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COVID-19 vaccines and global stock markets

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COVID-19
~~Pandemics~~
Stock markets
Vaccines

A B S T [redacted]

Global stock markets react positively when different phases of human clinical trials on COVID-19 vaccines begin. The average abnormal stock return on the first day of the trials is both statistically and economically significant at 8.08 basis points. The increase in the average abnormal stock return is threefold higher for leading vaccine candidates. The positive reaction is more pronounced upon the start of phase III trials, and it is also stronger for vaccine candidates developed by the U.S. and China.

1. Introduction

rior studies show that COVID-19 negatively affects liquidity (O'Hara and Zhou, 2021), aggregate equity markets (Gormsen and Koijen, 2020; Smales, 2021; Yarovaya et al., 2021), cross-sectional stock returns ([redacted]ing et al., 2021), cryptocurrency markets (Caferra and Vidal-Tomás, 2021; Corbet et al., 2022), real estate markets (Chong and hillips, 2022; Qian et al., 2021), sovereign credit risk (Augustin et al., 2022), trade credit (Luo, 2021) and firm performance (Haque et al., 2021).[1] Bao et al. (2021), Demir et al. (2021), Khalfaoui et al. (2021) and [redacted] find vaccine inoculation positively affect the stock market, while Acharya et al. (2021) show that the value of the vaccine is worth 5-15% of capital stocks. Hong et al. (2021) develop a model that suggests an earnings crash and lower earnings growth until vaccine arrives in late 2020. This study contributes to the literature by examining the development progress of COVID-19 vaccines, and its impact on global stock markets.

Using a dataset collected by the World Health Organization (WHO), we identify the start dates of three key human clinical trial phases conducted for 83 COVID-19 vaccine candidates developed worldwide from January 2020 to April 2021.[2] The start of each phase marks a milestone in vaccine development and indicates the successful completion of the previous phase, which is one step closer to obtain approval for large-scale inoculation. We contend that prior to public inoculation, the development of COVID-19 vaccines has a positive impact on stock markets around the globe. In other words, any potential breakthrough documented during the development of a vaccine reflects the potential economic and social benefits (e.g., minimal cross-border closure) of the vaccine, especially at times

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[1] Further, Acharya and Steffen (2020), Fahlenbrach et al., 2021, and Halling et al. (2020) provide evidence that COVID-19 influences firm policies, investment, and financing decisions.

[2] Human clinical trials in a vaccine development have three important phases. In ~~Phase I, the objective is to ascertain~~ the minimum dose required to create an optimal immune response in the test subjects. ~~Phase II involves more volunteers~~ with different demographics to evaluate the safety and efficacy of the vaccine. In phase III, a clinical trial on a larger scale ensues. This phase has the longest duration because it occurs in "natural disease conditions"; that is, the vaccine is administered to test subjects who are exposed to natural conditions of the disease.

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when pandemics such as COVID-19 occur, leading to a positive impact on the global stock markets.[3]

We provide empirical support to the above proposition. Upon the start of the clinical trials, global stock markets react positively with an average abnormal return of 8.08 basis points (bps). This result is economically meaningful: the 8.08 bps average abnormal return translates to an increase of USD46.4 billion in total market capitalization. To underscore our finding, Fig. 1 shows the average cumulative returns on all stock markets in a [-5, 5]-trading-day event window surrounding the start of clinical trial phases. As the figure shows, average stock market return increases significantly after the first day of each clinical trial phase. While there is no discernible pattern in the cumulative stock returns in days leading to “day + 1,” the average increase in returns persists for several days after “day + 1.” In short, Fig. 1 shows that global stock markets view clinical trials positively in terms of their impacts on the global economy.

Further analysis shows that the stock market reaction is stronger when clinical trials progress to the final phase III, with an average day-one abnormal return of 16.55 bps. We also analyze a group of leading vaccine candidates of which trials began early in the pandemic and have been subsequently approved for mass inoculation by the end of the sample period. These unique candidates, labelled as “first movers,” include the usual suspects such as fizer, Moderna, and AstraZeneca. Since first movers are at the forefront in the race to develop an effective vaccine, we expect a stronger stock market reaction on the first day of the trials for these leading candidates. The empirical finding supports our conjecture: the average day-one abnormal stock market return in response to the first movers is substantially higher at 40.33 bps for phase III.

