But not only health factors and demographics have been studied. Political factors have also been aimed as possible triggers of mortality rates. Sorci et al (2020), analyzed the Case Fatality Rate (CFR) and found that it was strongly associated with the share of the population over 70, GDP per capita and, interestingly, the level of the democracy. They also found that CFR was negatively associated with the number of hospital beds.

The preceding literature review shows that there is a wide array of factors affecting the Covid-19 mortality rate. In this paper, it is claimed that these same factors may also determine the success of vaccination campaigns. The main contribution of this study is to explore preliminary data on vaccination against Covid-19 (data reported on February 28th, 2021) to assess the importance of these factors in explaining the between-countries variability. One of the analyzed aspects is whether economic factors such as GDP per capita or the HDI affect the speed by which vaccinations are applied. In the same line, it is questioned whether population and population density affect vaccination efforts. The logic behind this idea is that territory extension and the presence of large metropolitan areas may affect the logistics of vaccine distribution. Finally, the political regime, which is correlated to the degree of economic freedom, is another potential candidate for predicting vaccination rates along with whether the country is a producer of the vaccine or not.

DATA ANALYSIS

In this section, current vaccination rates around the globe are studied. This data along with the information about the independent variables was obtained from "Our World in Data" (www.ourworldindata.org), which is gathered by researchers at the University of Oxford. The data set is cross-sectional and was taken on February 28th, 2021. Obviously, it is expected vaccination rates to increase every day, but the importance of understanding what factors can serve as predictors of vaccination success remains as every day that passes in a country without sufficient doses, inevitably translates into more deaths and slower economic growth. The selected variable of interest for this study was "the number of vaccinations per 100 inhabitants". This indicator does not represent the number of people that has been fully inoculated, which for most of the currently being used vaccines implies applying two shots. This explains why, for some countries, the vaccination rate may be greater than 100. It is claimed in this paper that countries with higher vaccination rates will be in a better position to return to "normality" and to begin a long-desired economic recovery. As explained before, the main objective of this paper is to identify economic and social variables that may serve as predictors of the differences that exist between vaccination rates among countries. Table 1 presents the list of countries included in our analysis. Only those countries that have already started vaccine distribution and for which data has been gathered by "Our World in Data" are included. The final data set includes 62 countries. The data has been arranged from largest to smallest vaccination rate.

Graph 1 presents the distribution of vaccination rates among countries. As it is clear from the histogram and the accompanying frequency table, the distribution is highly skewed to the right: most countries that have started vaccination campaigns have still very low vaccination rates (less than 10 vaccines per 100 inhabitants).

Table 2 presents summary statistics for the vaccination rate. Given the high degree of skewness in the distribution, the median is a better measure of central location than the mean. The median rate of vaccinations per 100 inhabitants is 7.01, which is typical of most European nations and lags the vaccination rates of leading nations such as Israel, the UK, and the United States. The standard deviation of 14.02 clearly shows that there is a wide dispersion of this variable among countries. In the following sections, different economic and social factors that may explain the wide differences among national vaccination rates are analyzed in detail.

POPULATION DENSITY

The question: what causes this high variability in vaccination rates?, is now explored. The first studied variable is the size of the population. There are reasons to believe that larger countries in terms of population would require more time for their full population to get vaccinated. For example, it may be more complicated to distribute vaccines in large countries with several metropolitan areas and multiple rural areas. Also, it has been harder for big less developed countries to secure enough vaccinations for their massive populations. The correlation between the vaccination rate and the size of the population was negative and low (-.14) suggesting that the larger the population size the lower the rate of vaccination, a result that is in line with the expected relationship.

However, we need to be cautious with this coefficient since it was not statistically significant at the 5% level.