We further show that the day-one impact of clinical trials in phases II and III is stronger for developed economies relative to emerging economies. Additionally, we find that the stock market reaction is conditional on the vaccine origins: the average day-one abnormal return in all phases is the highest for vaccines developed in China (and in the U.S. if we focus only on phase III). In contrast, the stock market reactions are relatively modest for vaccines produced by developers based in other countries.[4]

2. Data

We retrieve information (including the start dates of clinical trial phases) about the vaccine candidates from an official document issued by the WHO: “COVID-19 Vaccine Tracker and Landscape.”[5] We pinpoint 83 vaccine candidates that have had human clinical trials from January 2, 2020, to April 30, 2021, with the earliest trial beginning in mid-March 2020. Table 1 describes all 83 vaccine candidates. These vaccine candidates were developed in 24 countries, and we label them as “vac-countries.” Most of the vaccines developed in vac-countries are from the U.S. (26), followed by China (17). We also identify 30 “non-vac-countries” that did not have any vaccine undergoing human clinical trials during the sample period.

From the Morgan Stanley Capital International (MSCI) database, we use the MSCI All Country World Index (ACWI) to proxy for the aggregate global equity market. The ACWI consists of 23 developed economies and 27 emerging economies as of April 2021; together, these markets make up about 90% of the world’s gross domestic product.[6] We use the MSCI Investible Market Index (IMI) to measure the stock market return on individual country .

3. Empirical findings

We begin by estimating the following panel regression:

$$AR_{i,t} = \phi D_t + \gamma^T \boldsymbol{X} + \eta_i + \varepsilon_{i,t}, \tag{1}$$

where the daily abnormal return (   ) of country on day is calculated as:

$$AR_{i,t} = R_{i,t} - \left(\hat{\alpha}_i + \hat{\beta}_i \times R_{m,t} \right)$$

Both α and β are estimated from a market model over the daily estimation window from January to December 2019, and is the daily return on ACWI.

the market cap on the first day of the clinical trials.

We now test the stock market reactions to different phases. To this end, we separate the dichotomous variable in (1) into (a 0/1 dummy variable on the first day of phase II) and (a 0/1 dummy variable on the first day of phase III) for the following reasons. First, untabulated analysis shows that 39 vaccines (out of 83 candidates) have concurrent phases I and II and thus, by omitting the dummy variable corresponding to phase I, we can focus on the differential impact between phases II and III. Second, unreported experiment shows that the addition of the 0/1 dummy variable on the first day of phase I carries little explanatory power and its loading is statistically insignificant. Third, phase II is arguably more challenging than phase I and likewise, the beginning of phase III marks an even more significant milestone than that of hase II. Thus, we predict that the stock markets react more strongly to the beginning of phase III than to the start of phase II. These arguments lead us to conduct the following panel regression:

$$AR_{i,t} = \phi_{II} D_{II,t} + \phi_{III} D_{III,t} + \gamma^T \boldsymbol{X} + \eta_i + \varepsilon_{i,t}. \tag{2}$$

Column (2) of Table 2 reports results. Consistent with our prediction, the market reaction is 8.03 bps upon the start of phase II, and this estimate doubles to 16.55 bps for phase III.

Of all 83 vaccine candidates, 13 were approved by the WHO and/or the regulators of the respective countries by the end of the sample period. These unique candidates, which we label as “first movers”, include fizer, Moderna, and AstraZeneca, and their corresponding clinical trials were initiated early in the pandemic (see Table 1). As such, first movers are at the forefront in the race to develop an effective vaccine, and we posit a stronger stock market reaction on day one of the trials for the first movers relative to other vaccine candidates.

The results reported in Columns (3) and (4) of Table 2 are consistent with our prediction for the first movers. Column (3) shows that the day-one clinical trial effect of the first movers is more than threefold stronger than the case we include all vaccines in Column (1). When we use Eq. (2) and analyze the effect of each specific phase, the impact of first-movers is almost 16 bps (-statistic = 3.41) in phase II and 40.33 bps (-statistic = 6.43) in phase III, and both numbers are much larger than those from all vaccine candidates. Taken together, our findings show that the day-one

Table 1
Information on Vaccine Candidates, This table lists all 83 COVID-19 vaccine candidates that had started human clinical trials as of April 30, 2021. The table includes information on vaccine developers and the country where the vaccine developer is domiciled (referred to as "vac-country"). The last three columns report the earliest start dates of the clinical trial phases I, II, and III, respectively. Blank cells indicate that the clinical trials of a certain phase either do not exist or had not begun as of April 30, 2021. [redacted]*) in the first column are first movers.