It is hypothesized that the explanation for the population size not been significatly correlated with the vaccination rate is that is not just the number of inhabitants but the extension of the country which may affect vaccination rates. The population density, which is the number of inhabitants per square kilometer, was then selected as a more appropriate candidate for an explanatory variable. The correlation between the vaccination rate and the population density was 0.57 which suggests that countries with higher population densities are doing a better job in innoculating their inhabitants than countries where the population is spread along larger territories. It is claimed that a high population density facilitates the logistics of the distribution of vaccines. Table 3 shows the relationship between the density of population and the rate of vaccination.

As it can be seen from Table 3, only in the category of ultrapopulated countries (those with more than 3,450 inabitants per square kilometer), there was a nation (Gibraltar) that has been able to provide more than 100 vaccination shots per 100 inhabitants (this is because some residents have already received their second shots). Another country which has been recognized around the globe as an example of efficient vaccine distribution is Israel which has provided 93.87 vaccines per 100 people (as for February 28th) and has a high population density of over 400 inhabitants. Of the group of seven most industrialized nations, only the UK and the United States appear in the top ten of vaccinated countries which suggest that it is not income or economic development the main factor behind vaccine distribution. The fact that the UK has a moderate high population density (272 inhabitants) suggests that the density of population is a more powerful predictor of vaccination rates than income or wealth. Given the promisory performance of population density as a predictor of the vacination rate, a simple linear regression was estimated and the results are shown in Table 4.

As we can see, about 32% of the variability of the vaccination rates is explained by its relationship with the population density and this predictor is statistically significant at the 1% level.

GDP PER CAPITA

The attention is now turned to GDP per capita because it is known that industrialized nations financed pharmaceutical firms and signed deals to secure enough vaccinations for their inhabitants. The obtained results in relation to GDP per capita are mixed and not as conclusive as the results for population density. The Pearson correlation coefficient between per capita GDP and the vaccination rate was 0.28 which was statistically significant at the 5% level. The relationship is weak though, which suggests that it is not clear whether income is an actual determinant of the success of countries in their vaccination efforts. For example, from the Group of Seven (G7), only the United Kingdom and the United States are in the top ten of the list of countries with the highest vaccination rates. It is interesting to see that the countries of the European Union, including Germany and France, have not made significant progress in their vaccination efforts and their rates are pretty homogeneous and relatively low in comparison with the countries in the top ten, even though their incomes are relatively high compared with countries in other continents. Low income countries such as Serbia and Chile have made substantially more progress than most European economies in their vacccination rates.

An alternative appoach to the analysis of income was to determine whether grouping the countries in income brackets, instead of looking at them individually, would have a higher predicting power. Countries were divided in three groups based on their per capita GDP's: "Less than $15K", "Between $15K and $30K" and "More than $30K". Different income levels were tried but the aforementioned brackets provided the highest correlation between vaccination rates and GDP per capita. According to this classification, poor countries are those with GDP per capita less than $15,000 whereas middle-class countries would be those with incomes between $15,000 and $30,000 and rich nations are those with incomes greater than $30,000. Table 5 shows some interesting results.

Note that the only two countries with more than 90 vaccines per 100 inhabitantes which are Gibraltar and Israel have incomes that are greater than $30,000. In the same manner, in the range of vaccines from 60 to 70 there is only one country, the United Arab Emirates, which is also classified as a rich nation. Also, in the following vaccination category which is 30-40, there is only one nation which is the United Kingdom which also has a salary greater than 30,000. For categories with fewer vaccines, it is not clear whether income is an important factor. For example, in the lower part of the spectrum which is the 0 to 10 vaccines interval, we can see that almost half of the countries (48%) are in the "rich" category. A deeper analysis of these countries shows that the majority are wealthy European nations including Germany, France and Italy and affluent countries from other continents such as Canada and Australia. For these last two, it may be understandable that the low level of vacunation may be explained by the low density of their populations which as seen in the previous section is an important predictor of vaccination rates. It is puzzling that Hong Kong and South Korea appear in this same group of rich countries with low rates of vaccination. They have rates of 0.27 and 0.04 respectively which are similar to the rates of less developed countries. Even though we expect these countries to catch-up soon, it is worth noting the slow start they have had in their vaccination efforts. Table 6 shows the results of the regression with the vaccination rate as the independent variable and dummy variables for the level of GDP per capita based on the previously defined brackets: "Less than $15,000", "Between $15,000 and $30,000", and "More than $30,000". The F-test shows that this regression is statistically significant at the 10% level. However, only 9% of the variation in the vaccination rates among countries is explained by GDP per capita. The coefficients of the dummy variables show that as income increases, the vaccination rate also increases. For example, when income increases to more than $15,000, the vaccination rate increases by 5.10 vaccines on average. When a country has an income above the $30,000 level, the number of vaccines increases by 13.70 vaccines with respect to the benchmark which is an income of less than $15,000. The average for those countries with less than 15,000 is 2.32 vaccines.

HUMAN DEVELOPMENT INDEX

The third variable used in this study to explain the vaccination rates in countries around the world was the Human Development Index (HDI). The United Nations define

HDI as "a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living". This index may or may not be correlated with GDP per capita which was the selected measure of the wealth of a country. It was found that the correlation between HDI and the vaccination rate was 0.29, which is moderately higher than the correlation with GDP per capita. This correlation coefficient was found to be statistically significant at the 5% level of significance. Also, when a regression was estimated, it was found that the HDI was statistically significant at the 5% level. Table 7 shows the results of this regression.

In short, countries with higher HDI's have been more succesful in distributing the Covid-19 vaccine than those with lower HDI's. Table 8 illustrates the relationship between the two variables in more detail.

Note that, in the categories of countries with a low HDI (less than 0.7), none of them has administered more than 10 vaccines per 100 inhabitants. However, the results are not conclusive as to say that the HDI is strongly correlated with vaccination rates. In the case of the highly developed countries (those with an HDI between 0.9 and 1, which include Norway, Switzerland, Hong Kong among others), it was found that the vast majority (80.77%) have administered less than 10 vaccines. Only in the countries with intermediate degree of development (0.7 to 0.9), vaccination rates that are greater than 10 are observed with more frequency.

POLITICAL REGIME

In this section the political regime of a country is studied to determine if there is any relationship between this variable and the vaccination rate. The political regime indicator from "Our World in Data" based on Polity IV and Wimmer and Min was used. This scale goes from "-10 (full autocracy) to 10 (full democracy)". It is hard to get conclusions from the data since the number of observations is limited. There are only two countries in the sample that are classified as autocracies: China and Saudi Arabia. These countries have low vaccination rates of 3.65 and 2.24 respectively. There are also only three anocracies in the sample (an anocracy is a form of government that is loosely defined as part democracy and part dictatorship) which are Bangladesh, Russia and Turkey. The former has a very low vaccination rate of 1.89 and Turkey has a better rate of 10.14. Russia has a vaccination rate of only 3.6 even though it developed the first vaccine in the world. The majority of the countries with vaccination rates that are greater than 10 occur in full democracies such as the United States and the United Kingdom. The country of the world with the highest vaccination rate, Israel, has a political regime index of only 6.

VACCINE PRODUCER

The last variable studied in this article is the effect of being a vaccine producer on the vaccination rate. Pharmaceutical companies headquarted in the following countries have developed an approved vaccine against Covid-19: United States, United Kingdom, Sweden, Germany, China, Russia and India. As seen in Table 9, only the United States and the United Kingdom have reached a substantial success in their vaccination campaings. The rest of the countries in this group, which is a mix of democracies, anocracies and autocracies is far behind these two nations.

CONCLUSION

Countries around the world are trying to secure enough vaccine doses against Covid-19. They are doing so not by coordinating efforts to secure sufficient doses and equitable access for all the nations in the world, but by individual deals with the pharmaceutical companies. The observed success of these efforts is not just determined by the realtive wealth of the country, but it seems to be multifactorial. It is surprising that the European Union and in particular Germany, France and Italy are far behind other industrialized nations in their vaccination efforts. This is highly relevant because the risk of new infection waves will always be present unless enough inhabitants are inoculated in the shortest period of time. In this article, it was found significant evidence that the population density is a factor that greatly influences the number of administered doses but there is no single factor that solely determines success. Other factors such as GDP per capita, human development and political regime also play a role but to a lesser degree. Even the fact that a country produces its own vaccine is not a guarantor of success.