No.	Vaccine developer/manufacturer	Vac-country	~~Phase I~~	~~Phase II~~	~~Phase III~~
1*	~~Pfizer/ BioNTech/ Fosun Pharma#~~	Germany/ US/ Mainland China		2020-04-23	2020-04-29
2*	AstraZeneca/ University of Oxford	UK		2020-04-23	2020-05-28
3*	Sinopharm/ China National Biotec Group Co/ Wuhan Institute of Biological ~~Products~~	Mainland China		2020-04-11	2020-07-16
4*	Sinopharm/ China National Biotec Group Co/ Beijing Institute of Biological ~~Products~~	Mainland China		2020-04-28	2020-07-16
5*	Sinovac [redacted]., Ltd	Mainland China		2020-04-16	2020-07-21
6*	Moderna/ National Institute of Allergy and Infectious Diseases (NIAID)	US	2020-03-16	2020-05-29	2020-07-27
7*	Gamaleya [redacted]istry of the [redacted]	[redacted]		2020-06-17	2020-09-07
8*	Janssen ~~Pharmaceutical~~	US		2020-07-15	2020-09-07
9*	CanSino Biological Inc./ Beijing Institute of Biotechnology	Mainland China	2020-03-16	2020-04-12	2020-09-11
10	Novavax	US		2020-05-25	2020-09-28
11*	Bharat Biotech International Limited	India		2020-07-15	2020-11-16
12*	Federal Budgetary [redacted]nd Biotechnology "Vector"	[redacted]		2020-07-27	2020-11-18
13	Medicago Inc.				

Table 1 (   )

No.	Vaccine developer/manufacturer	Vac-country	~~Phase I~~	~~Phase II~~	~~Phase III~~
		Hong Kong SAR[redacted] Mainland China	[redacted] 01	[redacted]020-11-17	
34	Nanogen ~~Pharmaceutical Biotechnology~~	Vietnam		2020-12-10	
35	Shionogi	Japan		2020-12-16	
36	GeneOne Life Science, Inc.	Korea		2020-12-23	
37	Cellid Co., Ltd.	Korea		2020-12-29	
38	Medigen Vaccine Biologics/ Dynavax/ National Institute of Allergy and Infectious Diseases (NIAID)	Taiwan [redacted]	[redacted] 07	2020-12-30	
39	Kentucky Bioprocessing Inc.	US		2020-12-30	
40	SK Bioscience Co., Ltd./ ~~CEPI~~	Korea		2021-01-20	
41	Vaxxinity	US	2020-09-25	2021-01-30	
42	Takis/ [redacted]	Italy/ US		2021-02-03	
43	Erciyes University	Turkey	2020-11-05	2021-02-10	
44	~~POP Biotechnologies/ EuBiologics Co.~~,Ltd	US/ Korea		2021-02-23	
45	KM Biologics Co., Ltd.	Japan		2021-03-02	
46	Institute of Vaccines and Medical Biologicals, Vietnam	Vietnam		2021-03-10	
47	Sanofi ~~Pasteur/ Translate Bio~~	France/ US		2021-03-12	
48	Daiichi Sankyo Co., Ltd.	Japan		2021-03-15	
49	VBI Vaccines Inc.	US		2021-03-15	
50	The Government ~~Pharmaceutical Organization (GPO)/ PATH/ Dynavax~~	Thailand/ US		2021-03-20	
51	Entos ~~Pharmaceuticals Inc.~~	Canada		2021-04-07	
52	[redacted]	Iran	2021-01-29	2021-04-21	
53	National Vaccine and Serum Institute, China	Mainland China		2021-04-25	
54	Elixirgen Therapeutics, Inc	US		2021-04-28	
55	Imperial College London	UK	2020-06-16		
56	Clover Biopharmaceuticals Inc./ GSK/ Dynavax	Mainland China/ UK/ US	2020-06-19		
57	Vaxine ~~Pty Ltd.~~	Australia	2020-06-30		
58	The University of Queensland	Australia	2020-07-13		
59	Adimmune Corporation	Taiwan [redacted]	[redacted] 24		
60	Vaxart	US	2020-09-21		
61	University of Munich (Ludwig-Maximilians)	Germany	2020-10-05		
62	ImmunityBio, Inc	US	2020-10-19		
63	Academy of Military Science (AMS)/ Walvax Biotechnology/ Suzhou Abogen Biosciences	Mainland China	2020-10-28		
64	Symvivo Corporation	Canada	2020-11-02		
65	University Hospital Tuebingen	Germany	2020-11-27		
66	City of Hope Medical Center/ National Cancer Institute	US	2020-12-11		
67	Codagenix/ Serum Institute of India	US/ India			