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APPENDIX

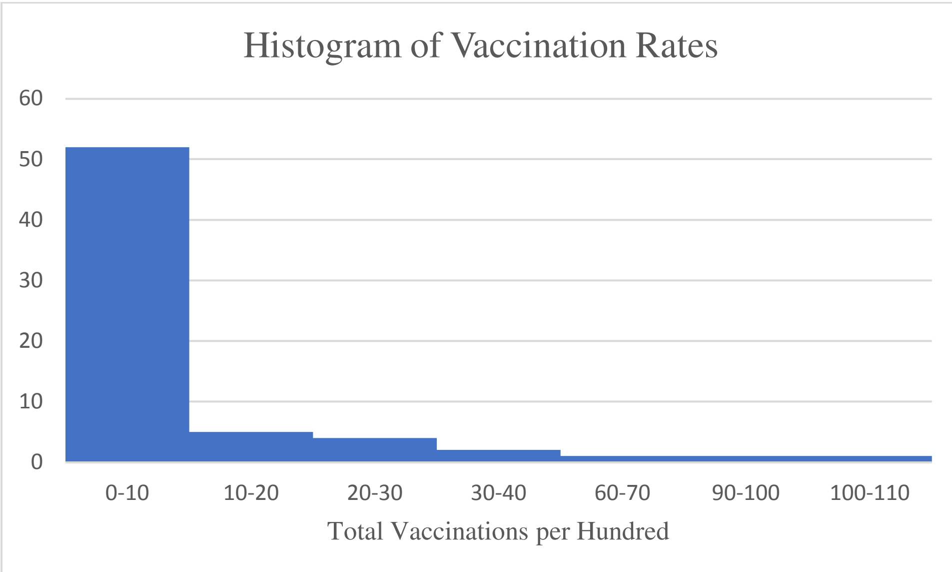
Table 1

Country	Vaccinations per Hundred
Gibraltar	109.25
Israel	93.89
United Arab Emirates	60.87
Jersey	33.16
United Kingdom	31.07
Isle of Man	25.23
United States	22.5
Serbia	21.11
Maldives	20.61
Malta	18.03
Chile	17.62
Barbados	13.44
Denmark	10.61
Turkey	10.14
Hungary	9.7
Switzerland	9.31
Norway	9.18
Ireland	8.91
Poland	8.82
Lithuania	8.77
Portugal	8.45
Slovenia	8.42
Slovakia	8.23
Spain	8.19
Sweden	8.19
Finland	8.16
Romania	7.97
Netherlands	7.8
Austria	7.47
Germany	7.32
Belgium	7.25
Italy	7.2
Liechtenstein	6.81
France	6.72
Czechia	6.17
Luxembourg	6.04
Canada	5
Brazil	3.97
China	3.65

Russia	3.6
Latvia	3.33
Bulgaria	3.06
Panama	2.73
Argentina	2.27
Saudi Arabia	2.24
Macao	2.22
Sri Lanka	2.18
Mexico	1.9
Bangladesh	1.89
India	1.04
Indonesia	0.98
Lebanon	0.59
Hong Kong	0.27
Colombia	0.26
Senegal	0.16
Australia	0.13
Zimbabwe	0.13
South Africa	0.12
South Korea	0.04
Honduras	0.03
New Zealand	0.03
Uruguay	0.01

Data taken from "Our World in Data". Data corresponding to February 28th, 2021.

Graph 1



Vaccination Rate	**Frequency**
0-10	52
10-20	5
20-30	4
30-40	2
60-70	1
90-100	1
100-110	1

Data taken from "Our World in Data". Data corresponding to February 28th, 2021.