(   )

projects. This finding is also consistent with the expectation that the COVID-19 vaccine is part of “public goods” of which the research-and-development cost is mostly borne by vac-countries, but the benefits are “shared” by both vac- and non-vac-countries.

The U.S. and China are widely regarded as being in the forefront in the race to develop COVID-19 vaccines. In addition, vaccines differ from each other in terms of medical fundamentals and success rates. For example, US-developed vaccines are perceived as safer and have a higher efficacy rate than vaccines developed by other countries because of U.S.’ track record, advancement in medical research and its domination in the global pharmaceutical industry. Conversely, it is also possible that China has a higher success rate than other countries in developing a safe and effective COVID-19 vaccine because of its prior experience in dealing with the 2002–2004 severe acute respiratory syndrome (SA[redacted]al stock markets to react heterogeneously to vaccines developed in the U.S. and China, versus in other countries, on the first day of clinical trial phases.

To this end, we modify Eq. (1) by replacing with , which is equal to 1 on the first day when vaccine candidates developed by pharmaceutical companies domiciled in the U.S. began their clinical trials in a generic phase, and 0 otherwise. Analogously, we substitute with for pharmaceutical companies domiciled in China, and for pharmaceutical companies domiciled elsewhere. We also modify Eq. (2) by replacing = with = = , and = , one at a time. The = variable, for example, is equal to 1 on the first day of phase for vaccines developed in the U.S., and 0 otherwise. In all the analyses, we test the abnormal returns on 50 stock markets.

Table 4 reports the results. The result of the modified Eq. (1) shows that the average increase in abnormal stock market returns is highest for vaccines developed in China (13.32 bps, -statistic = 3.56). Turning to the modified Eq. (2), the results show that the abnormal stock market reaction in phase III is strongest for vaccines developed in the U.S. (17.73 bps, -statistic = 2.00). Also, the abnormal stock market returns on day-one of phase III of vaccines developed in the U.S. and other countries are significantly higher than those at the start of phase II. For example, Column (2) in Panel A reports that the average day-one abnormal return increases by 17.73 bps when US-developed vaccines enter phase III versus -1.90 bps in phase II, for a return differential of 19.64 bps (-statistic = 1.91). In short, stock market reactions are heterogeneous and conditional on clinical trial phases and the vaccine origins.

4. Conclusion

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Table 2
Global stock market reactions on the first day of clinical trial phases.

	~~Panel A: All vaccine candidates~~		~~Panel B: First movers~~	
	(1)	(2)	(3)	(4)
	0.0808***		0.2914***	
	(3.57)		(5.59)	
		0.0803**		0.1597***
		(2.67)		(3.41)
		0.1655***		0.4033***
		(4.08)		(6.44)
	-0.0050**	-0.0046**	-0.0050**	-0.0044**
	(-2.46)	(-2.32)	(-2.49)	(-2.22)
	0.1491**	0.1595**	0.2197***	0.2233***
	(2.19)	(2.31)	(3.09)	(3.25)
	-1.1296***	-1.1298***	-1.1434***	-1.1281***
	(-5.00)	(-5.01)	(-5.03)	(-5.01)
	0.6142*	0.6056*	0.5980*	0.6027*
	(1.93)	(1.90)	(1.88)	(1.89)
	-0.0950***	-0.0951***	-0.0954***	-0.0958***
	(-4.47)	(-4.47)	(-4.48)	(-4.49)
Country FE	Yes	Yes	Yes	Yes
# of obs	17350	17350	17350	17350
Adj. ^{2}	0.0192	0.0196	0.0208	0.0212
ϕ minus ϕ	N/A	0.0852	N/A	0.2436***
		(1.57)		(2.99)

The table reports the results of stock market reactions on the first day of vaccine clinical trial phases with the parenthesized -statistics computed using standard errors clustered at the country level. ~~Panel A reports the results for all~~ vaccines. ~~Panel B reports the results for 13 "first~~ mover" vaccines that had gained approval in at least one governing body as of April 30, 2021, but the regressions are estimated on all 50 countries. The control variables are:

is daily growth rate of COVID-19-confirmed cases, estimated as ln(1+confirmed cases) - ln(1+confirmed cases $_{-1}$). Following Ding et al. (2021), we collect the number of confirmed cases in all 50 countries from the WHO's COVID-19 Dashboard (https://covid19.who.int/).

is daily growth rate of COVID-19-related death cases, estimated as ln(1+death) - ln(1+death $_{-1}$).

CBOE VIX is a proxy of investor "fear gauge" around the globe (Whaley, 1993).

Bull-bear spread ( ) is the American Association of Individual Investors Sentiment Survey bull-bear spread, estimated by subtracting the percentage of pessimistic investors who believe that the market would go bearish from the percentage of optimistic investors who believe the market would go bullish.

The lag of abnormal returns ($_{-1}$) control for short-term reversal effect (~~Pástor and Stambaugh, 2003~~).

The last row reports the coefficient differences between and dummy variables with -statistics are parenthesized. The sample period covers from January 2, 2020, to April 30, 2021. *, **, *** denote significance levels at 10%, 5%, and 1%, respectively.

Table 3
Stock market reactions on the first day of clinical trial phases by country group.

	~~Panel A: 20 vac-countries~~		~~Panel B: 30 non-vac-countries~~	
	13 developed economies	7 emerging economies	10 developed economies	20 emerging economies
	(1)	(2)	(3)	(4)
	0.0906*	0.0655	0.1483*	0.0474
	(2.07)	(0.48)	(2.14)	(1.14)
	0.1328*	-0.0025	0.2192***	0.2155***
	(1.89)	(-0.02)	(3.46)	(3.12)
ϕ minus ϕ	0.0422	-0.068	0.0709	0.1681*
	(0.60)	(0.31)	(0.61)	(1.83)

The table reports the results of stock market reactions, by various groupings of countries, on the first day of vaccines' clinical trial phases with the parenthesized -statistics computed using standard errors clustered at the country level. ~~Panel A reports the results for 20 v~~ac-countries, and panel B tabulates the results for 30 non-vac-countries. The MSCI ACWI classifies the following countries as "developed economies" - Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong SAR[redacted]Netherlands, New Zealand, Norway, ~~Portugal,~~ Singapore, Spain, Sweden, Switzerland, U.K., and U.S, - and the following countries as "emerging economies" - Argentina, Brazil, Chile, China, Colombia, Czech [redacted]ary, India, Indonesia, Korea, Kuwait, Malaysia, Mexico, ~~Pakistan, Peru, Philippines, Poland, Qatar,~~ [redacted]ica, Taiwan [redacted]UAE. Four vac-countries — Cuba, Iran, Kazakhstan, and Vietnam — are not part of the MSCI ACWI classification. The last row of each panel reports the coefficient differences between and dummy variables with -statistics presented in parentheses. The sample period covers from January 2, 2020, to April 30, 2021. *, **, *** denote significance levels at 10%, 5%, and 1%, respectively.

This study offers new insights to whether global stock markets react [illegible] human clinical trials for COVID-19 vaccine candidates begin. We show that they do: upon the start of vaccine clinical trials, the a[illegible]ge abnormal return of global stock markets increase by 8.08 basis points, and this increase is both economically and statisticall[illegible]nificant. Our findings also suggest that global stock markets convey important information about market-wide expectations on t[illegible]onomic value of the development of COVID-19 vaccines even before public vaccine inoculation begins.

CRediT authorship contribution statement

Kam Fong Chan: Writing – original draft, Writing – review & ed[illegible], Methodology, Supervision. **Zhuo Chen:** Conceptualization, Writing – original draft, Writing – review & editing, Supervision, Me[illegible]ology. **Yuanji Wen:** Writing – original draft, Writing – review & editing, Supervision, Methodology. **Tong Xu:** Formal analysis, D[illegible]uration, Methodology, Software, Validation.

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