Table 2

Vaccinations per Hundred	
Mean	10.84
Median	7.01
Mode	8.19
Standard Deviation	18.98
Sample Variance	360.30
Kurtosis	16.14
Skewness	3.83
Range	109.25
Minimum	0.00
Maximum	109.25
Count	62.00

Data taken from "Our World in Data". Data corresponding to February 28th, 2021.

Table 3

Vaccination	Population Density										
Rate	0-150	150-300	300-450	450-600	600-750	1200-1350	1350-1500	3450-3600	6900-7050	20400-20550	Total
0-10	35	5	3	4	0	1	0	0	1	1	50
10-20	3	0	0	0	1	0	1	0	0	0	5
20-30	3	0	0	0	0	0	1	0	0	0	4
30-40	0	1	0	0	0	0	0	0	0	0	1
60-70	1	0	0	0	0	0	0	0	0	0	1
90-100	0	0	1	0	0	0	0	0	0	0	1
100-110	0	0	0	0	0	0	0	1	0	0	1
Total	42	6	4	4	1	1	2	1	1	1	63

Data taken from "Our World in Data". Data corresponding to February 28th, 2021.

Table 4

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.57					
R Square	0.32					
Adjusted R Square	0.31					
Standard Error	12.11					
Observations	62.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1.00	4203.39	4203.39	28.68	0.00	
Residual	60.00	8792.19	146.54			
Total	61.00	12995.58				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.34	1.74	1.92	0.06	-0.15	6.82
Population Density	0.01	0.00	5.36	0.00	0.01	0.02

Table 5

	Vaccination Rate						
GDP Per Capita	0-10	10-20	20-30	30-40	60-70	90-100	100-110
0-$15,000	26.00%	0.00%	25.00%	0.00%	0.00%	0.00%	0.00%
$15,000-$30,000	26.00%	60.00%	25.00%	0.00%	0.00%	0.00%	0.00%
More than $30,000	48.00%	40.00%	50.00%	100.00%	100.00%	100.00%	100.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Data taken from "Our World in Data". Data corresponding to February 28th, 2021.

Table 6

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.30					
R Square	0.09					
Adjusted R Square	0.06					
Standard Error	18.61					
Observations	63.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2.00	2073.55	1036.78	2.99	0.06	
Residual	60.00	20778.70	346.31			
Total	62.00	22852.25				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.32	4.97	0.47	0.64	-7.63	12.27
Between $10K and $30K	5.10	6.72	0.76	0.45	-8.34	18.53
More than $30K	13.70	5.96	2.30	0.03	1.78	25.63

Table 7

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.29					
R Square	0.08					
Adjusted R Square	0.07					
Standard Error	18.52					
Observations	63.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1.00	1921.28	1921.28	5.60	0.02	
Residual	61.00	20930.97	343.13			
Total	62.00	22852.25				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-35.26	19.54	-1.80	0.08	-74.34	3.82
HDI	54.35	22.97	2.37	0.02	8.42	100.27

Table 8

	Human Development Index (HDI)				
Vaccination Rate	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1
0-10	100.00%	100.00%	90.91%	66.67%	80.77%
10-20	0.00%	0.00%	0.00%	19.05%	3.85%
20-30	0.00%	0.00%	9.09%	9.52%	3.85%
30-40	0.00%	0.00%	0.00%	0.00%	3.85%
60-70	0.00%	0.00%	0.00%	4.76%	0.00%
90-100	0.00%	0.00%	0.00%	0.00%	3.85%
100-110	0.00%	0.00%	0.00%	0.00%	3.85%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

Data taken from “Our World in Data”. Data corresponding to February 28th, 2021.

Table 9

Country	Vaccination Rate	Regime	Classification
United Kingdom	31.07	10	Democracy
United States	22.5	10	Democracy
Sweden	8.19	10	Democracy
Germany	7.32	10	Democracy
China	3.65	-7	Autocracy
Russia	3.6	4	Anocracy
India	1.04	9	Democracy

Data taken from "Our World in Data". Data corresponding to February 28th, 2021.